

# **Model Curriculum for Postgraduate Degree Courses in Engineering & Technology**

**January 2018**



**Volume II**

**ALL INDIA COUNCIL FOR TECHNICAL EDUCATION**  
Nelson Mandela Marg, Vasant Kunj, New Delhi 110070  
[www.aicte-india.org](http://www.aicte-india.org)

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Postgraduate Degree Courses in  
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# Preface

Post Graduate Education and Research in Engineering and Technology has gained distinct importance in context of challenges and opportunities in National development. The ambitious -Making in India Mission has already started showing targeted results in terms of increased manufacturing sector. Numbers of international projects are being setup in India through MoUs considering favourable policies and conditions. The start-ups projects have created a new generation of entrepreneurs in diverse fields of engineering by tapping vast potential of innovative minds. The skill development mission has attracted large number of youths to acquire skills of their liking and to convert skills in to employment and enterprise.

The advances in engineering sciences and their applications in service, manufacturing and agriculture sectors for commercial benefits has made paradigm shift from under graduate to post graduate level education in engineering and technology. The knowledge, skills and competency of engineers required by industry for enhancing their competitiveness in the market need to be developed from post graduate education and research in engineering and technology. The expansion of engineering PG education in the last decade has offered opportunity to bachelor degree holders to enhance their academic excellence and skills. There are number of PG programs in engineering and technology branches in different specializations which are offered at about 4000 colleges. The Post Graduate Education and Research in specialised subject have enhanced academic out comes. The teaching and research facilities created for conducting PG projects have connected institutes with industry for consultancy and research. Realizing of importance of PG education in engineering, orientation of curriculum of PG programmes to make it more relevant and useful is considered need the hour. The All India Board of PG Education and Research in Engineering and Technology of AICTE has decided to review and update curriculum for various courses and programs in technical education. The focus is fixed to design and develop model curricula at PG level in the light of fast changing technological advancement, new emerging areas and also changes in pedagogy and delivery system in teaching and learning process.

The model curriculum was developed for six branches of engineering-Electronics and Communications Engineering, Computer Science, Mechanical Engineering, Civil Engineering, Electrical Engineering and Chemical Engineering and Technology. The subcommittees constituted for the purses included experts of each branch. The philosophy of drafting model curriculum for PG level programmes has been evolved through elaborate deliberation through numbers of meetings. The major specializations in each branch of engineering are selected for making model curriculum. The course objectives and course outcomes are made part of the model curriculum to ensure development of specialized knowledge and relevant skill in integrated manner of learning.

A standard academic format common for all PG programmes describing numbers of credits, weight age for lecture, laboratories work and projects have been fixed considering the scope of study. The position and sequence of study of core courses and elective courses are made to ensure sequential and integral learning. The focus on advance study in core courses through theory and laboratories work supported by study on relevant programme specific electives are incorporated. The selection of unique courses in the basket of elective is a special features of model curricula ensuring flexibility and diversity. The emphasis on understanding advanced concepts of PG course is ensured through elaborate practical work conducted through actual and virtual laboratory experiments. The concept of designing experiments and developing concept application is made part of learning process. The PG course is spread over two years in four semesters and inclusion of mini project, audit courses, open electives and dissertation are the special features of the curriculum. The contents of course are unitised to facilitate its execution. The list of suggested reading is also made part of the curriculum.

The students are asked to learn IPR/ research methodology to understand importance and process of creation of patents through research. The introduction of two Audit courses covering subjects of developing desired attitude among the learners is on the line of initiatives such as Unnat Bharat Abhiyan, Yoga, Value education, Disaster management, Sanskrit, Pedagogy, Constitution of India, Personality development through Indian culture etc. The introduction of mini projects ensures preparedness of students to undertake major projects/ dissertation. The courses included under open electives are of importance in the context of special skill development and they are on Business analytics, industrial safety, operation research and cost management of engineering project. This courses shall make students capable to work in industrial environment. The dissertation/major project work of PG programme of one-year duration is given strong weight age in the curriculum. It is expected to undertake industrially relevant problem to develop an optimal solution through extensive research work. The students and faculty can design the research project in consultant with industry preferably in the region. The planning of laboratory work/ modelling/ computational work with execution schedule is suggested at the being of the programme to ensure expected outcome. This will lead to creation of patents from the result of the programme.

The exercise of drafting model PG curriculum has been undertaken along with feedback from experts from industry, research organizations and alumni to make it relevant, dynamic and updated. The extensive work performed by members of the sub committees to develop model curriculum in various specializations of core branches of engineering and technology through marathon meetings and tire less work is highly appreciated. I extent sincere thanks to all the members of subcommittees for their contributions in developing model PG curriculum. Adopting and implementing the model curriculum by institutions and universities would help create human resource with desired competency. The cooperate sector would be benefited from trained manpower for improvement in quality and productivity leading to competitiveness in

the global marketing through technological intervention. The students with advance knowledge and special skills would be able to offer innovative ideas, technology, product and process in national development process and fulfil their career goals. With the specialized curriculum of PG Programmes, the institutes can transform themselves into global institutes. This would not only retain the large number of graduate students going around for higher studies but would also attract international students making country a global place of higher learning and research in engineering and Technology.

November, 2017

New Delhi

**Prof. Vilas S. Sapkal**  
Chairman,  
All India Board of Post Graduate Education  
and Research in Engineering and Technology



## **Subcommittees for drafting model curriculum for PG programs in Engineering and Technology**

### **1) Electronics & Communication Engineering**

#### **Names of Members**

1. Dr. Priti Rege, Department of Electronics & Telecommunication, Govt. College of Engineering, Pune
2. Dr. Vineet Sahula, Professor Department of Electronics & Communication Engineering, MNIT, Jaipur
3. Dr. R.K. Baghel, Department of Electronics and Communication Engineering, MANIT, Bhopal

### **2) Computer Science**

#### **Names of Members**

1. Prof Rajesh Bhatia, Dean and Chairman PEC University, Chandigarh
2. Prof. Atal Chaudhari, Dept. of Computer Science & Engineering, Jadhapur University, Kolkata
3. Dr. Meenu Chawla, Prof., Computer Science, Maulana Azad National Institute of Technology Bhopal, Link road Number 3 Near Kali Mata Mandir, Bhopal, MP- 462 003.

### **3) Mechanical Engineering**

#### **Names of Members**

1. Prof. Sam Sher, Delhi Technological University, Delhi.
2. Prof. D.W. Pandey Professor, Mechanical Engineering College of Engineering Pune.
3. Dr. Gajendra Dixit, Prof, Mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal, Link road No 3, Near Kali Mata Mandir, Bhopal, MP 462 034.

### **4) Civil Engineering**

#### **Names of Members**

1. Dr. C.S.P. Ojha, Department of Civil Engineering, IIT Roorkee
2. Prof. G.S. waminatha, Civil Engineering, NIT, Tiruchirapulli
3. Dr. Rajendra R. Joshi, College of Civil Engineering, Pune

## **5) Electrical Engineering**

### **Names of Members**

1. Dr. M.K. Khedkar, Prof. Electrical Engineering. Visvesvaraya National Institute fo Technology, South Ambazari Road, Nagpur
2. Dr. Prerana Gour, NSIT, Dwarka, New Delhi
3. Dr. Abhijit Abhyankar, Department of Electrical Engineering, IIT, Delhi

## **6) Chemical Engineering & Technology**

### **Names of Members**

1. Dr. R.S. Sapkal, Ex-Director BCUD, Professor Department of Chemical Technology, SGB Amravati University, Amravati.
2. Dr. R.W, Gaikwad, Prof. Department of Chemical Engineering, Pravra Rural Engineering College, Loni, Distt Ahamdnagar 413 736
3. Dr. S.H. Sonawane, Department of Chemical Engineering, NIT, Warangal.

### **Distinct features of model PG curriculum in Engineering and Technology:**

- 1. Standardized academic structure for all PG Programs with uniform credit distribution.**
- 2. Advanced study of specialization through core subjects, flexible and diverse program specific electives.**
- 3. Open electives to widen skills.**
- 4. Enhanced engagement of industry in developing innovations and problem solutions.**
- 5. Collaborating and interactive learning to ensure talent development.**
- 6. Inbuilt mechanism for regular upgradation of curriculum.**
- 7. Focus on development of advanced knowledge and specific skills required for industrial development.**
- 8. Ensured competency development of learner.**

**Open Elective**

1. Business Analytics
2. Industrial Safety
3. Operations Research
4. Cost Management of Engineering Projects
5. Composite Materials
6. Waste to Energy

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

| <b>Research Methodology and IPR</b>   |  |
|---|--|
| <b>Teaching Scheme</b>  |  |
| Lectures: 1hrs/week   |  |
| <b>Course Outcomes:</b>   |  |
| At the end of this course, students will be able to   |  |
| <ul style="list-style-type: none"><li>• Understand research problem formulation.</li><li>• Analyze research related information</li><li>• Follow research ethics</li><li>• Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.</li><li>• Understanding that when IPR would take such important place in growth of individuals &amp; nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general &amp; engineering in particular.</li><li>• Understand that IPR protection provides an incentive to inventors for further research work and investment in R &amp; D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.</li></ul> |  |

## **Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

## **References:**

- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall, “Industrial Design”, McGraw Hill, 1992.
- Niebel, “Product Design”, McGraw Hill, 1974.
- Asimov, “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

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MODEL CURRICULUM  
of  
Engineering & Technology PG Courses

**CIVIL**



**ALL INDIA COUNCIL FOR TECHNICAL EDUCATION**

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**M. Tech. (Civil Engineering) Specialization: Structural Engineering****Semester I**

| <b>Sr. No.</b> | <b>Course Type/Code</b> | <b>Course Name</b>   |
|----------------|-------------------------|--|
| 1.             | Core 1                  | Advanced Structural Analysis   |
| 2.             | Core 2                  | Advanced Solid Mechanics   |
| 3.             | Program Elective        | Elective – I<br>1. Theory of Thin Plates and Shells<br>2. Theory and Applications of Cement Composites<br>3. Theory of Structural Stability      |
| 4.             | Program Elective        | Elective – II<br>1. Analytical and Numerical Methods for Structural Engineering<br>2. Structural Health Monitoring<br>3. Structural Optimization |
| 5.             | Core Lab I              | Structural Design Lab  |
| 6.             | Core Lab II             | Advanced Concrete Lab  |
| 7.             | MLC                     | Research Methodology and IPR   |
| 8.             | Audit 1                 | Audit Course   |

**Semester II**

| <b>Sr. No.</b> | <b>Course Type/Code</b> | <b>Course Name</b>  |
|----------------|-------------------------|---|
| 1.             | Core III                | FEM in Structural Engineering   |
| 2.             | Core IV                 | Structural Dynamics   |
| 3.             | Program Elective III    | Elective – III<br>1. Advanced Steel Design<br>2. Design of Formwork<br>3. Design of High Rise Structures<br>4. Design of Masonry Structures                           |
| 4.             | Program Elective IV     | Elective – IV<br>1. Design of Advanced Concrete Structures<br>2. Advanced Design of Foundations<br>3. Soil Structure Interaction<br>4. Design of Industrial Structure |
| 5.             | Core Lab III            | Model Testing Lab   |
| 6.             | Core Lab IV             | Numerical Analysis Lab  |
| 7.             | Core                    | Mini Project  |
| 8.             | Audit 2                 | Audit Course-2  |

### Semester III

| Sr. No. | Course Type/Code     | Course Name   |
|---------|----------------------|---|
| 1.      | Program Elective - V | Elective - V<br>1. Design of Prestressed Concrete Structures<br>2. Analysis of Laminated Composite Plates<br>3. Fracture Mechanics of Concrete Structures<br>4. Design of Plates and Shells |
| 2.      | Open Elective        | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy                       |
| 3.      | Dissertation         | Dissertation Phase – I  |

### Semester IV

| Sr. No. | Course Code  | Course Name             |
|---------|--------------|-------------------------|
| 1.      | Dissertation | Dissertation Phase – II |

#### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Addition
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

### M. Tech. (Civil Engineering) Specialization:Hydraulic Engineering

#### Semester I

| Sr. No. | Course Type/Code  | Course Name   |
|---------|-------------------|---|
| 1.      | Core-I            | Advanced Hydrology  |
| 2.      | Core-II           | Advanced Fluid Mechanics  |
| 3.      | Prog. Elective-I  | (1) Fluvial Hydraulics<br>(2) Hydraulic Structures<br>(3) Systems Engineering |
| 4.      | Prog. Elective-II | (1) Water Resources Systems Planning<br>(2) Irrigation and Drainage           |
| 5       | Lab 1             | Fluid Mechanics   |
| 6       | Lab 2             | Hydrology   |
| 7.      | Core              | Research Methodology and IPR  |
| 8.      | Audit 1           | Audit course 1  |



### Semester II

| Sr. No. | Course Code/Type   | Course Name  |
|---------|--------------------|--|
| 1.      | Core-III           | Ground Water Engineering   |
| 2.      | Core-IV            | Free Surface Flows   |
| 3.      | Prog. Elective-III | (1) Computational Methods in Fluid Mechanics<br>(2) Theory and Applications of GIS |
| 4.      | Prog. Elective-IV  | (1) Environmental Hydraulics<br>(2) Advanced Numerical Analysis                    |
|         | Lab 1              | Computational Fluid Dynamics   |
|         | Lab 2              | Open Channel Flow  |
| 5.      | Core               | Mini-Project   |
| 6.      | Audit 2            | Audit -2   |

### Semester III

| Sr. No. | Course Code           | Course Name   |
|---------|-----------------------|---|
| 1.      | Programme-Elective-V  | Computer Methods in Hydraulics and Hydrology<br>Stochastic Hydrology  |
| 2.      | Programme Elective-VI | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3.      | Dissertation          | Dissertation Phase – I  |

### Semester IV

| Sr. No. | Course Code  | Course Name             |
|---------|--------------|-------------------------|
| 1.      | Dissertation | Dissertation Phase - II |

#### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

## M. Tech (Civil Engineering) Model Curriculum Structure Specialization: Structural Engineering

### Program Outcomes (POs):

After completion of the program graduates will be able to

- A. Apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude
- B. Identify, formulate and solve engineering problems in the domain of structural engineering field.
- C. Use different software tools for Analysis and Design structural engineering domain.
- D. Design and conduct experiments, analyse and interpret data, for development of simulation experiments.
- E. Function as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.

| Model curriculum for ME (Civil) - specialization in Structural Engineering |                  |  |                 |          |          |           |
|--|------------------|--|-----------------|----------|----------|-----------|
| Semester I   |                  |  |                 |          |          |           |
| Sr. No.  | Course Type/Code | Course Name  | Teaching Scheme |          |          | Credits   |
|  |                  |  | Th              | Tuto     | Lab      |           |
| 1.   | Core 1           | Advanced Structural Analysis   | 3               | 0        | 0        | 3         |
| 2.   | Core 2           | Advanced Solid Mechanics   | 3               | 0        | 0        | 3         |
| 3.   | Program Elective | Elective – I<br>1. Theory of Thin Plates and Shells<br>2. Theory and Applications of Cement Composites<br>3. Theory of Structural Stability      | 3               | 0        | 0        | 3         |
| 4.   | Program Elective | Elective – II<br>1. Analytical and Numerical Methods for Structural Engineering<br>2. Structural Health Monitoring<br>3. Structural Optimization | 3               | 0        | 0        | 3         |
| 5.   | Core Lab I       | Structural Design Lab  | 0               | 0        | 2        | 2         |
| 6.   | Core Lab II      | Advanced Concrete Lab  | 0               | 0        | 2        | 2         |
| 7.   | MLC              | Research Methodology and IPR   | 2               | 0        | 0        | 2         |
| 8.   | Audit 1          | Audit Course   | 2               | 0        | 0        | 0         |
| <b>Total</b>   |                  |  | <b>16</b>       | <b>0</b> | <b>4</b> | <b>18</b> |

| Semester II  |                      |   |                 |          |          |           |
|--------------|----------------------|---|-----------------|----------|----------|-----------|
| Sr. No.      | Course Type/Code     | Course Name   | Teaching Scheme |          |          | Credits   |
|              |                      |   | Th              | Tuto     | Lab      |           |
| 1.           | Core III             | FEM in Structural Engineering   | 3               | 0        | 0        | 3         |
| 2.           | Core IV              | Structural Dynamics   | 3               | 0        | 0        | 3         |
| 3.           | Program Elective III | Elective – III<br>1. Advanced Steel Design<br>2. Design of Formwork<br>3. Design of High Rise Structures<br>4. Design of Masonry Structures                           | 3               | 0        | 0        | 3         |
| 4.           | Program Elective IV  | Elective – IV<br>1. Design of Advanced Concrete Structures<br>2. Advanced Design of Foundations<br>3. Soil Structure Interaction<br>4. Design of Industrial Structure | 3               | 0        | 0        | 3         |
| 5.           | Core Lab III         | Model Testing Lab   | 0               | 0        | 2        | 2         |
| 6.           | Core Lab IV          | Numerical Analysis Lab  | 0               | 0        | 2        | 2         |
| 7.           | Core                 | Mini Project  | 0               | 0        | 4        | 2         |
| 8.           | Audit 2              | Audit Course-2  | 2               | 0        | 0        | 0         |
| <b>Total</b> |                      |   | <b>14</b>       | <b>0</b> | <b>8</b> | <b>18</b> |

| Semester III |                    |   |                 |          |          |           |
|--------------|--------------------|---|-----------------|----------|----------|-----------|
| Sr. No.      | Course Type/Code   | Course Name   | Teaching Scheme |          |          | Credits   |
|              |                    |   | Th              | Tuto     | Lab      |           |
| 1.           | Program Elective-V | Elective - V<br>1. Design of Prestressed Concrete Structures<br>2. Analysis of Laminated Composite Plates<br>3. Fracture Mechanics of Concrete Structures<br>4. Design of Plates and Shells | 3               | 0        | 0        | 3         |
| 2.           | Open Elective      | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy                       | 3               | 0        | 0        | 3         |
| 3.           | Dissertation       | Dissertation Phase – I  | 0               | 0        | 20       | 10        |
| <b>Total</b> |                    |   | <b>6</b>        | <b>0</b> | <b>0</b> | <b>16</b> |

| Semester-IV  |              |                         |                 |    |    |           |
|--------------|--------------|-------------------------|-----------------|----|----|-----------|
| Sr. No.      | Course Code  | Course Name             | Teaching Scheme |    |    | Credits   |
| 1.           | Dissertation | Dissertation Phase – II | 0               | 0  | 32 | 16        |
| <b>Total</b> |              |                         | --              | -- | -- | <b>16</b> |

**Total Credits for the programme = 18 + 18 + 16 + 16 = 68**

#### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Addition
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

#### Semester I

#### Core 1 - Advanced Structural Analysis (Credits - 3:0:0 = 3)

Teaching Scheme

Lectures: 3 hrs/week

**Course outcomes:** At the end of the course, students will be able to

1. Analyze the skeleton structures using stiffness analysis code.
2. Use direct stiffness method understanding its limitations

#### Syllabus Contents:

- **Influence Coefficients:** Physical Significance, Effects of Settlements, Temperature Change and Lack of Fit, Member Approach and Structure Approach.
- **Stiffness Method applied to Large Frames:** Local Coordinates and Global Coordinates.
- **Stiffness Matrix Assembly of Structures:** Stiffness Matrix in Global Coordinates, Boundary Conditions, Solution of Stiffness Matrix Equations, Calculation of Reactions and Member Forces.
- **Applications to Simple Problems:** Beams, Plane Trusses, Plane Rigid Jointed Frames and Grids by Structure Approach and Member Approach.
- **Boundary Value Problems (BVP):** Approximate Solution of Boundary Value Problems, Modified Galerkin Method for One-Dimensional BVP, Matrix Formulation of the Modified Galerkin Method.

- **Linear Element:** Shape Functions, Solution for Poisson's Equation, General OneDimensional Equilibrium Problem.

**References:**

- Matrix Analysis of Framed Structures, Weaver and Gere.
- The Finite Element Method, Lewis P. E. and WardJ. P., Addison-Wesley Publication Co.
- Computer Methods in Structural Analysis, MeekJ. L., E and FN, Span Publication.
- The Finite Element Method, Desai and Able, CBS Publication.

**Core 2 - Advanced Solid Mechanics (Credits - 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course outcomes:** At the end of the course, students will be able to

1. Solve simple problems of elasticity and plasticity understanding the basic concepts.
2. Apply numerical methods to solve continuum problems.

**Syllabus Contents:**

- **Introduction to Elasticity:** Displacement, Strain and Stress Fields, Constitutive Relations, Cartesian Tensors and Equations of Elasticity.
- **Strain and Stress Field:** Elementary Concept of Strain, Strain at a Point, Principal Strains and Principal Axes, Compatibility Conditions, Stress at a Point, Stress Components on an Arbitrary Plane, Differential Equations of Equilibrium, Hydrostatic and Deviatoric Components.
- **Equations of Elasticity:** Equations of Equilibrium, Stress- Strain relations, Strain Displacement and Compatibility Relations, Boundary Value Problems, Co-axiality of the Principal Directions.
- **Two-Dimensional Problems of Elasticity:** Plane Stress and Plane Strain Problems, Airy's stress Function, Two-Dimensional Problems in Polar Coordinates.
- **Torsion of Prismatic Bars:** Saint Venant's Method, Prandtl's Membrane Analogy, Torsion of Rectangular Bar, Torsion of Thin Tubes.
- **Plastic Deformation:** Strain Hardening, Idealized Stress- Strain curve, Yield Criteria, von Mises Yield Criterion, Tresca Yield Criterion, Plastic Stress-Strain Relations, Principle of Normality and Plastic Potential, Isotropic Hardening.

**References:**

- Theory of Elasticity, Timoshenko S. and Goodier J. N., McGraw Hill, 1961.
- Elasticity, Sadd M. H., Elsevier, 2005.
- Engineering Solid Mechanics, Ragab A. R., Bayoumi S. E., CRC Press, 1999.
- Computational Elasticity, Ameen M., Narosa, 2005.
- Solid Mechanics, Kazimi S. M. A., Tata McGraw Hill, 1994.
- Advanced Mechanics of Solids, Srinath L. S., Tata McGraw Hill, 2000.

### **Program Elective I - Theory of Thin Plates and Shells (Credits - 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Use analytical methods for the solution of thin plates and shells.
2. Use analytical methods for the solution of shells.
3. Apply the numerical techniques and tools for the complex problems in thin plates.
4. Apply the numerical techniques and tools for the complex problems in shells.

#### **Syllabus Contents:**

- **Introduction:** Space Curves, Surfaces, Shell Co-ordinates, Strain Displacement Relations, Assumptions in Shell Theory, Displacement Field Approximations, Stress Resultants, Equation of Equilibrium using Principle of Virtual Work, Boundary Conditions.
- **Static Analysis of Plates:** Governing Equation for a Rectangular Plate, Navier Solution for Simply-Supported Rectangular Plate under Various Loadings, Levy solution for Rectangular Plate with other Boundary Conditions.
- **Circular Plates:** Analysis under Axi-Symmetric Loading, Governing Differential Equation in Polar Co-ordinates. Approximate Methods of Analysis- Rayleigh-Ritz approach for Simple Cases in Rectangular Plates.
- **Static Analysis of Shells: Membrane Theory of Shells** - Cylindrical, Conical and Spherical Shells,
- **Shells of Revolution: with Bending Resistance** - Cylindrical and Conical Shells, Application to Pipes and Pressure Vessels.
- **Thermal Stresses in Plate/ Shell**

#### **References:**

- Theory of Plates and Shells, Timoshenko S. and Krieger W., McGraw Hill.
- Stresses in Plates and Shells, Ugural Ansel C., McGraw Hill.
- Thin Elastic Shells, Kraus H., John Wiley and Sons.
- Theory of Plates, Chandrashekhara K., Universities Press.
- Design and Construction of Concrete Shells, Ramaswamy G.S.

### **Program Elective I - Theory and Applications of Cement Composites (Credits- 3:0:0=3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Formulate constitutive behaviour of composite materials – Ferrocement, SIFCON and Fibre Reinforced Concrete - by understanding their strain- stress behaviour.
2. Classify the materials as per orthotropic and anisotropic behaviour.
3. Estimate strain constants using theories applicable to composite materials.
4. Analyse and design structural elements made of cement composites.

**Syllabus Content:**

- **Introduction:** Classification and Characteristics of Composite Materials- Basic Terminology, Advantages. Stress-Strain Relations- Orthotropic and Anisotropic Materials, Engineering Constants for Orthotropic Materials, Restrictions on Elastic Constants, Plane Stress Problem, Biaxial Strength, Theories for an Orthotropic Lamina.
- **Mechanical Behaviour:** Mechanics of Materials Approach to Stiffness- Determination of Relations between Elastic Constants, Elasticity Approach to Stiffness- Bounding Techniques of Elasticity, Exact Solutions - Elasticity Solutions with Continuity, Halpin, Tsai Equations, Comparison of approaches to Stiffness.
- **Cement Composites:** Types of Cement Composites, Terminology, Constituent Materials and their Properties, Construction Techniques for Fibre Reinforced Concrete - Ferrocement, SIFCON, Polymer Concretes, Preparation of Reinforcement, Casting and Curing.
- **Mechanical Properties of Cement Composites:** Behavior of Ferrocement, Fiber Reinforced Concrete in Tension, Compression, Flexure, Shear, Fatigue and Impact, Durability and Corrosion.
- **Application of Cement Composites:** FRC and Ferrocement- Housing, Water Storage, Boats and Miscellaneous Structures. Composite Materials- Orthotropic and Anisotropic behaviour, Constitutive relationship, Elastic Constants.
- **Analysis and Design of Cement Composite Structural Elements -** Ferrocement, SIFCON and Fibre Reinforced Concrete.

**Reference Books:**

- Mechanics of Composite Materials, Jones R. M., 2<sup>nd</sup> Ed., Taylor and Francis, BSP Books, 1998.
- Ferrocement – Theory and Applications, Pama R. P., IFIC, 1980.
- New Concrete Materials, Swamy R.N., 1<sup>st</sup> Ed., Blackie, Academic and Professional, Chapman & Hall, 1983.

### **Program Elective I - Theory of Structural Stability (Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Determine stability of columns and frames
2. Determine stability of beams and plates
3. Use stability criteria and concepts for analysing discrete and continuous systems,

### Syllabus Contents:

- **Criteria for Design of Structures:** Stability, Strength, and Stiffness, Classical Concept of Stability of Discrete and Continuous Systems, Linear and nonlinear behaviour.
- **Stability of Columns:** Axial and Flexural Buckling, Lateral Bracing of Columns, Combined Axial, Flexural and Torsion Buckling.
- **Stability of Frames:** Member Buckling versus Global Buckling, Slenderness Ratio of Frame Members.
- **Stability of Beams:** lateral torsion buckling.
- **Stability of Plates:** axial flexural buckling, shear flexural buckling, buckling under combined loads.
- **Introduction to Inelastic Buckling** and Dynamic Stability.

### Reference Books:

- Theory of elastic stability, Timoshenko and Gere, Tata Mc Graw Hill, 1981
- Principles of Structural Stability Theory, Alexander Chajes, Prentice Hall, New Jersey.
- Structural Stability of columns and plates, Iyengar, N. G. R., Eastern west press Pvt. Ltd.
- Strength of Metal Structures, Bleich F. Bucking, Tata McGraw Hill, New York.

## Program Elective II – Analytical and Numerical Methods for Structural Engineering (Credits - 3:0:0 = 3)

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Solve ordinary and partial differential equations in structural mechanics using numerical methods.
2. Write a program to solve a mathematical problem.

### Syllabus Contents:

- **Fundamentals of Numerical Methods:** Error Analysis, Polynomial Approximations and Interpolations, **Curve Fitting;** Interpolation and extrapolation.
- **Solution of Nonlinear Algebraic and Transcendental Equations**
- **Elements of Matrix Algebra:** Solution of Systems of Linear Equations, Eigen Value Problems.
- **Numerical Differentiation & Integration:** Solution of Ordinary and Partial Differential Equations.
- **Finite Difference scheme:** Implicit & Explicit scheme.
- **Computer Algorithms:** Numerical Solutions for Different Structural Problems, Fuzzy Logic and Neural Network.

### Reference Books:

- An Introduction to Numerical Analysis, Atkinson K.E., J. Wiley and Sons, 1989.
- Theory and Problems of Numerical Analysis, Scheid F, McGraw Hill Book Company, (Shaum Series), 1988.
- Introductory Methods of Numerical Analysis, Sastry S. S, Prentice Hall of India, 1998.



### **Program Elective II – Structural Health Monitoring (Credits - 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Diagnosis the distress in the structure understanding the causes and factors.
2. Assess the health of structure using static field methods.
3. Assess the health of structure using dynamic field tests.
4. Suggest repairs and rehabilitation measures of the structure

**Syllabus Contents:**

- **Structural Health:** Factors affecting Health of Structures, Causes of Distress, Regular Maintenance.
- **Structural Health Monitoring:** Concepts, Various Measures, Structural Safety in Alteration.
- **Structural Audit:** Assessment of Health of Structure, Collapse and Investigation, Investigation Management, SHM Procedures.
- **Static Field Testing:** Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement.
- **Dynamic Field Testing:** Types of Dynamic Field Test, Stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition Systems, Remote Structural Health Monitoring.
- **Introduction to Repairs and Rehabilitations of Structures:** Case Studies (Site Visits), piezo-electric materials and other smart materials, electro-mechanical impedance (EMI) technique, adaptations of EMI technique.

**Reference Books:**

- Structural Health Monitoring, Daniel Balageas, Claus Peter Fritzen, Alfredo Güemes, John Wiley and Sons, 2006.
- Health Monitoring of Structural Materials and Components – Methods with Applications, Douglas E Adams, John Wiley and Sons, 2007.
- Structural Health Monitoring and Intelligent Infrastructure, Vol1, J. P. Ou, H. Li and Z. D. Duan, Taylor and Francis Group, London, UK, 2006.
- Structural Health Monitoring with Wafer Active Sensors, Victor Giurgutiu, Academic Press Inc, 2007.

### **Program Elective II – Structural Optimization (Credits - 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Use Variational principle for optimization
2. Apply optimization techniques to structural steel and concrete members.
3. Design using frequency constraint.

**Introduction:** Simultaneous Failure Mode and Design, Classical External Problems.  
**Calculus of Variation:** Variational Principles with Constraints,  
**Linear Programming,** Integer Programming, Nonlinear Programming, Dynamic Programming,  
**Geometric Programming and Stochastic Programming.**  
**Applications:** Structural Steel and Concrete Members, Trusses and Frames.  
**Design:** Frequency Constraint, Design of Layouts.

**Reference Books:**

- Elements of Structural Optimization, Haftka, Raphael T., Gürdal, Zafer, Springer.
- Variational methods for Structural optimization, Cherkaev Andrej, Springer

**Core Lab1 – Structural Design Lab (Credits - 0:0:4 = 2)**

Teaching Scheme

Lab: 2 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Design and Detail all the Structural Components of Frame Buildings.
2. Design and Detail complete Multi-Storey Frame Buildings.

**Syllabus Content:**

Design and detailed drawing of complete G+ 3 structures by individual student using latest relevant IS codes.

**Core Lab2 – Advanced Concrete Lab (Credits - 0:0:4 = 2)**

Teaching Scheme

Lab: 2 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Design high grade concrete and study the parameters affecting its performance.
2. Conduct Non Destructive Tests on existing concrete structures.
3. Apply engineering principles to understand behavior of structural/ elements.

**List of Experiments/Assignments:**

1. Study of stress-strain curve of high strength concrete, Correlation between cube strength, cylinder strength, split tensile strength and modulus of rupture.
2. Effect of cyclic loading on steel.
3. Non-Destructive testing of existing concrete members.
4. Behavior of Beams under flexure, Shear and Torsion.

**Reference Books:**

- Properties of Concrete, Neville A. M., 5th Edition, Prentice Hall, 2012.
- Concrete Technology, Shetty M. S., S. Chand and Co., 2006.

| <b>Research Methodology and IPR</b>  |  |
|--|--|
| <b>Teaching Scheme</b><br>Lectures: 1hrs/week  |  |
| <b>Course Outcomes:</b>  |  |
| <p>At the end of this course, students will be able to</p> <ul style="list-style-type: none"> <li>• Understand research problem formulation.</li> <li>• Analyze research related information</li> <li>• Follow research ethics</li> <li>• Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.</li> <li>• Understanding that when IPR would take such important place in growth of individuals &amp; nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general &amp; engineering in particular.</li> <li>• Understand that IPR protection provides an incentive to inventors for further research work and investment in R &amp; D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.</li> </ul>  |  |
| <b>Syllabus Contents:</b>  |  |
| <p><b>Unit 1:</b> Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.</p> <p>Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations</p> <p><b>Unit 2:</b> Effective literature studies approaches, analysis<br/>Plagiarism, Research ethics,</p> <p><b>Unit 3:</b> Effective technical writing, how to write report, Paper<br/>Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee</p> <p><b>Unit 4:</b> Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.</p> <p><b>Unit 5:</b> Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.</p> <p><b>Unit 6:</b> New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.</p> |  |
| <b>References:</b>   |  |
| <ul style="list-style-type: none"> <li>• Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science &amp; engineering students"</li> <li>• Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"</li> </ul>  |  |

- Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.
- Asimov , “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

### Semester II

#### Core 3 - Finite Element Method in Structural Engineering(Credits- 3:0:0 = 3)

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Use Finite Element Method for structural analysis.
2. Execute the Finite Element Program/ Software.
3. Solve continuum problems using finite element analysis.

#### Syllabus Contents:

- **Introduction:** History and Applications. Spring and Bar Elements, Minimum Potential Energy Principle, Direct Stiffness Method, Nodal Equilibrium equations, Assembly of Global Stiffness Matrix, Element Strain and Stress.
- **Beam Elements:** Flexure Element, Element Stiffness Matrix, Element Load Vector.
- **Method of Weighted Residuals:** Galerkin Finite Element Method, Application to Structural Elements, Interpolation Functions, Compatibility and Completeness Requirements, Polynomial Forms, Applications.
- **Types:** Triangular Elements, Rectangular Elements, Three-Dimensional Elements, Isoparametric Formulation, Axi-Symmetric Elements, Numerical Integration, Gaussian Quadrature.
- **Application to Solid Mechanics:** Plane Stress, CST Element, Plane Strain Rectangular Element, Isoparametric Formulation of the Plane Quadrilateral Element, Axi- Symmetric Stress Analysis, Strain and Stress Computations.
- **Computer Implementation** of FEM procedure, Pre-Processing, Solution, Post-Processing, Use of Commercial FEA Software.

#### Reference Books:

- Finite Element Analysis, Seshu P., Prentice-Hall of India, 2005.
- Concepts and Applications of Finite Element Analysis, Cook R. D., Wiley J., New York, 1995.
- Fundamentals of Finite Element Analysis, Hutton David, Mc-Graw Hill, 2004.
- Finite Element Analysis, Buchanan G.R., McGraw Hill Publications, New York, 1995.
- Finite Element Method, Zienkiewicz O.C. & Taylor R.L. Vol. I, II & III, Elsevier, 2000.
- Finite Element Methods in Engineering, Belegundu A.D., Chandrupatla, T.R., Prentice Hall India, 1991.

### Core 4 – Structural Dynamics (Credits - 3:0:0 = 3)

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Analyze and study dynamics response of single degree freedom system using fundamental theory and equation of motion.
2. Analyze and study dynamics response of Multi degree freedom system using fundamental theory and equation of motion.
3. Use the available software for dynamic analysis.

**Syllabus Contents:**

- **Introduction:** Objectives, Importance of Vibration Analysis, Nature of Exciting Forces, Mathematical Modeling of Dynamic Systems.
- **Single Degree of Freedom System:** Free and Forced Vibration with and without Damping, Response to Harmonic Loading, Response to General Dynamic Loading using Duhamel's Integral, Fourier Analysis for Periodic Loading, State Space Solution for Response.
- **Numerical Solution** to Response using Newmark  $\square$  Method and Wilson  $\square$  Method, Numerical Solution for State Space Response using Direct Integration.
- **Multiple Degree of Freedom System (Lumped parameter):** Two Degree of Freedom System, Multiple Degree of Freedom System, Inverse Iteration Method for Determination of Natural Frequencies and Mode Shapes, Dynamic Response by Modal Superposition Method, Direct Integration of Equation of Motion.
- **Multiple Degree of Freedom System (Distributed Mass and Load):** Single Span Beams, Free and Forced Vibration, Generalized Single Degree of Freedom System.
- **Special Topics in Structural Dynamics (Concepts only):** Dynamic Effects of Wind Loading, Moving Loads, Vibrations caused by Traffic, Blasting and Pile Driving, Foundations for Industrial Machinery, Base Isolation.

**Reference Books:**

- Dynamics of Structures, Clough R. W. and Penzien J., Mc Graw Hill.
- Structural Dynamics and Introduction to Earthquake Engineering, Chopra A. K.
- Vibration of Structures - Application in Civil Engineering Design, Smith J. W., Chapman and Hall.
- Dynamics of Structures, Humar J. L., Prentice Hall.
- Structural Dynamics - Theory and Computation, Paz Mario, CBS Publication.
- Dynamics of Structures, Hart and Wong.

### Program Elective III– Advanced Steel Design (Credits - 3:0:0 = 3)

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Design steel structures/ components by different design processes.
2. Analyze and design beams and columns for stability and strength, and drift.
3. Design welded and bolted connections.

**Syllabus Contents:**

- **Properties of Steel:** Mechanical Properties, Hysteresis, Ductility.  
**Hot Rolled Sections:** compactness and non-compactness, slenderness, residual stresses.
- **Design of Steel Structures:** Inelastic Bending Curvature, Plastic Moments, Design Criteria Stability, Strength, Drift.
- **Stability of Beams:** Local Buckling of Compression Flange & Web, Lateral Torsional Buckling.
- **Stability of Columns:** Slenderness Ratio, Local Buckling of Flanges and Web, Bracing of Column about Weak Axis.
- **Method of Designs:** Allowable Stress Design, Plastic Design, Load and Resistance Factor Design;
- **Strength Criteria:** Beams - Flexure, Shear, Torsion, Columns - Moment Magnification Factor, Effective Length, PM Interaction, Biaxial Bending, Joint Panel Zones.  
**Drift Criteria:** P Effect, Deformation Based Design;  
**Connections:** Welded, Bolted, Location Beam Column, Column Foundation, Splices.

Reference Books:

- Design of Steel Structures - Vol. II, Ramchandra. Standard Book House, Delhi.
- Design of Steel Structures - Arya A. S., Ajmani J. L., Nemchand and Bros., Roorkee.
- The Steel Skeleton- Vol. II, Plastic Behaviour and Design - Baker J. F., Horne M. R., Heyman J., ELBS.
- Plastic Methods of Structural Analysis, Neal B. G., Chapman and Hall London.
- IS 800: 2007 – General Construction in Steel - Code of Practice, BIS, 2007.
- SP – 6 - Handbook of Structural Steel Detailing, BIS, 1987

**Program Elective III – Design of Formwork (Credits - 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Select proper formwork, accessories and material.
2. Design the form work for Beams, Slabs, columns, Walls and Foundations.
3. Design the form work for Special Structures.
4. Understand the working of flying formwork.
5. Judge the formwork failures through case studies.

**Syllabus Content:**

- **Introduction:** Requirements and Selection of Formwork.
- **Formwork Materials-** Timber, Plywood, Steel, Aluminium, Plastic, and Accessories. Horizontal and Vertical Formwork Supports.
- **Formwork Design:** Concepts, Formwork Systems and Design for Foundations, Walls, Columns, Slab and Beams.
- **Formwork Design for Special Structures:** Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Bridges.

- **Flying Formwork:** Table Form, Tunnel Form, Slip Form, Formwork for Precast Concrete, Formwork Management Issues –Pre- and Post-Award.
- **Formwork Failures:** Causes and Case studies in Formwork Failure, Formwork Issues in Multi-Story Building Construction.

**Reference Books:**

- Formwork for Concrete Structures, Peurify, Mc Graw Hill India, 2015.
- Formwork for Concrete Structures, Kumar NeerajJha, Tata McGraw Hill Education, 2012.
- IS 14687: 1999, False work for Concrete Structures - Guidelines, BIS.

**Program Elective III – Design of High Rise Structures (Credits - 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Analyse, design and detail Transmission/ TV tower, Mast and Trestles with different loading conditions.
2. Analyse, design and detail the RC and Steel Chimney.
3. Analyse. design and detail the tall buildings subjected to different loading conditions using relevant codes.

**Syllabus Content:**

- **Design of transmission/ TV tower,** Mast and trestles: Configuration, bracing system, analysis and design for vertical transverse and longitudinal loads.
- **Analysis and Design of RC and Steel Chimney,** Foundation design for varied soil strata.
- **Tall Buildings:** Structural Concept, Configurations, various systems, Wind and Seismic loads, Dynamic approach, structural design considerations and IS code provisions. Firefighting design provisions.
- **Application** of software in analysis and design.

**Reference Books:**

- Structural Design of Multi-storeyed Buildings, Varyani U. H., 2nd Ed., SouthAsian Publishers, New Delhi, 2002.
- Structural Analysis and Design of Tall Buildings, Taranath B. S., Mc Graw Hill, 1988.
- Illustrated Design of Reinforced Concrete Buildings (GF+3storeyed), Shah V. L. & Karve S. R., Structures Publications, Pune, 2013.
- Design of Multi Storeyed Buildings, Vol. 1 & 2, CPWD Publications, 1976.
- Tall Building Structures, Smith Byran S. and Coull Alex, Wiley India. 1991.
- High Rise Building Structures, Wolfgang Schueller, Wiley., 1971.
- Tall Chimneys, Manohar S. N., Tata Mc Graw Hill Publishing Company, New Delhi

### **Program Elective IV – Design of Advanced Concrete Structures (Credits - 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Analyse the special structures by understanding their behaviour.
2. Design and prepare detail structural drawings for execution citing relevant IS codes.

#### **Syllabus Contents:**

- **Design philosophy**, Modeling of Loads, Material Characteristics.
- **Reinforced Concrete** - P-M, M-phi Relationships, Strut-and- Tie Method, Design of Deep Beam and Corbel, Design of Shear Walls, Compression Field Theory for Shear Design, Design against Torsion; IS, ACI and Eurocode.
- **Steel Structures** -- Stability Design, Torsional Buckling - Pure, Flexural and Lateral, Design of Beam-Columns, Fatigue Resistant Design, IS code, AISC Standards and Eurocode.

#### **References Books:**

- Reinforced Concrete Design, Pillai S. U. and Menon D., Tata McGraw-Hill, 3rd Ed, 1999.
- Design of Steel Structures, Subramaniam N., Oxford University Press, 2008.
- Reinforced Concrete Structures, Park R. and Paulay T. , John Wiley & Sons, 1995.
- Advanced Reinforced Concrete Design, Varghese P. C., Prentice Hall of India, New Delhi.
- Unified Theory of Concrete Structures, Hsu T. T. C. and Mo Y. L., John Wiley & Sons, 2010.
- Steel Structures Design and Behavior Emphasizing Load and Resistance Factor Design, Salmon C. G., Johnson J. E. and Malhas F. A., Pearson Education, 5<sup>th</sup> Ed, 2009.
- Design of Steel Structures - Vol. II, Ramchandra. Standard Book House, Delhi.
- Plastic Methods of Structural Analysis, Neal B.G., Chapman and Hall London.

### **Program Elective IV – Advanced Design of Foundations (Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Decide the suitability of soil strata for different projects.
2. Design shallow foundations deciding the bearing capacity of soil.
3. Analyze and design the pile foundation.
4. Understand analysis methods for well foundation.

#### **Syllabus Contents:**

- **Planning of Soil Exploration** for Different Projects, Methods of Subsurface Exploration, Methods of Borings along with Various Penetration Tests.



- **Shallow Foundations**, Requirements for Satisfactory Performance of Foundations, Methods of Estimating Bearing Capacity, Settlements of Footings and Rafts, Proportioning of Foundations using Field Test Data, Pressure - Settlement Characteristics from Constitutive Laws.
- **Pile Foundations**, Methods of Estimating Load Transfer of Piles, Settlements of Pile Foundations, Pile Group Capacity and Settlement, Laterally Loaded Piles, Pile Load Tests, Analytical Estimation of Load- Settlement Behavior of Piles, Proportioning of Pile Foundations, Lateral and Uplift Capacity of Piles.
- **Well Foundation**, IS and IRC Code Provisions, Elastic Theory and Ultimate Resistance Methods.
- **Tunnels** and Arching in Soils, Pressure Computations around Tunnels.  
**Open Cuts**, Sheet piling and Bracing Systems in Shallow and Deep Open Cuts in Different Soil Types.
- **Coffer Dams**, Various Types, Analysis and Design, Foundations under uplifting loads, Soil-structure interaction

**Reference Books:**

- Design of foundation system, N.P. Kurian, Narosa Publishing House
- Foundation Analysis and Design, J. E. Bowles, Tata McGraw Hill New York
- Analysis and Design of Substructures, Sawmi Saran, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.

**Program Elective IV – Soil Structure Interaction (Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Understand soil structure interaction concept and complexities involved.
2. Evaluate soil structure interaction for different types of structure under various conditions of loading and subsoil characteristics.
3. Prepare comprehensive design oriented computer programs for interaction problems based on theory of sub grade reaction such as beams, footings, rafts etc.
4. Analyze different types of frame structure founded on stratified natural deposits with linear and non-linear stress-strain characteristics.
5. Evaluate action of group of piles considering stress-strain characteristics of real soils.

**Syllabus Contents:**

- Critical Study of Conventional Methods of Foundation Design, Nature and Complexities of Soil Structure Interaction.
- Application of Advanced Techniques of Analysis such as FEM and Finite Difference Method.
- Relaxation and Interaction for the Evaluation of Soil Structure Interaction for Different Types of Structure under various Conditions of Loading and Subsoil Characteristics.
- Preparation of Comprehensive Design Oriented Computer Programs for Specific Problems, Interaction Problems based on Theory of Sub Grade Reaction Such as Beams, Footings, Rafts Etc.
- Analysis of Different Types of Frame Structures Founded on Stratified Natural Deposits with Linear and Non-Linear Stress-Strain Characteristics.

- Determination of Pile Capacities and Negative Skin Friction, Action of Group of Piles Considering Stress-Strain Characteristics of Real Soils, Anchor Piles and Determination of Pullout Resistance.

**Reference Books:**

- Analytical and Computer Methods in Foundation, Bowels J.E., McGraw Hill Book Co., New York, 1974.
- Numerical Methods in Geotechnical Engineering, Desai C.S. and Christian J.T., McGraw Hill Book Co., New York.
- Soil Structure Interaction - The real behaviour of structures, Institution of Structural Engineers.
- Elastic Analysis of Soil Foundation Interaction, Developments in Geotechnical Engg. Vol-17, Elsevier Scientific Publishing Company.
- Elastic Analysis of Soil-Foundation Interaction, Selvadurai A.P.S., Elsevier Scientific Publishing Company.
- Analysis & Design of substructures, Swami Saran, Oxford & IBH Publishing Co. Pvt. Ltd.
- Design of Foundation System- Principles & Practices, Kurian N. P., Narosa Publishing

**Core Lab 3 – Testing Lab (Credits- 0:0:4 = 2)**

Teaching Scheme

Lectures: 2 hrs/week,

**Course Outcomes:** At the end of the course, students will be able to

1. Understand the response of structures.
2. Prepare the models.
3. Conduct model testing for static loading
4. Conduct model testing for free and forced vibrations

**Syllabus Content:**

- Response of structures and its elements against extreme loading events.
- Model Testing: Static - testing of plates, shells, and frames models.
- Model Testing: Free and forced vibrations, Evaluation of dynamic modulus.
- Beam vibrations, Vibration isolation, Shear wall building model, Time and frequency-domain study, Vibration Characteristics of RC Beams using Piezoelectric Sensors etc.

**Core Lab 4 – Numerical Analysis Lab (Credits- 0:0:4 = 2)**

Teaching Scheme

Lectures: 2 hrs/week

**Course Outcomes:** At the end of the course, students will be able to

1. Find Roots of non-linear equations by Bisection method and Newton's method.
2. Do curve fitting by least square approximations
3. Solve the system of Linear Equations using Gauss - Elimination/ Gauss - Seidal Iteration/ Gauss - Jordan Method
4. To Integrate Numerically Using Trapezoidal and Simpson's Rules
5. To Find Numerical Solution of Ordinary Differential Equations by Euler's Method, Runge- Kutta Method.

**Syllabus Contents:**

- Find the Roots of Non-Linear Equation Using Bisection Method.
- Find the Roots of Non-Linear Equation Using Newton's Method.
- Curve Fitting by Least Square Approximations.
- Solve the System of Linear Equations Using Gauss - Elimination Method.
- Solve the System of Linear Equations Using Gauss - Seidal Iteration Method.
- Solve the System of Linear Equations Using Gauss - Jordan Method.
- Integrate numerically using Trapezoidal Rule.
- Integrate numerically using Simpson's Rules.
- Numerical Solution of Ordinary Differential Equations By Euler's Method.
- Numerical Solution of Ordinary Differential Equations By Runge- Kutta Method.

**Core - Mini Project (Credits- 0:0:4 = 2)**

Teaching Scheme

Lectures: 4hrs/week

**Course Outcomes:** At the end of the course, the student will be able to:

1. Identify structural engineering problems reviewing available literature.
2. Study different techniques used to analyze complex structural systems.
3. work on the solutions given and present solution by using his/her technique applying engineering principles.

**Syllabus Contents:**

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.

Continuous assessment of Mini Project at Mid Sem and End Sem will be monitored by the departmental committee.

**Program Elective V - Design of Prestressed Concrete Structures  
(Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course outcomes:** At the end of the course, students will be able to

1. Find out losses in the prestressed concrete. Understand the basic aspects of prestressed concrete fundamentals, including pre and post-tensioning processes.
2. Analyse prestressed concrete deck slab and beam/ girders.
3. Design prestressed concrete deck slab and beam/ girders.
4. Design of end blocks for prestressed members.

### Syllabus Contents:

- **Introduction to prestressed concrete:** types of prestressing, systems and devices, materials, losses in prestress. Analysis of PSC flexural members: basic concepts, stresses at transfer and service loads, ultimate strength in flexure, code provisions.
- **Statically determinate PSC beams:** design for ultimate and serviceability limit states for flexure, analysis and design for shear and torsion, code provisions.
- **Transmission of prestress** in pretensioned members; Anchorage zone stresses for posttensioned members.
- **Statically indeterminate structures** - Analysis and design - continuous beams and frames, choice of cable profile, linear transformation and concordancy.
- **Composite construction** with precast PSC beams and cast in-situ RC slab - Analysis and design, creep and shrinkage effects. Partial prestressing - principles, analysis and design concepts, crack-width calculations
- **Analysis and design** of prestressed concrete pipes, columns with moments.

### References:

- Design of Prestressed Concrete Structures, Lin T.Y., Asia Publishing House, 1955.
- Prestressed Concrete, Krishnaraju N., Tata McGraw Hill, New Delhi, 1981.
- Limited State Design of Prestressed Concrete, Guyan Y., Applied Science Publishers, 1972.
- IS: 1343- Code of Practice for Prestressed Concrete
- IRC: 112

### **Program Elective V - Analytical and Finite Element Analysis of Laminated Composite Plates (Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course outcomes:** At the end of the course, students will be able to

1. Analyse the rectangular composite plates using the analytical methods.
2. Analyse the composite plates using advanced finite element method.
3. Develop the computer programs for the analysis of composite plates.

### Syllabus Contents:

- Introduction: Displacement Field Approximations for Classical Laminated Plate Theory (CLPT) and First Order Shear Deformation Theory (FSDT), Analytical Solutions for Bending of Rectangular Laminated Plates using CLPT.
- Governing Equations. Navier Solutions of Cross-Ply and Angle-Ply Laminated Simply-Supported Plates, Determination of Stresses. Levy Solutions for Plates with Other Boundary Conditions, Analytical Solutions for Bending of Rectangular Laminated Plates Using FSDT.
- Finite Element Solutions for Bending of Rectangular Laminated Plates using CLPT.
- Introduction to Finite Element Method, Rectangular Elements, Formation of Stiffness Matrix, Formation of Load Vector, Numerical Integration, Post Computation of Stresses.

- Finite Element Solutions for Bending of Rectangular Laminated Plates using FSDT. Finite Element Model, C<sup>0</sup> Element Formulation, Post Computation of Stresses.
- Analysis of Rectangular Composite Plates using Analytical Methods.

**References:**

- Mechanics of Laminated Composites Plates and Shells, Reddy J. N., CRC Press.

**Program Elective V - Fracture Mechanics of Concrete Structures  
(Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course outcomes:** At the end of the course, students will be able to

1. Identify and classify cracking of concrete structures based on fracture mechanics.
2. Implement stress intensity factor for notched members
3. apply fracture mechanics models to high strength concrete and FRC structures.
4. Compute J-integral for various sections understanding the concepts of LEFM.

**Syllabus Contents:**

- **Introduction:** Basic Fracture Mechanics, Crack in a Structure, Mechanisms of Fracture and Crack Growth, Cleavage Fracture, Ductile Fracture, Fatigue Cracking, Environment assisted Cracking, Service Failure Analysis.
- **Stress at Crack Tip:** Stress at Crack Tip, Linear Elastic Fracture Mechanics, Griffith's Criteria, Stress Intensity Factors, Crack Tip Plastic Zone, Erwin's Plastic Zone Correction, R curves, Compliance, J Integral, Concept of CTOD and CMD.
- **Material Models:** General Concepts, Crack Models, Band Models, Models based on Continuum Damage Mechanics, Applications to High Strength Concrete, Fibre Reinforced Concrete, Crack Concepts and Numerical Modeling.

**Reference Books:**

1. Fracture Mechanics, Suri C. T. and Jin Z.H., 1st Edition, Elsevier Academic Press, 2012.
2. Elementary Engineering Fracture Mechanics, Broek David, 3rd Rev. Ed. Springer, 1982.
3. Fracture Mechanics of Concrete Structures – Theory and Applications, Elfgreen L., RILEM Report, Chapman and Hall, 1989.
4. Fracture Mechanics – Applications to Concrete, Victor, Li C., Bazant Z. P., ACI SP 118, ACI Detroit, 1989.

**Program Elective III - Design of Masonry Structures (Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course outcomes:** At the end of the course, students will be able to

1. Understand the masonry design approaches.
2. Analyse Reinforced Masonry Members.
3. Determine interactions between members.
4. Determine shear strength and ductility of Reinforced Masonry members.
5. Check the stability of walls
6. Perform elastic and Inelastic analysis of masonry walls.

**Syllabus Contents:**

- **Introduction:** Historical Perspective, Masonry Materials, Masonry Design Approaches, Overview of Load Conditions, Compression Behaviour of Masonry, Masonry Wall Configurations, Distribution of Lateral Forces.
- **Flexural Strength** of Reinforced Masonry Members: In plane and Out-of-plane Loading.
- **Interactions:** Structural Wall, Columns and Pilasters, Retaining Wall, Pier and Foundation.
- **Shear Strength** and Ductility of Reinforced Masonry Members.
- **Prestressed Masonry** - Stability of Walls, Coupling of Masonry Walls, Openings, Columns, Beams.
- **Elastic and Inelastic Analysis**, Modeling Techniques, Static PushOver Analysis and use of Capacity Design Spectra.

**Reference Books:**

1. Design of Reinforced Masonry Structures, Narendra Taly, ICC, 2nd Edn,
2. Masonry Structures: Behavior and Design, Hamid Ahmad A. and Drysdale Robert G., 1994.
3. Mechanics of Masonry Structures, Editor: Maurizio Angelillo, 2014.
4. Earthquake-resistant Design of Masonry Buildings, Tomašević Miha, Imperial College Press, 1999.

**Program Elective IV - Design of Industrial Structures (Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, the student will be able to:

1. Design Steel Gantry Girders.
2. Design Steel Portal, Gable Frames.
3. Design Steel Bunkers and Silos.
4. Design Chimneys and Water Tanks.

**Syllabus Contents:**

- **Steel Gantry Girders** – Introduction, loads acting on gantry girder, permissible stress, types of gantry girders and crane rails, crane data, maximum moments and shears, construction detail, design procedure.
- **Portal Frames** – Design of portal frame with hinge base, design of portal frame with fixed base - Gable Structures – Lightweight Structures
- **Steel Bunkers and Silos** – Design of square bunker – Jansen’s and Airy’s theories – IS Code provisions – Design of side plates – Stiffeners – Hooper – Longitudinal beams Design of cylindrical silo – Side plates – Ring girder – stiffeners.

- **Chimneys** – Introduction, dimensions of steel stacks, chimney lining, breech openings and access ladder, loading and load combinations, design considerations, stability consideration, design of base plate, design of foundation bolts, design of foundation.
- **Water Tanks** – Design of rectangular riveted steel water tank – Tee covers – Plates – Stays – Longitudinal and transverse beams – Design of staging – Base plates – Foundation and anchor bolts –
- **Design of pressed steel water tank** – Design of stays – Joints – Design of hemispherical bottom water tank – side plates – Bottom plates – joints – Ring girder – Design of staging and foundation.

**Reference Books:**

- Design of Steel Structure, Punmia B. C., Jain Ashok Kr., Jain Arun Kr., 2nd Ed., Lakshmi Publishers, 1998.
- Design of Steel Structures, Ram Chandra, 12th Ed., Standard Publishers, 2009.
- Design of Steel Structures, Subramaniam.

**Program Elective V - Design of Plates and Shells(Credits- 3:0:0 = 3)**

Teaching Scheme

Lectures: 3 hrs/week, –

**Course Outcomes:** At the end of the course, the student will be able to:

1. Analyse and design prismatic folded plate systems.
2. Analyse and design shells using approximate solutions
3. Analyse and Design Cylindrical Shells
4. Design Doubly Curved Shells using Approximate Solutions.

**Syllabus Contents:**

- Prismatic folded Plate Systems
- Shell Equations
- Approximate Solutions
- Analysis and Design of Cylindrical Shells
- Approximate Design methods for Doubly Curved Shells.

**Reference Books:**

- Theory of Plates and Shells, Timoshenko and Woinowsky-Krieger S., Tata Mc Graw Hill Edition, 2010.
- Design and Construction of Concrete Shell Roofs, Ramaswamy G. S., 1st Edition, 2005.
- Design of Reinforced Concrete Shells & Folded Plate, Varghese P. C., 1st Edition, PHI.
- Design of Plate and Shell Structures, Jawad Maan H., Springer Science.

**Core - Dissertation I (Credits- 0:0:20 = 10)**

Teaching Scheme

Lectures: 3hrs/week      Mid Sem Evaluation weightage - 30%

End Sem Evaluation weightage - 70%

**Course Outcomes:** At the end of the course, the student will be able to:

- Identify structural engineering problems reviewing available literature.
- Identify appropriate techniques to analyze complex structural systems.
- Apply engineering and management principles through efficient handling of project

**Syllabus Contents:**

Dissertation-I will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions and must bring out individuals contribution.

Continuous assessment of Dissertation – I and Dissertation – II at Mid Sem and End Sem will be monitored by the departmental committee.

**Core - Dissertation II (Credits- 0:0:32 = 16)**

Teaching Scheme

Contact Hours: 3hrs/week

**Course Outcomes:** At the end of the course, the student will be able to:

1. Solve complex structural problems by applying appropriate techniques and tools.
2. Exhibit good communication skill to the engineering community and society.
3. Demonstrate professional ethics and work culture.

**Syllabus Contents:**

Dissertation – II will be extension of the to work on the topic identified in Dissertation – I.

Continuous assessment should be done of the work done by adopting the methodology decided involving numerical analysis/ conduct experiments, collection and analysis of data, etc. There will be presubmission seminar at the end of academic term. After the approval the student has to submit the detail report and external examiner is called for the viva-voce to assess along with guide.

**OPEN ELECTIVES  
Business Analytics**

**Teaching scheme**

**Lecture: - 3 h/week**

|                      |                           |
|----------------------|---------------------------|
| <b>Course Code</b>   |                           |
| <b>Course Name</b>   | <b>Business Analytics</b> |
| <b>Credits</b>       |                           |
| <b>Prerequisites</b> |                           |

Total Number of Lectures: 48



| <b>Course objective</b> |  |
|-------------------------|--|
| 1.                      | Understand the role of business analytics within an organization.  |
| 2.                      | Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.               |
| 3.                      | To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.                |
| 4.                      | To become familiar with processes needed to develop, report, and analyze business data.  |
| 5.                      | Use decision-making tools/Operations research techniques.  |
| 6.                      | Mange business process using analytical and management tools.  |
| 7.                      | Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| <b>LECTURE WITH BREAKUP</b>  | <b>NO. OF LECTURES</b> |
|--|------------------------|
| <p><b>Unit1:</b></p> <p>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.</p> <p>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p>  | 9                      |
| <p><b>Unit 2:</b></p> <p>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.</p> <p>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.</p>   | 8                      |
| <p><b>Unit 3:</b></p> <p>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.</p> <p>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.</p> | 9                      |
| <p><b>Unit 4:</b></p> <p>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression</p>   |                        |

|   |    |
|---|----|
| Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br><br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| <b>Unit 5:</b><br><br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.  | 8  |
| <b>Unit 6:</b><br><br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.   | 4  |

|  |  |
|--|--|
| <b>COURSE OUTCOMES</b>   |  |
| 1. Students will demonstrate knowledge of data analytics.  |  |
| 2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.                             |  |
| 3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |  |
| 4. Students will demonstrate the ability to translate data into clear, actionable insights.  |  |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

**OPEN ELECTIVES**  
**Industrial Safety**

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

**OPEN ELECTIVES**  
**Operations Research**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

### **Unit 5**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

### **References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

### **Open Elective**

#### **Cost Management of Engineering Projects**

#### **Teaching scheme**

**Lecture: - 3 h/week**

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#### Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

### **References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting

4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

### **Open Elective Composite Materials**

#### **Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT-IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

#### **TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

#### **References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

### **Open Elective Waste to Energy**

#### **Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

**AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING**

|  |  |              |
|--|--|--------------|
| <b>Course objectives:</b>  |  |              |
| Students will be able to:  |  |              |
| <ol style="list-style-type: none"> <li>1. Understand that how to improve your writing skills and level of readability</li> <li>2. Learn about what to write in each section</li> <li>3. Understand the skills needed when writing a Title</li> </ol> |  |              |
| Ensure the good quality of paper at very first-time submission   |  |              |
| <b>Syllabus</b>  |  |              |
| <b>Units</b>   | <b>CONTENTS</b>  | <b>Hours</b> |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4            |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4            |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4            |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4            |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4            |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4            |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

**AUDIT 1 and 2: DISASTER MANAGEMENT**

| <b>Course Objectives:</b> -Students will be able to:   |   |       |
|--|---|-------|
| <ol style="list-style-type: none"> <li>1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.</li> <li>2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.</li> <li>3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.</li> <li>4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in</li> </ol> |   |       |
| <b>Syllabus</b>  |   |       |
| Units  | CONTENTS  | Hours |
| 1  | <b>Introduction</b><br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.  | 4     |
| 2  | <b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4     |
| 3  | <b>Disaster Prone Areas In India</b><br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics  | 4     |
| 4  | <b>Disaster Preparedness And Management</b><br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.   | 4     |
| 5  | <b>Risk Assessment</b><br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.   | 4     |

|   |   |   |
|---|---|---|
| 6 | <b>Disaster Mitigation</b><br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India. | 4 |
|---|---|---|

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies” ,Deep &Deep Publication Pvt. Ltd., New Delhi.

**AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE**

**Course Objectives**

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

**Syllabus**

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul>          | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8     |

**Suggested reading**

1. “Abhyastakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

**Course Output**

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students



## AUDIT 1 and 2: VALUE EDUCATION

### **Course Objectives**

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

### **Syllabus**

| Unit | Content  | Hours |
|------|--|-------|
| 1    | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul>  | 4     |
| 2    | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty, Humanity. Power of faith, National Unity.</li> <li>• Patriotism.Love for nature ,Discipline</li> </ul>  | 6     |
| 3    | <ul style="list-style-type: none"> <li>• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> <li>• Doing best for saving nature</li> </ul> | 6     |
| 4    | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality, Nonviolence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind, Self-control.</li> <li>• Honesty, Studying effectively</li> </ul>  | 6     |

### **Suggested reading**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

### **Course outcomes**

Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

| <b>Course Objectives:</b>   |  |              |
|---|--|--------------|
| Students will be able to:   |  |              |
| 1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.<br>2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.<br>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution. |  |              |
| <b>Syllabus</b>   |  |              |
| <b>Units</b>  | <b>Content</b>   | <b>Hours</b> |
| <b>1</b>  | <b>•History of Making of the Indian Constitution:</b><br>History<br>Drafting Committee, ( Composition & Working)   | 4            |
| <b>2</b>  | <b>•Philosophy of the Indian Constitution:</b><br>Preamble<br>Salient Features   | 4            |
| <b>3</b>  | <b>•Contours of Constitutional Rights &amp; Duties:</b><br>•Fundamental Rights<br>•Right to Equality<br>•Right to Freedom<br>•Right against Exploitation<br>•Right to Freedom of Religion<br>•Cultural and Educational Rights<br>•Right to Constitutional Remedies<br>•Directive Principles of State Policy<br>•Fundamental Duties.  | 4            |
| <b>4</b>  | <b>•Organs of Governance:</b><br>•Parliament<br>•Composition<br>•Qualifications and Disqualifications<br>•Powers and Functions<br>• Executive<br>•President<br>•Governor<br>•Council of Ministers<br>•Judiciary, Appointment and Transfer of Judges, Qualifications<br>•Powers and Functions   | 4            |
| <b>5</b>  | <b>•Local Administration:</b><br>•District's Administration head: Role and Importance,<br>•Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.<br>•Pachayati raj: Introduction, PRI: ZilaPachayat.<br>•Elected officials and their roles, CEO ZilaPachayat: Position and role.<br>•Block level: Organizational Hierarchy (Different departments),<br>•Village level: Role of Elected and Appointed officials,<br>•Importance of grass root democracy | 4            |

|   |  |   |
|---|--|---|
| 6 | <ul style="list-style-type: none"> <li>• <b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul> | 4 |
|---|--|---|

**Suggested reading**

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**Course Outcomes:**

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

**AUDIT 1 and 2: PEDAGOGY STUDIES**

| <b>Course Objectives:</b>  |  |       |
|--|--|-------|
| Students will be able to:  |  |       |
| 4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers. |  |       |
| 5. Identify critical evidence gaps to guide the development.   |  |       |
| Syllabus   |  |       |
| Units  | Content  | Hours |
| 1  | <ul style="list-style-type: none"> <li>• <b>Introduction and Methodology:</b></li> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> <li>• Overview of methodology and Searching.</li> </ul> | 4     |
| 2  | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>   | 2     |
| 3  | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> </ul>  | 4     |

|          |  |   |
|----------|--|---|
|          | <ul style="list-style-type: none"> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers’ attitudes and beliefs and Pedagogic strategies.</li> </ul> |   |
| <b>4</b> | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul>   | 4 |
| <b>5</b> | <ul style="list-style-type: none"> <li>• <b>Research gaps and future directions</b></li> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> <li>• Dissemination and research impact.</li> </ul>  | 2 |

**Suggested reading**

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal Educational Development*, 33 (3): 272–282.
5. Alexander RJ (2001) *Culture and pedagogy: International comparisons in primary education*. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, ‘learning to read’ campaign.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf)

**Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

### AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

#### Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

#### Syllabus

| Unit | Content  | Hours |
|------|--|-------|
| 1    | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>  | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> <li>Do`s and Don`t`s in life.</li> <li>i) Ahinsa, satya, astheya, bramhacharya and aparigraha</li> <li>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan</li> </ul> | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> <li>i) Various yog poses and their benefits for mind &amp; body</li> <li>ii)Regularization of breathing techniques and its effects-Types of pranayam</li> </ul>      | 8     |

#### Suggested reading

1. ‘Yogic Asanas for Group Tarining-Part-I’ :Janardan Swami Yogabhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

#### Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

### AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

#### Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

#### Syllabus

| Unit | Content  | Hours |
|------|--|-------|
| 1    | Neetisatakam-Holistic development of personality <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont`s)</li> <li>• Verses- 71,73,75,78 (do`s)</li> </ul> | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>                        | 8     |

|   |  |   |
|---|--|---|
| 3 | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8 |
|---|--|---|

***Suggested reading***

1. “Srimad Bhagavad Gita” by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

## Specialization: GEOTECHNICAL ENGINEERING

### COURSE OBJECTIVES

1. To make students learn the principles of soil and rock mechanics. Understand different problems associated with geotechnical engineering. Explain how to select design soil/rock parameters for design purpose based on the subsurface exploration. Develop Analysis and Design procedure for various geotechnical structures.
2. Students should gain competency in the design of shallow/deep foundations, earth retaining structures, embankment and earthen dams, underground structures. Can assess stability of slopes and apply preventive measures for stability.

### COURSE OUTCOMES (POs):

1. Students will learn soil and rock behavior. Students will be able to perform various laboratory and in-situ tests on soil/rock to find out design parameters.
2. Students can design shallow/deep foundations, earth retaining structures, embankment and earthen dams, tunnel support systems for given site conditions.
3. Student can compute factor of safety to assess stability of slopes and apply preventive measures for stability.
4. Student can develop numerical models to estimate response of various geotechnical structures under different loadings.

| Semester I   |                     |  |                 |           |          |           |
|--------------|---------------------|--|-----------------|-----------|----------|-----------|
| Sr. No.      | Course Type/Code    | Course Name  | Teaching Scheme |           |          | Credits   |
|              |                     |  | Th              | Tuto      | Lab      |           |
| 1.           | Core-I              | Advanced Soil Mechanics  | 3               | --        | --       | 3         |
| 2.           | Core-II             | Advanced Foundation Engineering  | 3               | --        | --       | 3         |
| 3.           | Program Elective-I  | 1. Soil Structure Interaction<br>2. Ground Improvement Techniques<br>3. Pavement Analysis and Design | 3               | --        | --       | 3         |
| 4.           | Program Elective-II | 1. FEM in Geomechanics<br>2. Environmental Geotechnology<br>3. Critical Soil Mechanics               | 3               | --        | --       | 3         |
| 5.           | Core                | Core Lab I -   | --              | --        | 4        | 2         |
| 6.           | Core                | Core Lab II -  | --              | --        | 4        | 2         |
| 7.           | MLC 1               | Research Methodology   | 1               | --        | --       | 1         |
| 8.           | MLC 2               | Research Methodology and IPR   | 1               | --        | --       | 1         |
| 9.           | Audit 1             | Audit course   | 0               |           |          | 0         |
| <b>Total</b> |                     |  | <b>14</b>       | <b>--</b> | <b>4</b> | <b>18</b> |

| <b>Semester II</b> |                      |   |                 |           |          |           |
|--------------------|----------------------|---|-----------------|-----------|----------|-----------|
| Sr. No.            | Course Type/Code     | Course Name   | Teaching Scheme |           |          | Credits   |
|                    |                      |   | Th              | Tuto      | Lab      |           |
| 1.                 | Core-III             | Dynamics of soils and foundations   | 3               | --        | --       | 3         |
| 2.                 | Core-IV              | Subsurface investigations and instrumentation   | 3               | --        | --       | 3         |
| 3.                 | Program Elective-III | 1. Offshore Geotechnical Engineering/marine Geotechniques<br>2. Computational Geomechanics<br>3. Engineering rock mechanics     | 3               | --        | --       | 3         |
| 4.                 | Program Elective-IV  | 1. Earth Retaining Structures<br>2. Design of underground excavations<br>3. Physical and Constitutive Modelling on Geomechanics | 3               | --        | --       | 3         |
| 5.                 | Core                 | Core Lab III -  | --              | --        | 4        | 2         |
| 6.                 | Core                 | Core Lab IV -   | --              | --        | 4        | 2         |
| 7.                 | Core                 | Mini Project  | --              | --        | 4        | 2         |
| 8.                 | Audit 2              | Audit course  | 0               |           |          | 0         |
| <b>Total</b>       |                      |   | <b>12</b>       | <b>--</b> | <b>8</b> | <b>18</b> |

| <b>Semester III</b> |                     |   |                 |      |     |           |
|---------------------|---------------------|---|-----------------|------|-----|-----------|
| Sr. No.             | Course Type/Code    | Course Name   | Teaching Scheme |      |     | Credits   |
|                     |                     |   | Th              | Tuto | Lab |           |
| 1                   | Program Elective-IV | 1. Stability analysis of slopes<br>2. Foundations on weak rocks<br>3. Geotechnical earthquake engineering   | 3               |      |     | 3         |
| 2                   | Open Electives      | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3               |      |     | 3         |
| 3                   |                     | Dissertation Stage-I<br>(to be continued next semester)   |                 |      |     | 10        |
|                     | Total               |   |                 |      |     | <b>16</b> |



| Semester IV |                  |   |                 |      |     |           |
|-------------|------------------|---|-----------------|------|-----|-----------|
| Sr. No.     | Course Type/Code | Course Name   | Teaching Scheme |      |     | Credits   |
|             |                  |   | Th              | Tuto | Lab |           |
|             |                  | Dissertation final Stage<br>(continued from III semester) |                 |      |     | 16        |
|             | <b>Total</b>     |   |                 |      |     | <b>16</b> |

Total Credits for the programme = 18 + 18 + 16 + 16 = 68

#### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

| <b>Core-I ADVANCED SOIL MECHANICS</b>  |
|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/ week  |
| <b>COURSE OUTCOME</b> <ul style="list-style-type: none"> <li>• The students obtain the complete knowledge on strength of soil mass</li> <li>• The students are able to develop mathematical models for solving different problems in soil mechanics</li> </ul>   |
| <b>Syllabus Contents:</b> <p><b>Unit I: Compressibility of soils:</b> consolidation theory (one, two, and three dimensional consolidation theories), consolidation in layered soil and consolidation for time dependent loading, determination of coefficient of consolidation (Casagrande method and Taylors method)</p> <p><b>Unit II: Strength behavior of soils;</b> Mohr Circle of Stress; UU, CU, CD tests, drained and undrained behavior of sand and clay, significance of pore pressure parameters; determination of shear strength of soil; Interpretation of triaxial test results.</p> <p><b>Unit III: Stress path;</b> Drained and undrained stress path; Stress path with respect to different initial state of the soil; Stress path for different practical situations.</p> <p><b>Unit IV: Critical state soil mechanics;</b> Critical state parameters; Critical state for normally</p> |

consolidated and over consolidated soil; Significance of Roscoe and Hvorslev state boundary surface; drained and undrained plane. critical void ratio; effect of dilation in sands; different dilation models.

**Unit V: Elastic and plastic deformations:** elastic wall; introduction to yielding and hardening; yield curve and yield surface, associated and non-associated flow rule.

**References:**

Atkinson, J.H. and Bransby, P.L, The Mechanics of Soils: An introduction to Critical soil mechanics, McGraw Hill, 1978.

Atkinson J.H, An introduction to the Mechanics of soils and Foundation, McGraw- Hill Co., 1993.

Das, B.M., Advanced Soil Mechanics, Taylor and Francis, 2nd Edition, 1997.

Wood, D.M., Soil Behavior and Critical State Soil Mechanics, Cambridge University Press, 1990.

Craig, R.F., Soil Mechanics, Van Nostrand Reinhold Co. Ltd., 1987.

Terzaghi, K., and Peck, R.B., Soil Mechanics in Engineering Practice, John Wiley & Sons, 1967.

Lambe, T.W. and Whitman, R.V., Soil Mechanics, John Wiley & Sons, 1979.

**Core –II ADVANCED FOUNDATION ENGINEERING**

**Teaching Scheme**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- The students will be able to decide the type of foundations to be recommended for construction of different engineering structures
- The students will be able to design different types of foundations

**Syllabus Contents:**

**Unit I: Planning of soil exploration** for different projects, methods of subsurface exploration, methods of borings along with various penetration tests

**Unit II: Shallow foundations**, requirements for satisfactory performance of foundations, methods of estimating bearing capacity, settlements of footings and rafts, proportioning of foundations using field test data, IS codes.

**Unit III: Pile foundations**, methods of estimating load transfer of piles, settlements of pile foundations, pile group capacity and settlement, negative skin friction of piles, laterally loaded piles, pile load tests, analytical estimation of load- settlement behavior of piles, proportioning of pile foundations, lateral and uplift capacity of piles.

**Unit IV: Well foundation**, IS and IRC codal provisions, elastic theory and ultimate resistance methods

**Unit V: Foundations on problematic soils:** Foundations for collapsible and expansive soil

**Unit VI: Cofferdams**, various types, analysis and design Foundations under uplifting loads

**References:**

- Bowles. J.E., Foundation Analysis and Design, Tata McGraw-Hill International Edition, 5th Edn, 1997.
- Das B.M., Shallow Foundations: Bearing capacity and settlement, CRC Press, 1999.

- Tomlinson M.J., Pile design and construction Practice, Chapman and Hall Publication, 1994.
- Poulos, H. G. and Davis, F. H., “Pile Foundation Analysis and Design”, Wiley and Sons. 1980

### Core –III DYNAMICS OF SOILS AND FOUNDATIONS

#### Teaching Scheme

Lectures: 3 hrs/ week

#### COURSE OUTCOME

- Students understands theory of vibration and resonance phenomenon, dynamic amplification.
- Students understand propagation of body waves and surface waves through soil.
- Student exposed to different methods for estimation of dynamic soil properties required for design purpose.
- Students can predict dynamic bearing capacity and assess liquefaction potential of any site.
- Students apply theory of vibrations to design machine foundation based on dynamic soil properties and bearing capacity.

#### Syllabus Contents:

**Unit I: Fundamentals of vibrations:** single, two and multiple degree of freedom systems, vibration isolation, vibration absorbers, vibration measuring instruments

**Unit II: Wave propagation:** elastic continuum medium, semi-infinite elastic continuum medium, soil behaviour under dynamic loading.

**Unit III: Liquefaction of soils:** liquefaction mechanism, factors affecting liquefaction, studies by dynamic tri-axial testing, oscillatory shear box, shake table and blast tests, assessment of liquefaction potential.

**Unit IV: Dynamic elastic constants of soil:** determination of dynamic elastic constants, various methods including block resonance tests, cyclic plate load tests, wave propagation tests, oscillatory shear box test.

**Unit V: Machine foundations:** Design criteria for machine foundations; Elastic homogeneous half space and lumped parameter solutions, analysis and design of foundations for reciprocating and impact type machines, turbines, effect of machine foundation on adjoining structures.

**Unit VI: Bearing capacity of foundations:** Introduction to bearing capacity of dynamically loaded foundations, such as those of water towers, chimneys and high rise buildings, response of pile foundations.

#### References:

- Das, B.M., “Fundamentals of Soil Dynamics”, Elsevier, 1983.
- Steven Kramer, “Geotechnical Earthquake Engineering”, Pearson, 2008.
- Prakash, S., Soil Dynamics, McGraw Hill, 1981.
- Kameswara Rao, N.S.V., Vibration analysis and foundation dynamics, Wheeler Publication Ltd., 1998.

- Richart, F.E. Hall J.R and Woods R.D., Vibrations of Soils and Foundations, Prentice Hall Inc., 1970.
- Prakash, S. and Puri, V.K., Foundation for machines: Analysis and Design, John Wiley & Sons, 1998

#### **Core-IV SUBSURFACE INVESTIGATION AND INSTRUMENTATION**

##### **Teaching Scheme**

Lectures: 3 hrs/ week

##### **COURSE OUTCOME**

- Students can plan subsurface investigation based on the requirement of civil engineering project and site condition. Can finalize depth and number of boreholes
- Students can execute different subsurface exploration tests, collect disturbed/undisturbed samples for laboratory tests and can suggest design parameters.
- Student exposed to different methods for estimation of dynamic soil properties required for design purpose.
- Students can develop instrumentation scheme for monitoring of critical sites

##### **References:**

- Bowles, J.E., Foundation Analysis and Design, McGraw-Hill International Edition, 1997.
- Schnaid, F., “ In Situ Testing in Geomechanics”, Taylor and Francis.

#### **PE-I SOIL STRUCTURE INTERACTIONS**

##### **Teaching Scheme**

Lectures: 3 hrs/ week

##### **COURSE OUTCOME**

- Students can apply different soil response models for specific problem based on the requirement.
- Students can analyze footings/rafts resting on soil as beams/plates on elastic foundation and work out design bending moments/shear and displacements.
- Student can compute pile response for various loading condition for design purpose.

##### **Syllabus Contents:**

**Unit I: Soil-Foundation Interaction:** Introduction to soil-foundation interaction problems, Soil behavior, Foundation behavior, Interface behavior, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behavior, Time dependent behavior.

**Unit II: Beam on Elastic Foundation-** Soil Models: Infinite beam, Two parameters, Isotropic

elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness.

**Unit III: Plate on Elastic Medium:** Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.

**Unit IV: Elastic Analysis of Pile:** Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.

**Unit V: Laterally Loaded Pile:** Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. An introduction to soil-foundation interaction under dynamic loads.

**References:**

- Selvadurai, A.P.S, Elastic Analysis of Soil-Foundation Interaction, Elsevier, 1979.
- Poulos, H.G., and Davis, E.H., Pile Foundation Analysis and Design, John Wiley, 1980.
- Scott, R.F., Foundation Analysis, Prentice Hall, 1981.
- Structure Soil Interaction - State of Art Report, Institution of Structural Engineers, 1978.
- ACI 336. (1988), Suggested Analysis and Design Procedures for combined footings and Mats, American Concrete Institute.

**PE-I GROUND IMPROVEMENT TECHNIQUES**

**Teaching Scheme**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- At the completion of the course the students will be able to understand the different types of ground modification can be done depending upon the site Pcondition, type and purpose of structure to be constructed.

**Syllabus Contents:**

**Unit I: Introduction:** situations where ground improvement becomes necessary

**Unit II: Mechanical modification:** dynamic compaction, impact loading, compaction by blasting, vibro-compaction; pre-compression, stone columns; Hydraulic modification: dewatering systems, preloading and vertical drains, electro-kinetic dewatering

**Unit III: Chemical modification;** modification by admixtures, stabilization using industrial wastes, grouting

**Unit IV: Thermal modification:** ground freezing and thawing.

**Unit V: Soil reinforcement:** Reinforced earth, basic mechanism, type of reinforcements, selection of stabilisation/improvement of ground using Geotextiles, Geogrid, geomembranes, geocells, geonets, and soil nails.

**Unit VI: Application of soil reinforcement:** shallow foundations on reinforced earth, design of reinforced earth retaining walls, reinforced earth embankments structures, wall with reinforced backfill, analysis and design of shallow foundations on reinforced earth, road designs with geosynthetics

|   |
|---|
| <p><b>References:</b></p> <ul style="list-style-type: none"> <li>• Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill International Editions, 1990.</li> <li>• Yonekura, R., Terashi, M. and Shibazaki, M. (Eds.), Grouting and Deep Mixing, A.A. Balkema, 1966.</li> <li>• Moseley, M.P., Ground Improvement, Blackie Academic &amp; Professional, 1993.</li> <li>• Xanthakos, P.P., Abramson, L.W. and Bruce, D.A., Ground Control and Improvement, John Wiley &amp; Sons, 1994.</li> <li>• Koerner, R. M., Designing with Geosynthetics, Prentice Hall Inc. 1998.</li> <li>• Shukla, S.K., Yin, Jian-Hua, “Fundamentals of Geosynthetic Engineering”, Taylor &amp; Francis.</li> </ul> |
| <p><b>PE-I PAVEMENT ANALYSIS AND DESIGN</b></p>   |
| <p><b>Teaching Scheme</b><br/>Lectures: 3 hrs/ week</p>   |
| <p><b>COURSE OUTCOME</b></p> <ul style="list-style-type: none"> <li>• The students will be able to design flexible as well rigid pavements</li> </ul>   |
| <p><b>Syllabus Contents:</b></p> <p><b>Unit I:</b> Philosophy of design of flexible and rigid pavements,<br/> <b>Unit II:</b> analysis of pavements using different analytical methods,<br/> <b>Unit III:</b> selection of pavement design input parameters – traffic loading and volume,<br/> <b>Unit IV:</b> material characterization, drainage, failure criteria, reliability,<br/> <b>Unit V:</b> design of flexible and rigid pavements using different methods,<br/> <b>Unit VI:</b> comparison of different pavement design approaches, design of overlays and drainage system.</p>   |
| <p><b>References:</b></p> <ul style="list-style-type: none"> <li>• Yang and H. Huang, Pavement Analysis and Design, Pearson Prentice Hall, 2004.</li> <li>• Yoder and Witzech, Pavement Design, McGraw-Hill, 1982.</li> <li>• Sharma and Sharma, Principles and Practice of Highway Engg., Asia Publishing House, 1980.</li> <li>• Teng, Functional Designing of Pavements, McGraw- Hill, 1980.</li> </ul>  |
| <p><b>PE-2 FEM IN GEOTECHNICAL ENGINEERING</b></p>  |
| <p><b>Teaching Scheme</b><br/>Lectures: 3 hrs/ week</p>   |
| <p><b>COURSE OUTCOME</b></p> <ul style="list-style-type: none"> <li>• Students can understand basic stress-strain relationship for soil and develop Stress-deformation analysis.</li> <li>• Students can develop finite element formulation for different geotechnical problems including shallow foundation, seepage and consolidation problems.</li> </ul>  |
| <p><b>Syllabus Contents:</b></p>  |

**Unit I:** Stress-deformation analysis: One dimensional, Two dimensional and Three-dimensional formulations.

**Unit II:** Discretization of a Continuum, Elements, Strains, Stresses, Constitutive, Relations, Hooke's Law, Formulation of Stiffness Matrix, Boundary Conditions, Solution Algorithms.

**Unit III:** Principles of discretization, element stiffness and mass formulation based on direct, variational and weighted residual techniques and displacements approach, Shape functions and numerical integrations, convergence.

**Unit IV:** Displacement formulation for rectangular, triangular and isoparametric elements for two dimensional and axisymmetric stress analysis.

**Unit V:** Settlement Analysis, 2-D elastic solutions for homogeneous, isotropic medium, Steady Seepage Analysis: Finite element solutions of Laplace's equation, Consolidation Analysis: Terzaghi consolidation problem, Choice of Soil Properties for Finite Element Analysis

**References:**

- O.C. Zienkiewicz and R.L. Taylor, Finite element methods Vol I & Vol II, McGraw Hill, 1989, 1992.
- K.J. Bathe, Finite element procedures, PHI Ltd., 1996.
- David M Potts and Lidija Zdravkovic, "Finite Element Analysis in Geotechnical Engineering Theory and Application", Thomas Telford. 1999

**PE-2 ENVIRONMENTAL GEOTECHNOLOGY**

**Teaching Scheme**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- Students can understand Soil-environment interaction, Soil mineralogy and Mechanisms of soil-water interaction
- Students can learn ground water flow and predict contaminant transport phenomenon. Can apply remediation techniques for contaminated site.

**Syllabus Contents:**

**Unit I: Soil as a multiphase system;** Soil-environment interaction; Properties of water in relation to the porous media; Water cycle with special reference to soil medium.

**Unit II: Soil mineralogy;** significance of mineralogy in determining soil behavior; Mineralogical characterization.

**Unit III: Mechanisms of soil-water interaction:** Diffuse double layer models; Force of attraction and repulsion; Soil-water-contaminant interaction; Theories of ion exchange; Influence of organic and inorganic chemical interaction.

**Unit IV: Concepts of waste containment;** Sources, production and classification of wastes, Environmental laws and regulations, physico-chemical properties of soil, ground water flow and contaminant transport, desirable properties of soil; contaminant transport and retention; contaminated site remediation.

**Unit V: Soil characterization techniques;** volumetric water content; gas permeation in soil; electrical and thermal properties; pore-size distribution; contaminant analysis. contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, ground water monitoring, end uses of landfill sites, slurry walls and barrier systems, design and construction, stability, compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches.

**References:**

- Mitchell, J.K and Soga, K., Fundamentals of Soil Behavior, John Wiley and Sons Inc., 2005.
- Fang, H-Y., Introduction to Environmental Geotechnology, CRC Press,1997.
- Daniel, D.E, Geotechnical Practice for Waste Disposal, Chapman and Hall, 1993.
- Rowe, R.K., Quigley, R.M. and Booker, J.R., Clay Barrier Systems for Waste Disposal Facilities, E & FN Spon, 1995.
- Rowe, R.K, Geotechnical and Geoenvironmental Engineering Handbook, Kluwer Academic Publishers, 2001.
- Reddi, L.N. and Inyang, H.F, Geoenvironmental Engineering - Principles and Applications, Marcel Dekker Inc, 2000.
- Sharma, H.D. and Lewis, S.P, Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation, John Wiley & Sons Inc., 1994.

**PE-2 CRITICAL SOIL MECHANICS**

**Teaching Scheme**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- At the completion of the course the students will be able to decide the type of mathematical models to be used for analyzing the behavior of soil mass at critical state

**Syllabus Contents:**

**Unit I: Soil Behavior:** State of stress and strain in soils, Stress and strain paths and invariants, behavior of soils under different laboratory experiments

**Unit II: The Critical state line** and the Roscoe surface: Families of undrained tests, Families of drained tests, the critical state line, drained and undrained surfaces, The Roscoe surface

**Unit III: Behavior of Overconsolidated samples:** The Hvorslev surface: Behaviour of overconsolidated samples, drained and undrained tests, The Hvorslev surface, complete State Boundary Surface, Volume changes and pore water pressure changes

**Unit IV: Behaviour of Sands:** The critical state line for sands, Normalized plots, the effect of dilation, Consequences of Taylor's model

**Unit V: Behaviour of Soils before Failure:** Elastic and plastic deformations, Plasticity theory, Development of elastic-plastic model based on critical state soil mechanics, The Cam-clay model, The modified Cam-clay model



**References:**

- J. H. Atkinson and P. L. Bransby, “The mechanics of soils: An introduction to critical state soil mechanics”, McGraw Hill, 1978
- D. M. Wood, “Soil behaviour and critical state soil mechanics”, Cambridge University Press, 1990
- B. M. Das, “Fundamental of geotechnical engineering”, Cengage Learning, 2013

**Research Methodology and IPR**

**Teaching Scheme**

Lectures: 1hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**

- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2nd Edition , “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.
- Asimov , “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.

T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

**PE-III MARINE GEOTECHNIQUES**

**Teaching Scheme**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

Students can execute investigation program for marine soil deposits and select necessary design parameters. Design suitable marine foundation as per project requirement. Can develop numerical model for response of marine foundation for offshore conditions.

**Syllabus Contents:**

**Unit I: Marine soil deposits:** Offshore environment, Offshore structures and foundations, Specific problems related to marine soil deposits, Physical and engineering properties of marine soils

**Unit II: Behavior of soils subjected to repeated loading:** Effect of wave loading on offshore foundations, Behavior of sands and clays under cyclic loading, Laboratory experiments including repeated loading, Cyclic behavior of soils based on fundamental theory of mechanics, Approximate engineering methods which can be used for practical cases

**Unit III: Site Investigation in the case of marine soil deposits:** Challenges of site investigation in marine environment, Different site investigation techniques, sampling techniques, Geophysical methods, Recent advancements in site investigation and sampling used for marine soil deposits

**Unit IV: Foundations in marine soil deposits:** Different offshore and nearshore foundations, Gravity platforms, Jack-up rigs, pile foundations. cassions, spudcans

**Unit V: Numerical modeling of marine foundations subjected to wave loading:** Numerical modeling of cyclic behavior of soils, empirical models, elastic-plastic models, FEM analysis of marine foundations subjected to wave loading

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| <p><b>References:</b></p> <ul style="list-style-type: none"> <li>• H. G. Poulos. “Marine Geotechnics”, Unwin Hyman Ltd, London, UK, 1988</li> <li>• D. V. Reddy and M. Arockiasamy, “Offshore Structures”, <i>Volume: 1</i>, R.E. Kreiger Pub and Co., 1991</li> <li>• D. Thomson and D. J. Beasley, “Handbook of Marine Geotechnical Engineering”, US Navy, 2012</li> </ul> |
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| <p><b>PE-III COMPUTATIONAL GEOMECHANICS</b></p>  |
| <p><b>Teaching Scheme</b><br/>Lectures: 3 hrs/ week</p>  |
| <p><b>COURSE OUTCOME</b></p> <ul style="list-style-type: none"> <li>• Students can understand different numerical and statistical tools for analyzing various geotechnical engineering problems.</li> <li>• Students can apply probabilistic approach for selection of design parameters and compute their impact on risk assessment</li> </ul>  |
| <p><b>Syllabus Contents:</b></p> <p><b>Unit I: Solution of Non-linear Equations:</b> Bisection, False Position, Newton-Raphson, Successive approximation method, Iterative methods</p> <p><b>Unit II: Solution of Linear Equations:</b> Jacobi’s method, Gauss Seidal method, Successive over relaxation method.</p> <p><b>Unit III: Finite Difference Method:</b> Two point Boundary value problems – Disichlet conditions, Neumann conditions; ordinary and partial differential equations.</p> <p><b>Unit IV: Finite Element Method:</b> Fundamentals, Constitutive finite element models for soils.</p> <p><b>Unit V: Correlation and Regression Analysis:</b> Correlation - Scatter diagram, Karl Pearson coefficient of correlation, Limits of correlation coefficient; Regression –Lines of regression, Regression curves, Regression coefficient, Differences between correlation and regression analysis.</p> <p><b>Unit VI: One-dimensional Consolidation</b> - Theory of consolidation, Analytical procedures, Finite difference solution procedure for multilayered systems, Finite element formulation</p> <p><b>Unit VII: Flow Through Porous Media</b> - Geotechnical aspects, Numerical methods, Applications and Design analysis, Flow in jointed media.</p> <p><b>Unit VIII: Risk assessment in Geotechnical Engg.</b> - Probabilistic site characterisation and design of foundations</p> |
| <p><b>References:</b></p> <ul style="list-style-type: none"> <li>• S. Chandrakant., Desai and John T. Christian, “Numerical Methods in Geotechnical Engineering”, Mc. Graw Hill Book Company, 1977.</li> <li>• M.K. Jain, S.R.K. Iyengar and R.K. Jain, “Numerical Methods for Scientific and Engineering computations”, Third edition, New Age International (P) Ltd. Publishers, New Delhi.</li> <li>• D.J. Naylor and G.N. Pande, “Finite Elements in Geotechnical Engineering”, Pineridge</li> </ul>   |

Press Ltd., UK.

- Sam Helwany, “Applied soil mechanics”, John Wiley & sons, Inc,

### PE-III PHYSICAL AND CONSTITUTIVE MODELLING ON GEOMECHANICS

#### Teaching Scheme

Lectures: 3 hrs/ week

#### COURSE OUTCOME

- Students can understand theory of plasticity and various yield criteria and flow rule.
- Students can apply critical state concept to consolidation and triaxial soil behavior.

#### Syllabus Contents:

**Unit I: Role of constitutive modeling;** Importance of laboratory testing with relation to constitutive modeling; Elasticity: linear, quasi linear, anisotropic;

**Unit II: Plasticity basics:** yield criteria, flow rule, plastic potential, hardening/softening; Rate Independent Plasticity: mohr-coulomb, nonlinear failure criteria, Drucker Prager, and cap models;

**Unit III: Critical state soil mechanics:** critical state concept, cam clay models, simulation of single element test using cam clay,

**Unit IV: Consolidation,** drained and undrained triaxial test; Stress dilatancy theory;

**Unit V: Work hardening plasticity theory:** formulation and implementation; Applications of elasto-plastic models; Special Topics: hypoelasticity-plasticity, disturbed state concept.

#### References:

- Hicher and Shao, “Constitutive Modeling of Soils and Rocks”, John Wiley. 2008
- C.S. Desai and H. J. Siriwardane, “Constitutive Laws for Engineering Materials with Emphasis on Geologic Materials”, Prentice-Hall, Inc., New Jersey. 1984
- David M Potts and Lidija Zdravkovic, “Finite Element Analysis in Geotechnical Engineering Theory and Application”, Thomas Telford. 1999
- C.S. Desai, “Mechanics of Materials and Interfaces: The Disturbed State Concept”, CRC Press LLC. 2000
- A.P.S. Selvadurai, M.J. Boulon, “Mechanics of Geomaterial Interfaces, Elsevier.

### PE-V DESIGN OF UNDERGROUND EXCAVATIONS

#### Teaching Scheme

Lectures: 3 hrs/ week

#### COURSE OUTCOME

- Students can understand the use of elastic and plastic analysis in the design of underground support system.
- Students will have idea about the field tests generally conducted during and after construction of under structures.

**Syllabus Contents:**

**Unit I:** Introduction, planning of and exploration for various underground construction projects, stereographic projection method, principle and its application in underground excavation design.

**Unit II:** Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theory

**Unit III:** Application of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uniaxial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels and caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering.

**Unit IV:** Rock mass-tunnel support interaction analysis, ground response and support reaction curves, Ladanyi's elasto-plastic analysis of tunnels, design of various support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts

**Unit V:** In-situ stress, flat jack, hydraulic fracturing and over coring techniques and USBM type drill hole deformation gauge, single and multi-point bore hole extensometers, load cells, pressure cells, etc. Instrumentation and monitoring of underground excavations, during and after construction, various case studies

**References:**

Hoek, E and and Brown, E. T.,” Underground Excavations in Rocks”, Institute of Mining Engineering.

Obert, L. and Duvall, W.I., “Rock Mechanics and Design of Structures in Rocks”, John Wiley.

Singh, B. and Goel, R.K.,”Rock Mass Classification- A Practical Engineering Approach”, Elsevier.

Singh, B. and Goel, R.K., “Tunnelling in Weak Rocks”, Elsevier

**PE- IV EARTH RETAINING STRUCTURES**

**Teaching Scheme**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- The students will be able to do analysis and design of different types of retaining structures

**Syllabus Contents:**

**Unit I: Earth Pressure:** Rankine and Coulomb theories, active, passive and pressure at rest; concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill.

**Unit II: Retaining walls:** Proportioning of retaining walls, stability of retaining walls,

mechanically stabilized retaining walls/reinforced earth retaining walls

**Unit III: Sheet Pile wall:** free earth system, fixed earth system

**Unit IV: Bulkheads:** bulkheads with free and fixed earth supports, equivalent beam method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates

**Unit V: Tunnel and Conduit:** Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils,

**Unit VI: Braced excavations:** Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays

**References:**

- Das, Braja M., “Principles of Foundation Engineering”, PWS Publishing. 1998
- Bowles. J.E., Foundation Analysis and Design, Tata McGraw-Hill International Edition, 5th Edn, 1997.

**PE-IV ENGINEERING ROCK MECHANICS**

**Teaching Scheme**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

The students will be able to perform various laboratory tests on rock and classify rock mass. Be able to predict strength of rock mass with respect to various Civil Engineering applications

**Syllabus Contents:**

**Unit I: Rock:** Formation of rocks, Physical properties, Classification of rocks and rock masses, Elastic constants of rock; Insitu stresses in rock

**Unit II: Rock Testing:** Laboratory and Field tests

**Unit III: Discontinuities in Rock Masses:** Discontinuity orientation, Effect of discontinuities on strength of rock ;

**Unit IV: Strength Behaviour:** Compression, Tension and Shear, Stress-Strain relationships, Rheological behavior ;

**Unit V: Strength/ Failure Criterion:** Mohr-Coulomb, Griffith theory, Hoek and Brown, strength and other strength criteria. Stresses in rock near underground openings;

**Unit VI: Application of rock mechanics in Civil Engineering:** Rock tunneling, rock slope stability, bolting, blasting, grouting and rock foundation design. Modern modelling techniques & analyses in rocks.

**References:**

- Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the

Principles, 1997. Elsevier, Oxford

- Goodman, R.E. Introduction to Rock Mechanics, John Wiley & Sons.
- Ramamurthy, T., “Engineering in Rocks”, PHI Learning Pvt. Ltd.
- Jaeger, J.C. and Cook, N.G.W, Fundamentals of Rock Mechanics, Chapman and Hall, 1976.
- Wyllie, D.C., Foundations on Rock, E & FN Spon. 2nd Edition, 1992.

### STABILITY ANALYSIS OF SLOPES

#### Teaching Scheme

Lectures: 3 hrs/ week

#### COURSE OUTCOME

- Student will be able to check the stability of earthen dams, and the safety measures to be undertaken to prevent the instability of slopes, earthen dams and embankments

#### Syllabus Contents:

**Unit I: Slopes:** Types and causes of slope failures, mechanics of slope failure, failure modes.

**Unit II: Stability analysis:** infinite and finite slopes with or without water pressures; concept of factor of safety, pore pressure coefficients, Mass analysis, Wedge methods, friction circle method ; Method of slices, Bishop’s method, Janbu’s method, Morgenstern and Price, Spencer’s method

**Unit III: Stability analysis in the presence of seepage:** two dimensional flow – Laplace equation and it’s solution, graphical method, determination of phreatic line, flow nets in homogeneous and zoned earth dams under steady seepage and draw-down conditions, seepage control in earth dams, influence of seepage on slope stability stability analysis of dam body during steady seepage

**Unit IV: Strengthening measures:** stabilization of slopes by drainage methods, surface and subsurface drainage, use of synthetic filters, retaining walls, stabilization and strengthening of slopes, shotcreting, rock bolting and rock anchoring, instrumentation and monitoring of slopes, slope movements, warning devices, maintenance of slopes

#### References:

- Chowdhary R and ChowdharyI , ”Geotechnical Slope Analysis”, CRC Press.
- Harr M.E.,” Ground Water and Seepage”, McGraw Hill. 1962

### FOUNDATIONS ON WEAK ROCKS

#### Teaching Scheme

Lectures: 3 hrs/ week

#### COURSE OUTCOME

The students will be able to classify different types of rock mass and design different types of foundations placed over rock mass.

**Syllabus Contents:**

**Unit I:** Engineering properties of weak rocks, different rock mass classification systems, relative merits and demerits

**Unit II:** Failure criteria for weak rocks, bi-linear Mohr-Coulomb failure criterion, Hoek and Brown criterion and modified Hoek and Brown failure criterion etc.

**Unit III:** Effect of structural planes on rock foundations, possible modes of failure of foundations on rocks/ rock masses, determination of in-situ shear strength of rocks and rock masses

**Unit IV:** Requirements for satisfactory performance of foundations, bearing capacity of foundations on rocks and rock masses, allowable bearing pressure of rock foundations using a nonlinear failure criterion, monotonic and cyclic plate load tests

**Unit V:** Pressure-settlement characteristics, effect of layering, anisotropy, heterogeneity and in-elasticity

**Unit VI:** Shallow foundations, shallow foundations on sloping ground, raft foundations, stilt foundations, foundations for suspension bridges, transmission line towers, framed buildings etc, treatment of foundations - open joints, solution cavities, weak seams

**Unit VII:** Piles in weak rocks, bearing capacity and settlement of piles, piles in stratified rock masses, field load tests on piles in weak rocks, behaviour of bored / driven piles in soft / weathered rocks

**References:**

- Wyllie Duncan C.,” Foundations on Rock: Engineering Practice”, E&FN Spon, Taylor and Francis.
- Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles, 1997. Elsevier, Oxford
- Singh, B. and Goel, R.K.,”Rock Mass Classification- A Practical Engineering Approach”, Elsevier .
- Ramamurthy, T., “Engineering in Rocks”, PHI Learning Pvt. Ltd.
- Hoek, E., “Practical Rock Engineering”, Rock science.

**GEOTECHNICAL EARTHQUAKE ENGINEERING**

**Teaching Scheme**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- Students will know the causes and quantification of earthquake.
- Student will be exposed to the effect of earthquake and the design criteria to be followed for the design different geotechnical structures

**Syllabus Contents:**

**Unit I: Earthquake seismology** – Causes of earthquake, Plate tectonics, Earthquake fault sources, Seismic waves, Elastic rebound theory, Quantification of earthquake, Intensity and magnitudes, Earthquake source models.



**Unit II: Earthquake ground motion** – Seismograph, Characteristics of ground motion, Effect of local site conditions on ground motions, Design earthquake, Design spectra, Development of site specification and code-based design.

**Unit III: Ground response analysis** – One-dimensional ground response analysis: Linear approaches, Equivalent linear approximation of non-linear approaches, Computer code “SHAKE”.

**Unit IV:** Liquefaction and lateral spreading - Liquefaction related phenomena, Liquefaction susceptibility: Historical, Geological, Compositional and State criteria. Evaluation of liquefaction by cyclic stress and cyclic strain approaches, Lateral deformation and spreading, Criteria for mapping liquefaction hazard zones.

**Unit V:** Seismic design of foundations, Seismic slope stability analysis: Internal stability and weakening instability and Seismic design of retaining walls.

**References:**

- Steven Kramer, “Geotechnical Earthquake Engineering”, Pearson, 2008.
- Seco e Pinto, P., Seismic behaviour of ground and Geotechnical structure, A. A.
- Naeim, F., The Seismic Design Handbook, Kluwer Academic Publication, 2<sup>nd</sup> Edition, 2001.
- Ferrito, J.M, Seismic design criteria for soil liquefaction, Tech. Report of Naval Facilities service centre, Port Hueneme, 1997.

**Lab-I (Soil Mechanics-I)**

Lab: 3hrs/week

**List of Practicals:**

1. Determination of Moisture Content and Specific gravity of soil
2. Grain Size Distribution Analysis and Hydrometer Analysis
3. Atterberg Limits (Liquid Limit, Plastic limit, Shrinkage limit)
4. Visual Classification Tests
5. Vibration test for relative density of sand
6. Standard and modified proctor compaction test
7. Falling head permeability test and Constant head permeability test
8. Consolidation test

**Lab-II (Soil Mechanics-II)**

Lab: 3hrs/week

**List of Practicals:**

1. Unconfined compression test
2. Direct shear test
3. Tri-axial compression test – UU, CU, CD tests
4. Laboratory vane shear test
5. Field Vane shear test
6. Field direct shear test

**Lab-III (Sub soil exploration)**

Lab: 3hrs/week

**List of Practicals:**

1. Exploratory borings by different methods including auger boring, wash boring, percussion drilling and rotary drilling.
4. Standard penetration test
5. Dynamic cone penetration test
6. Static cone penetration test
7. Plate load test
8. Pressure meter test
9. Geophysical exploration tests

**Lab-IV(Soil dynamics)**

Lab: 3hrs/week

**List of Practicals:**

1. Spectral analysis of surface waves (SASW) Test / Multi-channel analysis of surface waves (MASW)test
2. Seismic cross-hole test
3. Seismic down-hole / up-hole test
4. Seismic dilatometer test
5. Resonant column test
6. Piezoelectric bender element test
7. Cyclic triaxialtest
8. Cyclic direct shear test

**OPEN ELECTIVES**

**Business Analytics**

**Teaching scheme**

**Lecture: - 3 h/week**

|                      |                           |
|----------------------|---------------------------|
| <b>Course Code</b>   |                           |
| <b>Course Name</b>   | <b>Business Analytics</b> |
| <b>Credits</b>       |                           |
| <b>Prerequisites</b> |                           |

Total Number of Lectures: 48

**Course objective**

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.

5. Use decision-making tools/Operations research techniques.
6. Mangle business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

| LECTURE WITH BREAKUP   | NO. OF LECTURES |
|--|-----------------|
| <p><b>Unit1:</b></p> <p>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.</p> <p>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p>  | 9               |
| <p><b>Unit 2:</b></p> <p>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.</p> <p>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.</p>   | 8               |
| <p><b>Unit 3:</b></p> <p>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.</p> <p>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.</p> | 9               |
| <p><b>Unit 4:</b></p> <p>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.</p>  | 10              |

|  |   |
|--|---|
| Monte Carlo Simulation and Risk Analysis: Monte Carlo Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.                |   |
| <b>Unit 5:</b><br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. | 8 |
| <b>Unit 6:</b><br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.  | 4 |

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|--|--|
| <b>COURSE OUTCOMES</b>   |  |
| 1. Students will demonstrate knowledge of data analytics.  |  |
| 2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.                             |  |
| 3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |  |
| 4. Students will demonstrate the ability to translate data into clear, actionable insights.  |  |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

**OPEN ELECTIVES**

**Industrial Safety**

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of

maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

**OPEN ELECTIVES**  
**Operations Research**

**Teaching Scheme**

Lectures: 3 hrs/week

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**Course Outcomes:** At the end of the course, the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

**Open Elective**

**Cost Management of Engineering Projects**

**Teaching scheme**

**Lecture: - 3 h/week**

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Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

### References:

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## **Open Elective Composite Materials**

### Teaching scheme

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III: Manufacturing of Metal Matrix Composites:** Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT-IV: Manufacturing of Polymer Matrix Composites:** Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V: Strength:** Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight

strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

**Open Elective**  
**Waste to Energy**

**Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion -



Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

**AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING**

| <b>Course objectives:</b>  |  |       |
|--|--|-------|
| Students will be able to:  |  |       |
| <ol style="list-style-type: none"> <li>1. Understand that how to improve your writing skills and level of readability</li> <li>2. Learn about what to write in each section</li> <li>3. Understand the skills needed when writing a Title</li> </ol> |  |       |
| Ensure the good quality of paper at very first-time submission   |  |       |
| <b>Syllabus</b>  |  |       |
| Units  | CONTENTS   | Hours |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4     |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4     |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4     |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4     |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4     |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4     |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

**AUDIT 1 and 2: DISASTER MANAGEMENT**

| <b>Course Objectives:</b> -Students will be able to:  |   |       |
|---|---|-------|
| 1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.  |   |       |
| 2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.  |   |       |
| 3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.   |   |       |
| 4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in |   |       |
| <b>Syllabus</b>   |   |       |
| Units   | CONTENTS  | Hours |
| 1   | <b>Introduction</b><br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.  | 4     |
| 2   | <b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4     |
| 3   | <b>Disaster Prone Areas In India</b><br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics  | 4     |
| 4   | <b>Disaster Preparedness And Management</b><br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data   | 4     |

|   |   |   |
|---|---|---|
|   | From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.   |   |
| 5 | <b>Risk Assessment</b><br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. | 4 |
| 6 | <b>Disaster Mitigation</b><br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.   | 4 |

### SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

### AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

#### Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

#### Syllabus

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul>          | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8     |

**Suggested reading**

1. “Abhyastakam” – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

**Course Output**

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

**AUDIT 1 and 2: VALUE EDUCATION**

**Course Objectives**

Students will be able to

- 1.Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

**Syllabus**

| <b>Unit</b> | <b>Content</b>   | <b>Hours</b> |
|-------------|--|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul>  | 4            |
| 2           | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty, Humanity. Power of faith, National Unity.</li> <li>• Patriotism.Love for nature ,Discipline</li> </ul>  | 6            |
| 3           | <ul style="list-style-type: none"> <li>• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> </ul> | 6            |

|   |   |   |
|---|---|---|
|   | <ul style="list-style-type: none"> <li>• Doing best for saving nature</li> </ul>  |   |
| 4 | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality, Nonviolence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind, Self-control.</li> <li>• Honesty, Studying effectively</li> </ul> | 6 |

**Suggested reading**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

**Course outcomes**

Students will be able to

- 1.Knowledge of self-development
- 2.Learn the importance of Human values
- 3.Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

|   |  |              |
|---|--|--------------|
| <b>Course Objectives:</b>   |  |              |
| Students will be able to:   |  |              |
| <ol style="list-style-type: none"> <li>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>2. To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</li> <li>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ol> |  |              |
| <b>Syllabus</b>   |  |              |
| <b>Units</b>  | <b>Content</b>   | <b>Hours</b> |
| <b>1</b>  | <ul style="list-style-type: none"> <li>•<b>History of Making of the Indian Constitution:</b></li> <li>History</li> <li>Drafting Committee, ( Composition &amp; Working)</li> </ul>   | 4            |
| <b>2</b>  | <ul style="list-style-type: none"> <li>•<b>Philosophy of the Indian Constitution:</b></li> <li>Preamble</li> <li>Salient Features</li> </ul>   | 4            |
| <b>3</b>  | <ul style="list-style-type: none"> <li>•<b>Contours of Constitutional Rights &amp; Duties:</b></li> <li>• Fundamental Rights</li> <li>• Right to Equality</li> <li>• Right to Freedom</li> <li>• Right against Exploitation</li> </ul> | 4            |

|          |  |   |
|----------|--|---|
|          | <ul style="list-style-type: none"> <li>• Right to Freedom of Religion</li> <li>• Cultural and Educational Rights</li> <li>• Right to Constitutional Remedies</li> <li>• Directive Principles of State Policy</li> <li>• Fundamental Duties.</li> </ul>   |   |
| <b>4</b> | <ul style="list-style-type: none"> <li>• <b>Organs of Governance:</b></li> <li>• Parliament</li> <li>• Composition</li> <li>• Qualifications and Disqualifications</li> <li>• Powers and Functions                             <ul style="list-style-type: none"> <li>• Executive</li> <li>• President</li> <li>• Governor</li> <li>• Council of Ministers</li> </ul> </li> <li>• Judiciary, Appointment and Transfer of Judges, Qualifications</li> <li>• Powers and Functions</li> </ul>   | 4 |
| <b>5</b> | <ul style="list-style-type: none"> <li>• <b>Local Administration:</b></li> <li>• District's Administration head: Role and Importance,</li> <li>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.</li> <li>• Pachayati raj: Introduction, PRI: ZilaPachayat.</li> <li>• Elected officials and their roles, CEO ZilaPachayat: Position and role.</li> <li>• Block level: Organizational Hierarchy (Different departments),</li> <li>• Village level: Role of Elected and Appointed officials,</li> <li>• Importance of grass root democracy</li> </ul> | 4 |
| <b>6</b> | <ul style="list-style-type: none"> <li>• <b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul>   | 4 |

**Suggested reading**

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**Course Outcomes:**

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

### AUDIT 1 and 2: PEDAGOGY STUDIES

| <b>Course Objectives:</b>  |   |       |
|--|---|-------|
| Students will be able to:  |   |       |
| <ol style="list-style-type: none"> <li>4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.</li> <li>5. Identify critical evidence gaps to guide the development.</li> </ol> |   |       |
| Syllabus   |   |       |
| Units  | Content   | Hours |
| 1  | <ul style="list-style-type: none"> <li>• <b>Introduction and Methodology:</b></li> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> <li>• Overview of methodology and Searching.</li> </ul>  | 4     |
| 2  | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>  | 2     |
| 3  | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers' attitudes and beliefs and Pedagogic strategies.</li> </ul> | 4     |
| 4  | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul>  | 4     |
| 5  | <ul style="list-style-type: none"> <li>• <b>Research gaps and future directions</b></li> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> </ul>   | 2     |

- |                                      |
|--------------------------------------|
| • Dissemination and research impact. |
|--------------------------------------|

### Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal Educational Development*, 33 (3): 272–282.
5. Alexander RJ (2001) *Culture and pedagogy: International comparisons in primary education*. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, ‘learning to read’ campaign.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf)

### Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

### Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

### Syllabus

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> </ul> Do`s and Don`t`s in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> </ul> i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam    | 8     |

### Suggested reading

1. ‘Yogic Asanas for Group Tarining-Part-I’ :Janardan Swami Yogabhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata



**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

**AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**

**Course Objectives**

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

**Syllabus**

| Unit | Content  | Hours |
|------|--|-------|
| 1    | Neetisatakam-Holistic development of personality <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont's)</li> <li>• Verses- 71,73,75,78 (do's)</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>   | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8     |

**Suggested reading**

1. “Srimad Bhagavad Gita” by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

**Course Outcomes**

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

**M. Tech (Civil Engineering)**  
**Model Curriculum Structure**  
**Specialization: HYDRAULIC ENGINEERING**

**PROGRAM OBJECTIVES**

1. To learn the principles, processes and design of pressurized and free surface system.
2. To achieve competency in the pipe network design, analysis of channel networks, pressure rise in pipes due to sudden closure of valves, etc.
3. To assess the impact of climate change detection, Land use/Land cover changes on water availability
4. Efficient use of water in irrigation under varying climate change.
5. Impact of climate change on glaciers, consumptive use of surface and ground water, and optimum allocation of water.
6. Evaluation of various hydrologic processes including flow forecasting and the related practical applications.

| <b>Semester I</b> |                         |   |                        |      |          |                |
|-------------------|-------------------------|---|------------------------|------|----------|----------------|
| <b>Sr. No.</b>    | <b>Course Type/Code</b> | <b>Course Name</b>  | <b>Teaching Scheme</b> |      |          | <b>Credits</b> |
|                   |                         |   | Th                     | Tuto | Lab      |                |
| 1.                | Core-I                  | Advanced Hydrology  | 3                      | --   | 0        | 3              |
| 2.                | Core-II                 | Advanced Fluid Mechanics  | 3                      |      | 0        | 3              |
| 3.                | Prog. Elective-I        | (1) Fluvial Hydraulics<br>(2) Hydraulic Structures<br>(3) Systems Engineering | 3                      | --   | --       | 3              |
| 4.                | Prog. Elective-II       | (1) Water Resources Systems Planning<br>(2) Irrigation and Drainage           | 3                      | --   | --       | 3              |
| 5.                | Lab 1                   | Fluid Mechanics   |                        |      | 4        | 2              |
| 6.                | Lab 2                   | Hydrology   |                        |      | 4        | 2              |
| 7.                | Core                    | Research Methodology and IPR  | 2                      | --   | --       | 2              |
| 8.                | Audit 1                 | Audit course 1  | 2                      |      |          | 0              |
| <b>Total</b>      |                         |   | <b>16</b>              |      | <b>8</b> | <b>18</b>      |

| Semester II  |                    |  |                 |          |           |           |
|--------------|--------------------|--|-----------------|----------|-----------|-----------|
| Sr. No.      | Course Code/Type   | Course Name  | Teaching Scheme |          |           | Credits   |
|              |                    |  | L               | T        | P         |           |
| 1.           | Core-III           | Ground Water Engineering   | 3               | 0        | 0         | 3         |
| 2.           | Core-IV            | Free Surface Flows   | 3               | 0        | 0         | 3         |
| 3.           | Prog. Elective-III | (1) Computational Methods in Fluid Mechanics<br>(2) Theory and Applications of GIS | 3               | --       | --        | 3         |
| 4.           | Prog. Elective-IV  | (1) Environmental Hydraulics<br>(2) Advanced Numerical Analysis                    | 3               |          |           | 3         |
|              | Lab 1              | Computational Fluid Dynamics   |                 |          | 4         | 2         |
|              | Lab 2              | Open Channel Flow  |                 |          | 4         | 2         |
| 5.           | Core               | Mini-Project   | --              | --       | 4         | 2         |
| 6.           | Audit 2            | Audit -2   | 2               |          |           | 0         |
| <b>Total</b> |                    |  | <b>14</b>       | <b>0</b> | <b>12</b> | <b>18</b> |

| Semester III |                       |   |                 |    |           |           |
|--------------|-----------------------|---|-----------------|----|-----------|-----------|
| Sr. No.      | Course Code           | Course Name   | Teaching Scheme |    |           | Credits   |
|              |                       |   | L               | T  | P         |           |
| 1.           | Programme-Elective-V  | Computer Methods in Hydraulics and Hydrology<br>Stochastic Hydrology  | 3               | -  | -         | 3         |
| 2.           | Programme Elective-VI | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3               | -  | -         | 3         |
| 3.           | Dissertation          | Dissertation Phase – I  | --              | -- | 20        | 10        |
| <b>Total</b> |                       |   | <b>6</b>        |    | <b>20</b> | <b>16</b> |

| Semester-IV |              |                         |                 |    |    |         |
|-------------|--------------|-------------------------|-----------------|----|----|---------|
| Sr. No.     | Course Code  | Course Name             | Teaching Scheme |    |    | Credits |
|             |              |                         | L               | T  | P  |         |
| 1.          | Dissertation | Dissertation Phase - II | --              | -- | 32 | 16      |

|              |    |    |    |           |
|--------------|----|----|----|-----------|
| <b>Total</b> | -- | -- | -- | <b>16</b> |
|--------------|----|----|----|-----------|

Total Credits for the programme = 18 + 18 + 16 + 16 = 68

### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

### Core-I ADVANCED HYDROLOGY

#### Teaching Scheme:

Lectures: 3 hrs/ week

#### COURSE OUTCOME

- To develop basic tools for analysis of hydrologic processes
- To apply time series models for hydrologic data generation and forecasting.
- To be familiar with the hydrologic design concepts and methods including estimation of the design flows
- To assess impact of climate change and Land use/Land cover on water availability

#### Syllabus Contents:

**Unit I:** Introduction: Hydrologic system and hydrologic budget, fundamental laws of hydrology; atmospheric water vapor.

**Unit II:** Hydrologic Inputs: Precipitation and its forms, snowfall and rainfall; measurement techniques and space-time characteristics

**Unit III:** Hydrologic Abstractions: Infiltration, depression storage, evapotranspiration; measurement techniques, space time characteristics and their modelling.

**Unit IV:** Stream flow: Measurement techniques, space-time characteristics, rating curves  
System Approach: Unit Hydrograph IUH, GIUH

**Unit V:** Mathematical Modelling: Linear and Nonlinear models, Physically based models

**Unit VI:** Hydrological routing, Flood forecasting

**Unit VII:** Advanced Method of Frequency Analysis: Outliers, Time series analysis.

Unit VIII: Impact of climate change and Land use/Land cover on basin response

#### References:

- Chow, V.T., Maidment, D.R. and Mays, W.L., "Applied Hydrology", McGraw Hill. 1988

- Ojha, C.S.P., Berndtsson, R. and Bhunya, P., “Engineering Hydrology”, Oxford University Press. 2008
- Wanielista, M., Kersten, R. and Eaglin, R., “Hydrology”, John Wiley. 1997

### Core-II ADVANCED FLUID MECHANICS

#### Teaching Scheme:

Lectures: 3 hrs/ week

#### COURSE OUTCOME

- To have mathematical and physical background to analyse real life problems in fluid mechanics.
- To possess skills to take up research activities involving fluid motions.

#### Syllabus Contents:

**Unit I:** Kinematics of Flow: Equation of continuity in cartesian, polar and cylindrical coordinates,

**Unit II:** Standard 2D Flow Patterns: Source, sink, doublet and their combinations, construction of flows by superposition, D’Alembert’s paradox

**Unit III:** Laplace Equation: Solution by graphical and relaxation methods, conformal mapping, solution by separation of variables

**Unit IV:** Laminar Flow: Derivation of Navier-Stokes equations – exact solutions for flow between parallel plates, Couette flow, flow near a suddenly accelerated plate and an oscillating plate.

**Unit V:** Boundary Layers: Similarity solutions of boundary layer equations, Falkner-Skan Wedge flows, Karman’s momentum integral equations, Karman-Pohlhausen approximate solution, separation in boundary layer under adverse pressure gradient, turbulent boundary layer.

**Unit VI:** Turbulent Flows: Reynolds equations of motion, semi-empirical theories of turbulence, velocity profiles for inner, outer and overlap layers, equilibrium boundary layers.

**Unit VII:** Measurement of Turbulence and Statistical Theory of Turbulence: Isotropic and homogeneous turbulence, probability density functions, correlation coefficients, decay of isotropic turbulence.

#### References:

- White, F.M., "Fluid Mechanics", McGraw-Hill. 1979
- Schlichting, H., "Boundary Layer Theory", McGraw-Hill. 1979
- Garde, R.J., "Turbulent Flow", Wiley Eastern Limited. 1994
- Pope, S. B., "Turbulent Flows", Cambridge University Press. 2000
- Rouse, H., "Advanced Mechanics of Fluids", John Wiley and Sons. 1959
- Ojha, C.S.P., Berndtsson, R. and Chandaramouli, P.N., “Fluid Mechanics”, Oxford University Press. 2010

### Core-IV FREE SURFACE FLOWS

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- Analysis of flows in channel networks.
- Flow measurement in rivers/channels.
- Dam break analysis

**Syllabus Contents:**

**Unit I:** Introduction: Free surface flows, velocity distribution, resistance relationships, specific energy and specific force, normal and critical depths computations, governing equation and computation of gradually varied flows.

**Unit II:** Hydraulic Jump: Elements of hydraulic jump, hydraulic jump in variety of situations including contracting and expanding geometries and rise in floor levels, control of hydraulic jump using baffle walls and cross jets.

**Unit III:** Supercritical Flows: Flow past deflecting boundaries, oblique shock waves.

Spatially Varied Flows: Flows past side weirs, De Marchi equations, design of side weirs, flow past bottom racks, trench weirs and waste water gutters.

**Unit IV:** Aerated Flows: Bulking of flow, mechanism of air entrainments, modelling of aerated flows, development of self-aerated flows, uniform aerated region, aeration over spillway.

Stratified Flows: Thermal stratification in water bodies including reservoirs, modelling of stratified flows.

**Unit V:** Unsteady Flows: St. Venant's equations and their solution using method of characteristics and finite difference schemes; dam break problem, hydraulic flood routing.

Channel Transitions: Sub-critical and supercritical.

**References:**

- Chow, V.T., "Open Channel Hydraulics", McGraw Hill. 1959
- Choudhary, M.H., "Open-Channel Flows", Prentice-Hall. 1994
- Ranga Raju, K.G., "Flow Through Open Channels, Tata McGraw Hill. 2003
- Chanson, H., "The Hydraulics of Open Channel Flow: An Introduction", Elsevier. 2004
- French, R.H., "Open-Channel Hydraulics", McGraw-Hill. 1994
- Wood, I.R., "Air entrainment in free-surface flows", A.A. balkema. 1991

## MODELING, SIMULATION AND OPTIMIZATION

### Syllabus Contents:

**Unit I:** Systems and Models: Fundamentals of systematic approach, system modelling, classification of models, model structure, Linear, non-linear, time-invariant, time variant models, State-space models, Distributed parameter models, System synthesis, Direct and inverse problems, Role of optimization, Role of computers, examples from hydrology/water resources engineering

**Unit II:** Regression Analysis: Linear and Multiple Regression analysis, analysis of residues, tests of goodness of fit, Parsimony criterion, role of historical data, examples from hydrology/ water resources engineering

**Unit III:** Spatial Distribution: Polynomial surfaces, Kriging, Spline functions, Cluster Analysis

**Unit IV:** Time Series Analysis: Auto-cross correlation analysis, identification of trend, spectral analysis, identification of dominant cycles, smoothing techniques, Filters, time series of rainfall and stream flow.

**Unit V:** Random Variables: Basic concepts, probability density distribution functions, Expectation and standard deviation of discrete and continuous random variables and their functions, covariance and correlation, commonly used theoretical probability distributions (uniform, normal, binomial, Poisson and negative exponential), Fitting distribution to raw data, Chi-square and Kolmogorov-Smirnov's tests of the goodness of fit, Central Limit theorem, various algorithms for generation of random numbers.

**Unit VI:** Monte Carlo Simulations: Basic concepts, generation of synthetic observations, statistical interpretation of output, Evaluation of definite integrals.

**Unit VII:** Optimization: Introduction, Classical methods, Linear Programming, Dynamic Programming, Non-linear optimization, Constrained optimization techniques

**References:**

- Ljung, L., "System Identification Theory for the Users", Prentice Hall. 1999
- Daniel, C. and Wood, P.S., "Fitting Equations to Data", John Wiley Interscience. 1980
- Law, A.M. and Kelton, W.D., "Simulation Modeling and Analysis", Tata McGraw Hill. 2007
- Rao S. S., "Engineering Optimization, Theory and Practice", New Age International Publishers. 2012
- Deb, K., "Optimization for Engineering design", Prentice Hall of India. 2006
- Vedula S. and Mujumdar P. P. "Water Resources Systems", Tat McGraw Hill. 2005

**Core-III GROUNDWATER ENGINEERING**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OBJECTIVE**

- The objective of this course is enable to the student to understand the basic empirical knowledge of the residence and movement of groundwater, as well as a number of quantitative aspects.
- At the end of the course, one should be able to evaluate the aquifer parameters and groundwater level variations for different hydro-geological boundary conditions.

**COURSE OUTCOME**

- Students are able to understand aquifer properties and movement of ground water flow after the completion of the course. It imparts exposure towards well design and practical problems of ground water aquifers.



**Syllabus Contents:**

**Unit I:** Introduction: Definition of groundwater, role of groundwater in hydrological cycle, groundwater bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity.

**Unit II:** Governing Equations for Groundwater Flow: Dupuit-Forchheimer assumptions, general differential equations governing groundwater flows, analytical solutions.

**Unit III:** Wells and Well Hydraulics: Different types of wells, construction of wells, steady and unsteady state solutions for confined, unconfined and leaky aquifers, effect of boundaries, method of images, pumping test analysis.

**Unit IV:** Groundwater Conservation: Regional groundwater budget; resource assessment; estimation of recharge, Indian practice for artificial recharge

**Unit V:** Groundwater Quality: General problem of contamination of groundwater, sources, remedial and preventive measures, seawater intrusion in coastal aquifers.

**Unit VI:** Groundwater Flow Modelling: Role of groundwater flow models, reference to hydraulic, Hele-Shaw and analog models, introduction to numerical modeling.

**Unit VII:** Planning of Groundwater Development: constraints on the development, role of flow models, optimal groundwater development.

**References:**

- Todd, D.K., "Groundwater Hydrology", John Wiley. 1959
- Bear, J., "Hydraulics of Groundwater", McGraw. 1979
- Bouwer, H., "Groundwater Hydrology", McGraw Hill. 1978
- Walton, W.C., "Groundwater Resources Evaluation", McGraw Hill. 1970
- Freeze and Cherry, "Groundwater", Prentice Hall. 1979
- Driscoll, F.G., "Ground Water and Wells", Johnson Division. 1986
- Raghunath, H. M., "Ground Water", New Age International (P) Limited. 2007

**PE-I FLUVIAL HYDRAULICS**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OBJECTIVE**

- Application of principles of fluid mechanics to the solution of problems encountered in both natural and constructed water systems.
- Use of model studies and computers in solving a host of problems in river engineering.

**COURSE OUTCOME**

- Exposure to resistance laws in mobile bed channels/rivers.
- Scour around bridge piers
- Design of river protection works

**Syllabus Contents:**

**Unit I:** The sediment problems, properties of sediments, incipient motion of uniform and non-uniform sediments.

**Unit II:** Bed forms and channel resistance.

**Unit III:** Bed load and suspended load transport for uniform and non-uniform bed material, total load equations, sediment sampling.

**Unit IV:** Stable channel design and sediment control.

**Unit V:** Bed level variations, local scour, degradation, aggradation and reservoir sedimentation.

**Unit VI:** Physical and mathematical models.

**Unit VII:** Design of guide bunds and other river training banks.

**References:**

- Garde, R.J., “River Morphology”, New International Publishers. 2006
- Julien, P.Y., “Erosion and Sedimentation”, Cambridge University Press. 1998
- Jansen, P.P.H., “Principals of River Engineering”, VSSD Publications. 1994
- Garde, R.J. and Ranga Raju, K.G., "Mechanics of Sediment Transportation and Alluvial Stream Problems", Wiley Eastern Limited. 2006

**PE-IHYDRAULIC STRUCTURES**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- Analysis and design of various types of hydraulic structures

**Syllabus Contents:**

**Unit I:** Introduction: Hydraulic structures for water resources projects.

**Unit II:** Embankment Dams: Types, design considerations, seepage analysis and control, stability analysis, construction techniques.

**Unit III:** Gravity Dams: Forces acting on failure of a gravity dam, stress analysis, elementary profile, design of gravity dam, other functional features of a gravity dam.

**Unit IV:** Dam Outlet Works: Types of outlet structures, ogee spillway, chute spillway, siphon spillway, side channel spillway, Labyrinth and Pianokey weir.

**Unit V:** Terminal Structures: Hydraulic jump types, stilling basin, roller bucket, ski jump basin, baffled spillway, drop structure

**Unit VI:** Hydraulic Modeling: Basic principles, dimensional analysis, design of physical models

of hydraulic structures

**References:**

- Peterka, A.J, “Hydraulic Design of Stilling Basins and Energy Dissipators”, USBR Engineering Monographs No. 25”. 1984
- Design of Small Dams”, Third Edition, Water Resources Technical Publication – US Bureau of Reclamation. 1987
- Singh, B., and Varshney, R.S., "Embankment Dam and Engineering", Nem Chand and Brothers. 2004
- Novak, P. and Nalluri, C., “Hydraulic Structures”, Edition 4, Taylor & Francis. 2007
- Creager, Justin and Hinds, “Engineering for Dams”, Vol. I and II, John Wiley.

**PE-ISYSTEMS ENGINEERING**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OBJECTIVE**

- Students will be introduced to application of systems concept to water resources planning and management. Optimization technique for modeling water resources systems and advanced optimization techniques to cover the socio-technical aspects will be taught.

**COURSE OUTCOME**

- At the completion of the course the students will be able to understand the system behaviors and know how to apply the various simulation and optimization techniques to achieve optimum utilisation of water resources

**Syllabus Contents:**

**Unit I:** Definitions and components of a system, system control, systems modelling and model development.

**Unit I:** System synthesis. economic analysis, conflicts and role of optimization in their resolution.

**Unit II:** Unconstrained optimization – analytical and numerical.

**Unit III:** Constrained optimization – analytical and numerical.

**Unit IV:** Integer programming.

**Unit V:** Geometric programming.

**Unit VI:** Linear programming.

**Unit VII:** Dynamic programming.

**Unit VIII:** Stochastic programming.

**References:**

- Aguilera, R.J., "Systems Analysis and Design", Prentice Hall. 1973
- Ossenbruggen, P. J., "Systems Analysis for Civil Engineering", John Wiley. 1984
- de Neufville, R., "Systems Analysis for Engineer" , McGraw Hill. 1971
- Rao, S.S., "Engineering Optimization – Theory and Practice", New Age International (P) Ltd. 1999
- Hamdy, A.T., "Operations Research – An Introduction", Prentice Hall. 1997

**PE-II WATER RESOURCES SYSTEMS PLANNING**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- Optimum utilisation of surface and subsurface water
- Rational allocation of reservoir water
- Exposure to various algorithms to solve linear as well as non-linear problems.

**Syllabus Contents:**

**Unit I:** Introduction: Water resources planning process, multi-objective planning.

**Unit II:** Evaluation of Water Plans: Basic concepts of engineering economics, welfare economics, economic comparison of alternatives.

**Unit III:** Water Plan Optimization: Plan formulation, objective functions and constraint, analytical optimization, numerical optimization, linear programming, dynamic programming, simulation, planning under uncertainty.

**Unit IV:** Deterministic River Basin Modeling: Stream flow modeling, estimation of reservoir storage requirements – dead storage, active storage for water supply/ irrigation / power generation, flood storage, optimal allocation.

**Unit V:** Conjunctive Use/Groundwater Management Models: LP based conjunctive use modeling, aquifer response models, link - simulation, embedded, matrix response based models, soft modeling.

**Unit VI:** Water Quality Management Models: Basic water quality modeling, objectives of management, control alternatives, optimal plans.

**References:**

- Hall, W.A. and Dracup, J.A., "Water Resources Systems Engineering", McGraw Hill Book Company. 1970
- Loucks, D.P., "Water Resource Systems Planning and Analysis", Prentice Hall. 1981
- Maass et al., "Design of Water-Resource Systems", Harvard University Press. 1962
- Vedula S. and Mujumdar, P.P., "Water Resources Systems", Tata McGraw Hill. 2005

**PE-II IRRIGATION AND DRAINAGE**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- Assessment of crop water requirement
- Optimum scheduling of irrigation
- Management of salinity problems and leaching process.

**Syllabus Contents:**

**Unit I:** Introduction, objectives of irrigation, type of irrigation and suitability; selection of irrigation method.

**Unit II:** Irrigation requirement, water balance, soil water relationships, water storage zone, infiltration.

**Unit III:** Flow of moisture through root zone, soil physical and chemical properties, crop evaporative and drainage requirements, irrigation efficiency and uniformity.

**Unit IV:** Surface irrigation systems, types of surface systems, basin irrigation, border irrigation, furrow irrigation, field measurement techniques, flow measurement, flumes, weirs, irrigation events, advance, wetting, depletion and recession phases.

**Unit V:** Infiltration, infiltrometer, ponding methods, soil water, tensiometers, neutron probe, time domain reflectometer, evapotranspiration, crop coefficient, leaf area index, FAO guide lines on evapotranspiration estimation.

**Unit VI:** Fundamentals of surface irrigation hydraulics, continuity equation, momentum equation

**Unit VII:** Hydrodynamic model, zero inertia model, kinematic wave model.

**Unit VIII:** Drainage principles, need for drainage, steady state equations, Hooghoudt, Kirkham, Dagan and Ernst equations.

**Unit IX:** Salt balance, water and salt balance of the root zone, salt equilibrium equation and leaching requirement, leaching efficiency.

**References:**

- Walker, W.R., and Skogerboe, G.V., "Surface Irrigation Theory and Practice", Prentice Hall, INC. 1987
- Drainage Principles and Applications, "International Institute for Land Reclamation and Improvement", Wageningen. 1973
  - Michael, A.M., "Irrigation: Theory and Practice", Vikas Publishing House. 1978
  - Asawa, G.L., "Irrigation Engineering", New Age International Publishers. 1996
  - Majumdar, D.K., "Irrigation Water Management", PHI Learning. 2009
  - Luthin, J.N., "Drainage Engineering", John Wiley. 1966

**PE-III COMPUTATIONAL METHODS IN FLUID MECHANICS**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OUTCOME**

- To analyse flow field in a variety of practical situations without going for physical model setup

**Syllabus Contents:**

**Unit I:** Review of numerical techniques like method of characteristics, finite difference method.

**Unit II:** Finite element method.

**Unit III:** Modelling of steady state flow and hydraulic transients in pipes.

**Unit IV:** Modelling of non-uniform, transient spatially varied flows in open channels.

**Unit V:** Numerical solutions for Navier-Stokes, boundary layer and Reynolds equations.

**Unit VI:** Modelling of groundwater flow and contaminant transport in groundwater.

**References:**

- Anderson, "Computational Fluid Mechanics and Heat Transfer", McGraw Hill. 1984
- Chung, T. J., "Finite Element Analysis in Fluid Dynamics", McGraw Hill. 1978
- Anderson, & Weessner, "Applied Groundwater Modelling", Academic Press. 1992
- Chaudhary, H. M., "Applied Hydraulic Transient", McGraw Hill. 1976
- Streeter and Wylie, "Fluid Transients", McGraw Hill. 1976
- Smith, G.D., "Numerical Solution of Partial Differential Equations-FDM". 1985

**PE-III THEORY AND APPLICATIONS OF GIS**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OBJECTIVE**

- To teach the principles and applications of remote sensing, GPS and GIS in the context of water resources. At the end of the course, the student will appreciate the importance of remote sensing and GIS in solving the spatial problems in water resources.

**COURSE OUTCOME**

- Introduce the technology and principles of Satellite Imaging
- Theoretical explanations on Image processing and information extraction from Satellite Data Products
- Functional elucidation of GIS integrating Satellite Data Products into the GIS platform for Decision making
- Potential of remote sensing and GIS is solving problems in water resources through case studies.

**Syllabus Contents:**

**Unit I:** Introduction, Geographical concepts and Terminology, Difference between Image Processing system and GIS, Utility of GIS.

**Unit II:** Various GIS packages and their salient features, Essentials components of GIS, Data acquisition through scanners and digitizers

**Unit III:** Raster and Vector Data: Introduction, Descriptions: Raster and Vector data, Raster Versus Vector, Raster to Vector conversion, Remote Sensing Data in GIS, Topology and Spatial Relationships, Data storage verification and editing

**Unit IV:** Data preprocessing, Georeferencing, Data compression and reduction techniques, Runlength encoding, Interpolation of data, Database Construction, GIS and the GPS, Data Output Database structure, Hierarchical data, Network systems, Relational database, Database management, Data manipulation and analysis

**Unit V:** Spatial and mathematical operations in GIS, Overlay, Query based, Measurement and statistical modelling, Buffers, Spatial Analysis, Statistical Reporting and Graphing

**Unit VI:** Programming languages in GIS, Virtual GIS, Web GIS

**Unit VII:** Application of GIS to various natural resources mapping and monitoring and engineering problems

**References:**

- Burrough, P.A. and Mc Donnel, R.A., “Principles of Geographic Information System”, Oxford University Press. 2000
- Chrisman, Nicholas R., “Exploring Geographic Information Systems”, John Wiley. 2002
- Demers, Michael N., “Fundamentals of Geographic Information System”, 2nd Ed. Wiley. 2008
- Ghosh, S.K. and Chandra, A.M., “Remote Sensing and GIS”, Narosa Publishing House. 2008
- Lo, C.P. and Young, A.K.W., “Concepts and Techniques of Geographical Information System”, Prentice Hall India. 2002
- Longley, Paul A, Goodchild, Michael F., Maguire, David J. and Rhind, David W., “Geographic Information Systems and Science”, Wiley. 2001

### PE-IV ENVIRONMENTAL HYDRAULICS

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OBJECTIVE**

- To apply the knowledge of fluid mechanics to analyze and predict mixing in natural bodies of water.
- To study the hydrodynamic aspects of water quality management in natural bodies of water.

**COURSE OUTCOME**

- The students will be able to gain a basic knowledge of advection-dispersion processes in the environment.
- They will gain the skills to take up research activities in solving environmental problems involving fluid motions.

**Syllabus Contents:**

**Unit I:** Introduction and scope, review of basic principles of engineering fluid mechanics, continuity, momentum, and energy equations, steady flow through pipes- hydraulic gradient and total energy line, basics of open channel flow; Ground water, well hydraulics, well design and constructions,

**Unit II:** Parallel, compound and equivalent pipes, head losses in pipes, design of pressurized conduits,

**Unit III:** Various forms of mixing in the environment, modeling of the mixing process:



advection dispersion equation, Various forms of advection dispersion eq. and its solution.

**Unit IV:** Special cases of mixing, density stratified flow, tide, etc.

**Unit V:** Mass transfer in gas-liquid and liquid -liquid system with special emphasis on aeration

**Unit VI:** Project presentation

**References:**

- Roberson, J.A., Cassidy, J.J., Chaudhry, M.H. “Hydraulic Engineering”, 2nd Edition, Wiley. 1998
- Chadwick, A., Morfett, J., Borthwick, M. “Hydraulics in Civil and Environmental Engineering”, 5th Edition, CRC Press. 2004
- Lee, C. C., Lin, S.D. “Handbook of Environmental Engineering Calculations”, McGraw Hill. 2007
- Schnoor, J.L., Environmental Modeling: Fate of Chemicals in Water, Air and Soil, John Wiley & Sons, New York. 1996

**PE-V COMPUTER METHODS IN HYDRAULICS AND HYDROLOGY**

**Teaching Scheme:**

Lectures: 3 hrs/ week

**COURSE OBJECTIVE**

- To develop skills of the students in software usage for simulation of various hydrologic and hydraulic processes

**COURSE OUTCOME**

- To be able to apply the computational knowledge in the field of water resources systems.

**Syllabus Contents:**

**Unit I:** Basic: Introduction to computer programming and computation with Matlab.

**Unit II:** Open channel flow: Estimation of normal and critical depth; uniform flow computations; computation of water surface profile (WSP) - gradually varied flow estimation using standard step and direct step methods, WSP in presence of hydraulic structures; unsteady flow - Saint-Venant equation, kinematic wave routing, diffusion routing, overland flow; steady and unsteady modelling using HEC-RAS.

**Unit III:** Groundwater hydrology: Solving groundwater flow equation - saturated and unsaturated flow, Richards’ equation, Green-Ampt infiltration model; introduction to MODFLOW.

**Unit IV:** Surface water hydrology: Estimation of Unit hydrographs; lumped and distributed flow routing; hydrologic statistics - parameter estimation, time series analysis, frequency analysis, geostatistics; hydrologic modelling using HEC-HMS/SWAT.

**Unit V:** Closed conduit flow: Steady and unsteady state modeling; pipe network analysis; introduction to EPANET.

**Unit VI:** Application of soft computing methods and GIS in Hydraulic and Hydrologic modeling.

**References:**

- Chow V.T., Maidment D.R. and Mays L.W. (1988), Applied Hydrology, McGraw-Hill. 1988
- Todd D.K. and Mays L.W. (2008), Groundwater Hydrology, 3rd Edition, John Wiley & Sons. 2008
- Chaudhry M.H. (2007), Open-Channel Flow, 2nd Edition, Springer, 2007
- Pratap R. (2010), Getting started with Matlab, Oxford. 2010
- P.K. Swamee and Sharma A.K. (2008), Design of water supply pipe networks, John Wiley & Sons. 2008

**Research Methodology and IPR**

**Teaching Scheme**

Lectures: 1hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**

- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.
- Asimov, “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

**Lab- I(Fluid Mechanics)**

Lab: 4 hrs/week

**List of Practicals:**

1. To study the surface profile and the total head distribution in a forced vortex flow.
2. To study the flow behavior in a pipe bend and to calibrate the pipe bend (i.e., bend or elbow meter) for discharge measurement.

3. To study the boundary layer velocity profile, and to determine the exponent in the power law of velocity distribution, boundary layer thickness and displacement thickness.
4. To study the velocity distribution in a pipe flow and to estimate the energy and momentum correction factors.
5. To study velocity distribution and Reynolds stresses in turbulent flow

### Lab-II Hydrology

Lab: 4 hrs/week

**List of Practicals:**

1. Downloading and processing of remote sensing products
2. The hands on experiments in the image processing, GIS platforms
3. Georeferencing of toposheet and creating vector layers(MapInfo/ArcGIS)
4. Creation of attribute tables and layout preparation (MapInfo/ArcGIS)
5. Creation of Digital Elevation Model using Vertical Mapper.
6. GPS Survey and its data transformation into GIS environment.
7. Converting \*.tab file to \*.shp& vice versa using Universal Translator.
8. Use of D8 pointer algorithm for deriving flow direction, flow accumulation and watersheddelineation.

### Lab-III Computational Fluid Dynamics

Lab: 4 hrs/week

**List of Practicals:**

Exposure to software's such as ANSYS, FLUENT, creation of Geometry, Mesh, description of boundary condition and solution of flow problems in 1D, 2D and 3D. typical examples should include flow around sphere, cylinders, bridge piers etc.

### Lab-IV Open Channel Flow

Lab: 4 hrs/week

**List of Practicals:**

1. To calibrate a broad-crested weir and study the pressure distribution at the upstream end of the weir.
2. To study the characteristics of a hydraulic jump.
3. To study the velocity distribution downstream of an expansion (with and without splitter plates) in a channel.
4. To obtain pressure distribution over spillway profile
5. To study energy dissipation using baffle blocks
6. To study air entrainment in open channel flow
7. To study the velocity distribution in an open channel and to estimate the energy and momentum correction factors.

## OPEN ELECTIVES

### Business Analytics

**Teaching scheme**

**Lecture: - 3 h/week**

|                      |                           |
|----------------------|---------------------------|
| <b>Course Code</b>   |                           |
| <b>Course Name</b>   | <b>Business Analytics</b> |
| <b>Credits</b>       |                           |
| <b>Prerequisites</b> |                           |

Total Number of Lectures: 48

|   |
|---|
| <b>Course objective</b>   |
| <ol style="list-style-type: none"> <li>1. Understand the role of business analytics within an organization.</li> <li>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.</li> <li>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.</li> <li>4. To become familiar with processes needed to develop, report, and analyze business data.</li> <li>5. Use decision-making tools/Operations research techniques.</li> <li>6. Manage business process using analytical and management tools.</li> <li>7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.</li> </ol> |

| <b>LECTURE WITH BREAKUP</b>   | <b>NO. OF LECTURES</b> |
|---|------------------------|
| <p><b>Unit1:</b></p> <p>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.</p> <p>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p> | 9                      |
| <p><b>Unit 2:</b></p> <p>Trendiness and Regression Analysis: Modelling Relationships and Trends in</p>  |                        |

|   |    |
|---|----|
| Data, simple Linear Regression.<br><br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.   | 8  |
| <b>Unit 3:</b><br><br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br><br>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.   | 9  |
| <b>Unit 4:</b><br><br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br><br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| <b>Unit 5:</b><br><br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.  | 8  |
| <b>Unit 6:</b><br><br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.   | 4  |

|   |  |
|---|--|
| <b>COURSE OUTCOMES</b>  |  |
| <ol style="list-style-type: none"> <li>1. Students will demonstrate knowledge of data analytics.</li> <li>2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.</li> <li>3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.</li> </ol> |  |

4. Students will demonstrate the ability to translate data into clear, actionable insights.

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

**OPEN ELECTIVES**  
**Industrial Safety**

**Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets,

Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

**OPEN ELECTIVES**  
**Operations Research**

**Teaching Scheme**

Lectures: 3 hrs/week

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**Course Outcomes:** At the end of the course, the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

**Open Elective**  
**Cost Management of Engineering Projects**



## Teaching scheme

**Lecture: - 3 h/week**

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Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

### References:

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## **Open Elective Composite Materials**

### Teaching scheme

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

**Open Elective  
Waste to Energy**

**Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for

thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

**AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING**

| <b>Course objectives:</b>  |  |       |
|--|--|-------|
| Students will be able to:  |  |       |
| <ol style="list-style-type: none"> <li>1. Understand that how to improve your writing skills and level of readability</li> <li>2. Learn about what to write in each section</li> <li>3. Understand the skills needed when writing a Title</li> </ol> |  |       |
| Ensure the good quality of paper at very first-time submission   |  |       |
| <b>Syllabus</b>  |  |       |
| Units  | CONTENTS   | Hours |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4     |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4     |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4     |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4     |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4     |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4     |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

### AUDIT 1 and 2: DISASTER MANAGEMENT

| <b>Course Objectives:</b> -Students will be able to:  |   |       |
|---|---|-------|
| 1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.  |   |       |
| 2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.  |   |       |
| 3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.   |   |       |
| 4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in |   |       |
| <b>Syllabus</b>   |   |       |
| Units   | CONTENTS  | Hours |
| 1   | <b>Introduction</b><br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.  | 4     |
| 2   | <b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4     |
| 3   | <b>Disaster Prone Areas In India</b><br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics  | 4     |
| 4   | <b>Disaster Preparedness And Management</b><br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.   | 4     |
| 5   | <b>Risk Assessment</b><br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.   | 4     |
| 6   | <b>Disaster Mitigation</b><br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of   | 4     |

|  |                               |  |
|--|-------------------------------|--|
|  | Disaster Mitigation In India. |  |
|--|-------------------------------|--|

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies” ,Deep &Deep Publication Pvt. Ltd., New Delhi.

**AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE****Course Objectives**

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

**Syllabus**

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul>          | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8     |

**Suggested reading**

1. “Abhyaspustakam” – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

**Course Output**

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

**AUDIT 1 and 2: VALUE EDUCATION**

### **Course Objectives**

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

### **Syllabus**

| <b>Unit</b> | <b>Content</b>   | <b>Hours</b> |
|-------------|--|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul>  | 4            |
| 2           | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty, Humanity. Power of faith, National Unity.</li> <li>• Patriotism. Love for nature ,Discipline</li> </ul>   | 6            |
| 3           | <ul style="list-style-type: none"> <li>• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> <li>• Doing best for saving nature</li> </ul> | 6            |
| 4           | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality,Nonviolence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind, Self-control.</li> <li>• Honesty, Studying effectively</li> </ul>   | 6            |

### **Suggested reading**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

### **Course outcomes**

Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

| <p><b>Course Objectives:</b><br/>                 Students will be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</li> <li>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ol> |  |       |
|---|--|-------|
| <b>Syllabus</b>   |  |       |
| Units   | Content  | Hours |
| 1   | <ul style="list-style-type: none"> <li>• <b>History of Making of the Indian Constitution:</b></li> <li>History</li> <li>Drafting Committee, ( Composition &amp; Working)</li> </ul>  | 4     |
| 2   | <ul style="list-style-type: none"> <li>• <b>Philosophy of the Indian Constitution:</b></li> <li>Preamble</li> <li>Salient Features</li> </ul>  | 4     |
| 3   | <ul style="list-style-type: none"> <li>• <b>Contours of Constitutional Rights &amp; Duties:</b></li> <li>• Fundamental Rights</li> <li>• Right to Equality</li> <li>• Right to Freedom</li> <li>• Right against Exploitation</li> <li>• Right to Freedom of Religion</li> <li>• Cultural and Educational Rights</li> <li>• Right to Constitutional Remedies</li> <li>• Directive Principles of State Policy</li> <li>• Fundamental Duties.</li> </ul>  | 4     |
| 4   | <ul style="list-style-type: none"> <li>• <b>Organs of Governance:</b></li> <li>• Parliament</li> <li>• Composition</li> <li>• Qualifications and Disqualifications</li> <li>• Powers and Functions                             <ul style="list-style-type: none"> <li>• Executive</li> </ul> </li> <li>• President</li> <li>• Governor</li> <li>• Council of Ministers</li> <li>• Judiciary, Appointment and Transfer of Judges, Qualifications</li> <li>• Powers and Functions</li> </ul>   | 4     |
| 5   | <ul style="list-style-type: none"> <li>• <b>Local Administration:</b></li> <li>• District's Administration head: Role and Importance,</li> <li>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.</li> <li>• Pachayati raj: Introduction, PRI: Zila Pachayat.</li> <li>• Elected officials and their roles, CEO Zila Pachayat: Position and role.</li> <li>• Block level: Organizational Hierarchy (Different departments),</li> <li>• Village level: Role of Elected and Appointed officials,</li> </ul> | 4     |

|          |  |   |
|----------|--|---|
|          | <ul style="list-style-type: none"> <li>• Importance of grass root democracy</li> </ul>   |   |
| <b>6</b> | <ul style="list-style-type: none"> <li>• <b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul> | 4 |

### Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

### Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGY STUDIES

| <b>Course Objectives:</b><br>Students will be able to: <ol style="list-style-type: none"> <li>4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.</li> <li>5. Identify critical evidence gaps to guide the development.</li> </ol> |  |       |
|---|--|-------|
| <b>Syllabus</b>   |  |       |
| Units   | Content  | Hours |
| <b>1</b>  | <ul style="list-style-type: none"> <li>• <b>Introduction and Methodology:</b></li> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> <li>• Overview of methodology and Searching.</li> </ul>                           | 4     |
| <b>2</b>  | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>   | 2     |
| <b>3</b>  | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> </ul> | 4     |



|          |  |   |
|----------|--|---|
|          | <ul style="list-style-type: none"> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers’ attitudes and beliefs and Pedagogic strategies.</li> </ul>  |   |
| <b>4</b> | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul> | 4 |
| <b>5</b> | <ul style="list-style-type: none"> <li>• <b>Research gaps and future directions</b></li> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> <li>• Dissemination and research impact.</li> </ul>  | 2 |

### Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal Educational Development*, 33 (3): 272–282.
5. Alexander RJ (2001) *Culture and pedagogy: International comparisons in primary education*. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, ‘learning to read’ campaign.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf).

### Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

### Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

### Syllabus

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> </ul> Do`s and Don`t`s in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan   | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> </ul> i) Various yog poses and their benefits for mind & body<br>ii) Regularization of breathing techniques and its effects-<br>Types of pranayam | 8     |

### Suggested reading

1. ‘Yogic Asanas for Group Training-Part-I’ : Janardan Swami Yogabhyasi Mandal, Nagpur

2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

**AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH  
LIFE ENLIGHTENMENT SKILLS**

**Course Objectives**

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

**Syllabus**

| Unit | Content   | Hours |
|------|---|-------|
| 1    | Neetisatakam-Holistic development of personality <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont’s)</li> <li>• Verses- 71,73,75,78 (do’s)</li> </ul>  | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>   | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17,Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8     |

**Suggested reading**

1. “Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

MODEL CURRICULUM  
of  
Engineering & Technology PG Courses

# MECHANICAL



**ALL INDIA COUNCIL FOR TECHNICAL EDUCATION**  
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070  
[www.aicte-india.org](http://www.aicte-india.org)

**M. Tech. (Mechanical Engineering) Specialization: Design Engineering****Semester I**

| <b>Sr. No.</b> | <b>Course Type/Code</b>             | <b>Course Name</b>  |
|----------------|-------------------------------------|---|
| 1.             | Core-I                              | Advanced Stress Analysis  |
| 2.             | Core-II                             | Advanced Vibrations and Acoustics   |
| 3.             | Programme Elective-I<br>*See Notes  | 1. Advanced Machine Design<br>2. Design for Manufacturing and Assembly<br>3. Mathematical Methods in Engineering    |
| 4.             | Programme Elective-II<br>*See Notes | 1. Advanced Engineering Materials<br>2. Mechanics of Composite Materials<br>3. Analysis and Synthesis of Mechanisms |
| 5.             | Core                                | Lab-I   |
| 6.             | Core                                | Lab-II  |
| 7.             | Core                                | Research Methodology and IPR  |
| 8.             | Audit                               | Audit Course - 1  |

**Semester II**

| <b>Sr. No.</b> | <b>Course Code/Type</b> | <b>Course Name</b>                    |
|----------------|-------------------------|---------------------------------------|
| 1.             | Core-III                | Finite Element Method                 |
| 2.             | Core-IV                 | Computer Aided Design                 |
| 3.             | Programme Elective-III  | 1. Tribology in Design<br>2. Robotics |

|    |                                     |   |
|----|-------------------------------------|---|
|    | *See Notes                          | 3. Fracture Mechanics   |
| 4. | Programme Elective-IV<br>*See Notes | 1. Multi-body Dynamics<br>2. Condition Based Monitoring<br>3. Optimization Techniques in Design |
| 5. | Core                                | Lab-III   |
| 6. | Core                                | Lab-IV  |
| 7. | Audit                               | Audit -2  |
| 8. | Core                                | Mini-Project  |

### Semester III

| Sr. No. | Course Code                         | Course Name   |
|---------|-------------------------------------|---|
| 1.      | Programme-Elective-V<br>* See Notes | 1. Advanced Finite Element Method<br>2. Advanced Metallurgy   |
| 2.      | Open Elective                       | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3.      | Dissertation                        | Dissertation Phase – I  |

### Semester IV

| Sr. No. | Course Code  | Course Name             |
|---------|--------------|-------------------------|
| 1.      | Dissertation | Dissertation Phase - II |

#### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**Model Curriculum for PG Programme in M. Tech. Mechanical Engineering Specialization:  
Thermal Engineering**

L – Theory lecture, T – Tutorial; P – lab work: Numbers under teaching scheme indicate contact clock hours

Curriculum Structure – Semester-wise

| Semester I   |                                     |  |                 |           |          |           |
|--------------|-------------------------------------|--|-----------------|-----------|----------|-----------|
| Sr. No.      | Course Type/Code                    | Course Name  | Teaching Scheme |           |          | Credits   |
|              |                                     |  | L               | T         | P        |           |
| 1.           | Core-I                              | Thermodynamics and Combustion                                    | 3               | --        | --       | 3         |
| 2.           | Core-II                             | Advanced Fluid Dynamics  | 3               | --        | --       | 3         |
| 3.           | Programme Elective-I<br>*See Notes  | 1. Nuclear Engineering<br>2. Energy Conservation and Management. | 3               | --        | --       | 3         |
| 4.           | Programme Elective-II<br>*See Notes | 1. Air Conditioning System Design<br>2. Gas Turbines             | 3               | --        | --       | 3         |
| 5.           | Core                                | Lab-I Thermal Engineering Lab Practice-I                         | --              | --        | 4        | 2         |
| 6.           | Core                                | Lab-II Thermal Engineering Lab Practice-II                       | --              | --        | 4        | 2         |
| 7.           | Core                                | Research Methodology and IPR                                     | 2               | --        | --       | 2         |
| 8.           | Audit                               | Audit Course - 1   | 2               | --        | --       | 0         |
| <b>Total</b> |                                     |  | <b>16</b>       | <b>--</b> | <b>8</b> | <b>18</b> |



| Semester II  |                                      |   |                 |           |           |           |
|--------------|--------------------------------------|---|-----------------|-----------|-----------|-----------|
| Sr. No.      | Course Code/Type                     | Course Name   | Teaching Scheme |           |           | Credits   |
|              |                                      |   | L               | T         | P         |           |
| 1.           | Core-III                             | Advanced Heat Transfer  | 3               | --        | --        | 3         |
| 2.           | Core-IV                              | Steam Engineering   | 3               | --        | --        | 3         |
| 3.           | Programme Elective-III<br>*See Notes | 1. Refrigeration and cryogenics<br>2. Design of Heat Exchangers | 3               | --        | --        | 3         |
| 4.           | Programme Elective-IV<br>*See Notes  | 1. Computational Fluid Dynamics<br>2. Modelling of IC Engines   | 3               | --        | --        | 3         |
| 5.           | Core                                 | Lab-III Thermal Engineering -III                                | --              | --        | 4         | 2         |
| 6.           | Core                                 | Lab-IV Thermal Engineering-IV                                   | --              | --        | 4         | 2         |
| 7.           | Audit                                | Audit- 2  | 2               | --        | --        | 0         |
| 8.           | Core                                 | Mini-Project  | --              | --        | 4         | 2         |
| <b>Total</b> |                                      |   | <b>14</b>       | <b>--</b> | <b>12</b> | <b>18</b> |

| Semester III |                                     |   |                 |           |           |           |
|--------------|-------------------------------------|---|-----------------|-----------|-----------|-----------|
| Sr. No.      | Course Code                         | Course Name   | Teaching Scheme |           |           | Credits   |
|              |                                     |   | L               | T         | P         |           |
| 1.           | Programme-Elective-V<br>* See Notes | 1. Design of Solar and Wind System<br>2. Advanced Mathematical Methods in Engineering   | 3               | --        | --        | 3         |
| 2.           | Open Elective                       | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3               | --        | --        | 3         |
| 3.           | Dissertation                        | Dissertation Phase – I  | --              | --        | 20        | 10        |
| <b>Total</b> |                                     |   | <b>6</b>        | <b>--</b> | <b>--</b> | <b>16</b> |

| <b>Semester-IV</b> |                    |                         |                        |           |           |                |
|--------------------|--------------------|-------------------------|------------------------|-----------|-----------|----------------|
| <b>Sr. No.</b>     | <b>Course Code</b> | <b>Course Name</b>      | <b>Teaching Scheme</b> |           |           | <b>Credits</b> |
|                    |                    |                         | <b>L</b>               | <b>T</b>  | <b>P</b>  |                |
| 1.                 | Dissertation       | Dissertation Phase - II | --                     | --        | 32        | 16             |
| <b>Total</b>       |                    |                         | <b>--</b>              | <b>--</b> | <b>32</b> | <b>16</b>      |

Total Credits for the programme = 18 + 18 + 16 + 16 = **68**

\*Notes:

1. List of programme electives is indicative. The University may decide this depending on facilities and expertise available with them. But the number of courses under this list must be as large as possible with minimum three being offered at beginning of any semester out of which a student would choose any one.
2. Lab sessions may be conducted for core courses of individual semesters as shown in the structure but marks of evaluation will be reported as consolidated under single head.

Contents of the courses listed in the structure are given on following pages

#### **Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

### **Thermodynamics and Combustion**

#### **Teaching Scheme**

Lectures: 3 hrs/week

#### **Course Outcomes:**

At the end of the course:

1. Student will get Knowledge of exergy, basic laws governing energy conversion in multi-component systems and application of chemical thermodynamics.
2. Student will be aware about advanced concepts in thermodynamics with emphasis on thermodynamic relations, equilibrium and stability of multiphase multi-component

systems.

3. Student will be aware about the molecular basis of thermodynamics.
4. To present theoretical, semi-theoretical and empirical models for the prediction of thermodynamic properties.
5. Student will be acquire the confidence in analyze the motion of combusting and non-combusting fluids whilst accounting for variable specific heats, non-ideal gas properties, chemical non-equilibrium and compressibility
6. Student should apply the fundamental principles of thermodynamics to non-ideal models of numerous engineering devices
7. Student can use a systems approach to simplify a complex problem

### Syllabus Contents:

- First law and State postulates, Second law and Entropy, Availability and Irreversibility, Transient flow analysis
- Nonreactive Ideal-Gas Mixture, PvT Behavior of Real gases and Real Gas mixture
- Generalized Thermodynamic Relationship
- Combustion and Thermo-chemistry, Second law analysis of reacting mixture, Availability analysis of reacting mixture, Chemical equilibrium
- Statistical thermodynamics, statistical interpretations of first and second law and Entropy,
- Third law of thermodynamics, Nerst heat theorem.

### References:

1. Cengel, "Thermodynamics", Tata McGraw Hill Co., New Delhi, 1980.
2. Howell and Dedcius, "Fundamentals of Engineering Thermodynamics", McGraw Hill Inc., U.S.A.
3. Van Wylen & Sonntag, "Thermodynamics", John Wiley and Sons Inc., U.S.A.
4. Jones and Hawkings, "Engineering Thermodynamics", John Wiley and Sons Inc., U.S.A, 2004.
5. Holman, "Thermodynamics", McGraw Hill Inc., New York, 2002.
6. Faires V.M. and Simmag, "Thermodynamics", Macmillan Publishing Co. Inc., U.S.A.
7. Rao Y.V.C., "Postulational and Statistical Thermodynamics", Allied Publishers Inc, 1994.

## Advanced Fluid Dynamics

### Teaching Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of the course:

1. The Students shall be able to understand and define the fluid flow problems along with range of governing parameters
2. The student shall be eligible to take up the fluid flow problems of industrial base.
3. The students shall be able to devise the experiments in the field of fluid mechanics.

4. The Students shall be able understand the flow patterns and differentiate between the flow regimes and its effects.

**Syllabus Contents:**

- Governing equations in Fluid Dynamics: Derivation of Continuity and Momentum equations using integral and differential approach, dimensionless form of governing equations, special forms of governing equations, integral quantities
- Exact Solutions of Navier-Stokes Equations: Fully developed flows, parallel flow in straight channel, Couette flow, Creeping flows
- Potential Flow: Kelvin's theorem, Irrotational flow, Stream function-vorticity approach,
- Laminar Boundary layers: Boundary layer equations, flow over flat plate, Momentum integral equation for boundary layer, approximate solution methodology for boundary layer equations
- Turbulent Flow: Characteristics of turbulent flow, laminar turbulent transition, time mean motion and fluctuations, derivation of governing equations for turbulent flow, shear stress models, universal velocity distribution
- Experimental Techniques: Role of experiments in fluid, layout of fluid flow experiments, sources of error in experiments, data analysis, design of experiments, review of probes and transducers, Introduction to Hot wire Anemometry, Laser Doppler Velocimetry and Particle Image Velocimetry

**References:**

1. Muralidhar and Biswas, Advanced Engineering Fluid Mechanics, , Alpha Science International, 2005
2. Irwin Shames, Mechanics of Fluids, , McGraw Hill, 2003
3. Fox R.W., McDonald A.T , Introduction to Fluid Mechanics, John Wiley and Sons Inc, 1985
4. Pijush K. Kundu, Ira M Kohen and David R. Dawaling, Fluid Mechanics, Fifth Edition, 2005

**Nuclear Engineering**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course:

1. Student will understand the basic concepts and processes taking place inside a nuclear reactor, such as nuclear fission, neutron production, scattering, diffusion, slowing down

and absorption.

2. The student will also be familiar with concepts of reactor criticality, the relationship between the dimension and fissile material concentration in a critical geometry.
3. The student will also be familiar with Time dependent (transient) behaviour of power reactor in non-steady state operation and the means to control the reactor.
4. The student will also be familiar with concepts of heat removal from reactor core, reactor safety and radiation protection.

### Syllabus Contents:

- **Basics of nuclear fission and power from fission**

Radioactivity, nuclear reactions, cross sections, nuclear fission, power from fission, conversion and breeding

- **Neutron transport and diffusion**

Neutron transport equation, diffusion theory approximation, Fick's law, solutions to diffusion equation for point source, planar source, etc., energy loss in elastic collisions, neutron slowing down

- **Multigroup, multiregion diffusion equation, concept of criticality**

Solution of multigroup diffusion equations in one region and multiregion reactors, concept of criticality of thermal reactors

- **Reactor kinetics and control**

Derivation of point kinetics equations, inhour equation, solutions for simple cases of reactivity additions, fission product poison, reactivity coefficients

- **Heat removal from reactor core**

Solution of heat transfer equation in reactor core, temperature distribution, critical heat flux

- **Reactor safety, radiation protection**

Reactor safety philosophy, defence in depth, units of radioactivity exposure, radiation protection standards

### References:

1. Introduction to Nuclear Engineering (3rd Edition) by John R. Lamarsh, Anthony J. Barrata, Prentice Hall, (2001)
2. Introduction to Nuclear Reactor Theory, by John R. Lamarsh, Addison-Wesley, 1966)
3. Nuclear Reactor Analysis, by James J. Duderstadt and Lewis J. Hamilton, John Wiley(1976)

## Energy Conservation and Management

### Teaching Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of the course:

1. The student should acquire insight about the importance of energy
2. The student should be capable to analyze all scenarios from energy consumption
3. The student should generate scenarios of energy consumption and predict the future trend
4. The student should suggest and plan energy conservation solutions

#### **Syllabus Contents:**

- The energy market, energy scenario, planning, utilization pattern and future strategy, Importance of energy management.
- Energy auditing- methodology and analysis,
- Energy economics,
- Energy conservation in industries, Cogeneration, Combined heating and power systems,
- Relevant international standards and laws.

#### **References:**

1. L.C. Witte, P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilization", Hemispherical Publication, 1988.
2. Callaghan "Energy Conservation".
3. D.A. Reeg, "Industrial Energy Conservation", Pergamon Press, 1980.
4. T.L. Boyen, "Thermal Energy Recovery" Wiley, 1980.
5. L.J. Nagrath, "Systems Modeling and Analysis", Tata McGraw Hill, 1982.
6. W.C. Turner, "Energy Management Handbook", Wiley, New York, 1982.
7. I.G.C. Dryden, "The Efficient Use of Energy", Butterworth, London, 1982.
8. R. Loftner, Van Nostrand Reinhold C. "Energy Handbook", 1978.
9. TERI Publications.

### **Air conditioning system Design**

#### **Teaching Scheme**

Lectures: 3 hrs/week

#### **Course Outcomes:**

At the end of the course:

1. Student should understand construction and design features Air-conditioning system.

2. Student should understand various types and its adoptability in the various environment and application areas.
3. Student should understand various health issues
4. Student should design seasonal energy efficient system

#### **Syllabus Contents:**

- Air conditioning systems,
- various air-conditioning processes,
- Enthalpy deviation curve, psychrometry , SHF, dehumidified air quantity, human comfort, indoor air quality,
- Design conditions and load calculations, air distribution, pressure drop, duct design, fans & blowers,
- Performance & selection, noise control.

#### **References:**

1. ASHRAE Handbook.
2. "Handbook of air-conditioning system design", Carrier Incorporation, McGraw Hill Book Co.,
3. U.S.A, 1965.
4. "Refrigeration and air-conditioning", ARI, Prentice Hall, New Delhi, 1993.
5. Norman C. Harris, "Modern Air Conditioning", New York, McGraw-Hill, 1974.
6. Jones W.P., "Air Conditioning Engineering", Edward Arnold Publishers Ltd., London, 1984.
7. Hainer R.W., "Control Systems for Heating, Ventilation and Air-Conditioning", Van Nostrand
8. Reinhold Co., New York, 1984. 7. Arora C.P., "Refrigeration & Air Conditioning", Tata Mc Graw Hill, 1985.
9. Manohar Prasad, "Refrigeration & Air Conditioning", New Age Publishers.
10. Stoecker, "Refrigeration & Air Conditioning", Mc Graw Hill, 1992.
11. 10. Stoecker, "Design of Thermal Systems", Mc Graw Hill, 1992.

## **Gas Turbines**

### **Teaching Scheme**

Lectures: 3 hrs/week

#### **Course Outcomes:**

At the end of the course:

1. Student should understand construction and design features of gas turbines as used for

power generation.

2. Student should understand thermodynamics cycles a, and different sizes and layouts of gas turbine plant
3. Able to understand thermodynamics and fluid mechanics component for enhancing the efficiency and effectively of gas turbines

**Syllabus Contents:**

- Introduction, Cycles, Performance characteristics and improvement,
- Gas dynamics, Centrifugal, axial and mixed flow compressor, principles and characteristics, Turbine construction, Blade materials, manufacturing techniques, blade fixing,
- Problems of high temperature operation, blade cooling, practical air cooled blades Combustion Systems, various fuels and fuel systems,
- Jet propulsion cycles and their analysis, parameters affecting performance, thrust augmentation, environmental considerations and applications.

**References:**

1. H Cohen, GFC Rogers and HIH Saravanamuttoo, “Gas Turbine Theory”, Pearson Education, 2000.
2. V. Ganesan, “Gas Turbines”, Tata McGraw Hill, 2003.
3. S.M.Yahya “Turbines, Compressors and Fans”, Tata McGraw Hill, 1992.
4. Vincent “The theory and design of Gas Turbine and Jet Engines”, McGraw Hill, 1950.
5. W W Bathic, “Fundamentals of Gas Turbines”, John Wiley and Sons.

**Research Methodology and IPR**

**Teaching Scheme**

Lectures: 1hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.



- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

### Syllabus Contents:

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

### References:

- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2 nd Edition, “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.

- Asimov, “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

## Advanced Heat Transfer

### Teaching Scheme

### Examination Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

At the end of the course:

1. The students are expected to understand the subject of Heat Transfer in detail with capability to solve Industrial Problems. This will also create the base and interest among the students to carry out the Future Research

#### Syllabus Contents:

- Conduction- one and two dimensional,
- Fins, conduction with heat source, unsteady state heat transfer,
- Natural and forced convection, integral equation, analysis and analogies,
- Transpiration cooling, ablation heat transfer, boiling, condensation and two phase flow mass transfer, cooling, fluidized bed combustion,
- Heat pipes, Radiation, shape factor, analogy, shields,
- Radiation of gases & vapours.

#### References:

1. J.P. Holman, "Heat Transfer", McGraw Hill Book Company, New York, 1990.
2. Incropera and Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, New York, 2000.
3. Frank Kreith, "Principles of Heat Transfer", Harper and Row Publishers, New York, 1973.
4. Donald Q. Kern "Process Heat Transfer", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1975.
5. Gupta and Prakash, "Engineering Heat Transfer", New Chand and Bros, Roorkee (U.P.) India, 1996.
6. R.C. Sachdeva "Fundamentals of Engineering Heat and Mass Transfer", Wiley Eastern Ltd., India,

## Steam Engineering

### Teaching Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of the course:

1. Students will have the ability to explain working of different boilers and significance of mountings and accessories.
2. Students will have the ability to use techniques, skills, and modern engineering tools necessary for boiler performance assessment.
3. Students will have a theoretical and practical background in thermal systems, and will have a good understanding of energy conservation fundamentals. Students will have the ability to analyze thermal systems for energy conservation.
4. Students will have the ability to design a steam piping system, its components for a process and also design economical and effective insulation.
5. Students will have the ability to analyze a thermal system for sources of waste heat design a systems for waste heat recovery.
6. Students will have the ability to design and develop controls and instrumentation for effective monitoring of the process.

Syllabus Contents:

- Introduction (7 hrs)  
Fundamentals of steam generation, Quality of steam, Use of steam table, Mollier Chart Boilers ,Types, Mountings and Accessories, Combustion in boilers, Determination of adiabatic flame temperature, quantity of flue gases, Feed Water and its quality, Blow down; IBR, Boiler standards
- Piping & Insulation (8 hrs)  
Water Line, Steam line design and insulation; Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria, Refractory-types, selection and application of refractory, Heat loss.
- Steam Systems (8 hrs)  
Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Steam Engineering Practices; Steam Based Equipments / Systems.
- Boiler Performance Assessment (8hrs)  
Performance Test codes and procedure, Boiler Efficiency, Analysis of losses; performance evaluation of accessories; factors affecting boiler performance.
- Energy Conservation and Waste Minimization,(5hrs)  
Energy conservation options in Boiler; waste minimization, methodology; economical viability of waste minimization
- Instrumentation & Control (6hrs)  
Process instrumentation; control and monitoring. Flow, pressure and temperature measuring and controlling instruments, its selection

### References:

1. T. D. Estop, A. McConkey, Applied Thermodynamics, Parson Publication
2. Domkundwar; A Course in Power Plant Engineering; Dhanapat Rai and Sons
3. Yunus A. Cengel and Boles, "Engineering Thermodynamics ",Tata McGraw-Hill Publishing Co. Ltd
4. Book II - Energy Efficiency in Thermal Utilities; Bureau of Energy Efficiency
5. Book IV - Energy Performance Assessment for Equipment & Utility Systems; Bureau of Energy Efficiency
6. Edited by J. B. Kitto & S C Stultz; Steam: Its Generation and Use; The Babcock and Wilcox Company
7. P. Chatopadhyay; Boiler Operation Engineering: Questions and Answers; Tata McGrawHill Education Pvt Ltd, N Delhi

## Refrigeration and Cryogenics

### Teaching Scheme

Lectures: 3 hrs/week, Tutorial: 1hr/week

### Course Outcomes:

At the end of the course, students will demonstrate the ability:

1. To learn the basics of refrigeration and cryogenics and its application area.
2. To design the refrigeration systems for domestic and industrial applications like cold storages
3. To learn about ODP, GWP and related environment issues

### Syllabus Contents:

- Vapour compression refrigeration, actual cycle, second law efficiency,
- Multistage compression with inter-cooling, Multi-evaporator systems, Cascade systems,
- Performance characteristics and capacity control of reciprocating and centrifugal compressors, screw compressor and scroll compressor,
- Design, selection of evaporators, condensers, control systems, motor selection,
- Refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations,
- Refrigeration applications, food preservation, transport,
- Introduction to Vapor absorption refrigeration, single effect and double effect systems,
- Gas liquefaction systems - Linde-Hampson, Linde dual pressure, Claude cycle.

**References:**

1. R.J.Dossat, “Principles of Refrigeration”, Pearson Education Asia, 2001.
2. C.P.Arora, “Refrigeration and Air-conditioning”, Tata McGraw-Hill, 2000.
3. Stoecker & Jones, “Refrigeration and Air-conditioning”, McGraw Hill Book Company, New York, 1982.
4. Jordan & Priester, “Refrigeration and Air-conditioning”.
5. A.R.Trott, “Refrigeration and Air-conditioning”, Butterworths, 2000.
6. J.L.Threlkeld, “Thermal Environmental Engineering”, Prentice Hall, 1970.
7. R.Barron, “Cryogenic systems”, McGraw–Hill Company, New Yourk, 1985.
8. G.G.Hasseldon. “Cryogenic Fundamentals”, Academic Press.
9. Bailey, “Advanced Cryogenics”, Plenum Press, London, 1971.
10. W.F.Stoecker, “Industrial Refrigeration Handbook”, McGraw-Hill, 1998.
11. John A.Corinchock, “Technician’s Guide to Refrigeration systems”, McGrawHill.
12. P.C.Koelet, “Industrial Refrigeration: Principles, Design and Applications”, Macmillan, 1992.
13. ASHRAE HANDBOOKS (i) Fundamentals (ii) Refrigeration.
14. Graham Walker, “Miniature Refrigerators for Cryogenic Sensors and Cold Electronics”, Clarendon Press, 1989

**Design of Heat Exchangers**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course:

1. Students will demonstrate a basic understanding of several types of heat exchangers that will include shell-and-tube, double pipe, plate-and-frame, finned tube, and plate-fin heat exchangers, Heat pipes.
2. Students will design and analyses of shell-and-tube double pipe, compact, plate heat exchangers.
3. Students will demonstrate the performance degradation of heat exchangers subject to fouling.

**Syllabus Contents:**

- Heat Exchangers – Classification according to transfer process, number of fluids, surface compactness, and construction features. Tubular heat exchanger, plate type heat exchangers, extended surface heat exchangers, heat pipe, Regenerators. Classification according to flow arrangement: counter flow, parallel flow, cross flow exchanger.
- Heat exchanger design methodology, assumption for heat transfer analysis, problem

formulation,  $e$ -NTU method,  $P$ -NTU method, Mean temperature difference method, fouling of heat exchanger, effects of fouling, categories of fouling, fundamental processes of fouling.

- Double Pipe Heat Exchangers: Thermal and Hydraulic design of inner tube, Thermal and hydraulic analysis of Annulus, Total pressure drop
- Compact Heat Exchangers: Thermal and Hydraulic design of compact heat exchanger
- Shell and Tube heat exchangers – Tinker’s, kern’s, and Bell Delaware’s methods, for thermal and hydraulic design of Shell and Tube heat exchangers
- Mechanical Design of Heat Exchangers – design standards and codes, key terms in heat exchanger design, material selection, and thickness calculation for major components such as tube sheet, shell, tubes, flanges and nozzles. Introduction to simulation and optimization of heat exchangers, flow induced vibrations.

#### References:

1. Ramesh K. Shah and Dusan P. Sekulic, “Fundamentals of Heat Exchanger Design” John Wiley & sons Inc., 2003.
2. D.C. Kern, “Process Heat Transfer”, McGraw Hill, 1950.
3. Sadik Kakac and Hongton Liu, “Heat Exchangers: Selection, Rating and Thermal Design” CRC Press, 1998.
4. A .P. Frass and M.N. Ozisik, “Heat Exchanger Design”, McGraw Hill, 1984
5. Afgan N. and Schlinder E.V. “Heat Exchanger Design and Theory Source Book”.
6. T. Kuppan, “Hand Book of Heat Exchanger Design”.
7. “T.E.M.A. Standard”, New York, 1999.
8. G. Walkers, “Industrial Heat Exchangers-A Basic Guide”, McGraw Hill, 1982.

## Computational Fluid Dynamics

### Teaching Scheme

### Examination Scheme

Lectures: 3 hrs/week, Tutorial :1hr/week

#### Course Outcomes:

At the end of the course:

1. The students are expected to understand the subject of Computational Fluid Dynamics and know how to use it as tool to solve the Heat Transfer and Fluid Mechanics related Industrial Problems. This will also create the base and interest among the students to carry out the Future Research.

### Syllabus Contents:

- **Introduction to CFD:** Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations.
- **Governing Equations:** Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.
- **Finite Volume Method:** Domain discretization, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach
- **Geometry Modeling and Grid Generation:** Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance
- **Methodology of CFDHT:** Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation
- **Solution of N-S Equations for Incompressible Flows:** Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows

### References:

1. Computational Fluid Dynamics, The Basic with applications by John A. Anderson, Jr., McGraw Hill International editions, Mechanical Engineering series.
2. Numerical Methods in Fluid Flow & Heat Transfer by Dr. Suhas Patankar.
3. An Introduction to Computational Fluid Flow (Finite Volume Method), by H.K. Versteeg, W.Malalasekera, Printice Hall
4. Computational Methods for Fluid Dynamics by Ferziger and Peric, Springer Publication.
5. An Introduction to Computational Fluid Mechanics by Chuen-Yen Chow, Wiley Publication.
6. Computational Fluid Flow & Heat Transfer by Murlidhar and Sundarrajan, Narosa Publication.

## Modelling of IC Engine

### Teaching Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of the course:

1. Students will demonstrate a basic understanding of several types of engine models that will include zero dimensional thermodynamic model, one dimensional and multi-dimensional, single zone, two zone etc models.
2. Students will develop models and simulate them for diesel engine petrol engine, gas engine.
3. Students will demonstrate the performance evaluation and emission standards for such modeled engines



### Syllabus Contents:

- **Fundamentals:** Governing equations, Equilibrium charts of combustion chemistry, chemical reaction rates, and approaches of modeling, model building and integration methods, gas exchange through valves, engine and porting geometry, exhaust gas recirculation, valve lift curves.
- **Thermodynamic Combustion Models of CI Engines:** Single zone models, premixed and diffusive combustion models, combustion heat release using wiebe function, wall heat transfer correlations, ignition delay, internal energy estimations, two zone model, application of heat release analysis.
- **Fuel spray behavior:** Fuel injection, spray structure, fuel atomization, droplet turbulence interactions, droplet impingement on walls.
- *Modeling of charging system:* Constant pressure and pulse turbo charging, compressor and turbine maps, charge air cooler.
- **Mathematical models of SI Engines:** Simulation of Otto cycle at full throttle, part throttle and supercharged conditions. Progressive combustion, Autoignition modeling, single zone models, mass burning rate estimation, SI Engine with stratified charge. Friction in pumping, piston assembly, bearings and valve train etc. friction estimation for warm and warm up engines.

### References:

1. Haywood, "I.C. Engines", Mc Graw Hill.
2. Ramos J (1989) Internal Combustion Engine Modeling. Hemisphere Publishing Company
3. C. D. Rakopoulos and E. G. Giakoumis, "Diesel Engine Transient
4. Operation Principles of Operation and Simulation Analysis", Springer, 2009.
5. V. Ganeshan, "Internal Combustion Engines", Tata McGraw Hill, New Delhi, 1996.
6. P.A. Lakshminarayanan and Y. V. Aghav, "Modelling Diesel Combustion" Springer, 2010
7. Bernard Challen and Rodica Baranescu, "Diesel Engine Reference Book" Butterworth-Heinemann, 1999.

## (DCE-III) Design of Solar and Wind Systems

### Teaching Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of the course:

1. Student should update about the technological status of implementation of NCES in India
2. Student should capable to analyze various techno economical obstacles in the commercial development of NCES in India
3. Student should capable to conceptually model and design general NCES systems and predict the long term performance.

4. Student should suggest and plan hybrid NCES solutions to conventional energy systems

**Syllabus Contents:**

- Conventional sources of energy, Nuclear, Alternative energy sources,
- Solar Radiation-estimation, prediction & measurement, Solar energy utilization,
- Performance of Solar flat plate collectors, concentrating collectors, thermal storage,
- Wind energy, Direct Energy conversion- PV, MHD,
- Fuel cells, thermionic, thermoelectric, Biomass, biogas, hydrogen, Geothermal.

**References:**

1. D.Y. Goswami, F. Kreith and J.F. Kreider, “Principle of Solar Engineering”, Taylor and Francis, 2000.
2. Sukhatme S.P., “Solar Energy”, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
3. Bansal and othes, “Non-Conventional Energy Sources”.
4. J.F. Kreider, F. Kreith, “Solar Energy Handbook”, McGraw Hill, 1981
5. J.A. Duffie and W.A. Beckman, “Solar Engineering of Thermal Processes”, John Wiley, 1991.

**Advanced Mathematical Methods in Engineering**

**Teaching Scheme**

Lectures: 3 hrs/week, Tutorial: 1hr/week

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Students will be able to analyse and develop the mathematical model of thermal system.
2. Student should able analyse the reliability and maintainability of the series and parallel thermal system.
3. Students will be able to solve differential equations using numerical techniques.

**Syllabus Contents:**

- Ordinary Differential Equations: First-order equations (Linear, Equidimensional, Separable Exact, Homogeneous,); Second-order linear differential equations (homogeneous and nonhomogeneous); Solution methods such as undertermined coefficients and variation of parameters.
- Partial Differential Equations: First order partial differential equations; Second order linear partial differential equations; Canonical forms; Fourier series, Second order equation

(Parabolic, Elliptic and Hyperbolic) in rectangular, cylindrical polar and spherical coordinate systems; Solution techniques such as separation of variables, eigenfunction expansions, integral transforms (Fourier and Laplace transforms); D'Alembert's solution for the Wave equation; Maximum principle for Elliptic equations; Variational methods for approximate solutions of differential equations.

- Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc. Central Limit Theorem and its significance. Some sampling distributions like  $\chi^2$ , t, F.
- ANOVA: One – way, Two – way with/without interactions, Latin
- Squares ANOVA technique, Principles of Design Of Experiments, some standard designs such as CRD, RBD, LSD.
- Some of the relevant topics required for ANOVA (sample estimates and test hypothesis) may also be included.

### References:

1. J.B. Doshi, “Differential Equations for Scientists and Engineers”, Narosa, 2010.
2. Peter O'Neil, “Advanced Engineering Mathematics”, Seventh Edition, Cengage Learning, 2012 (Indian Edition).
3. Michael Greenberg, “Advanced Engineering Mathematics”, Second Edition, Pearson Education, 2002 (Indian Edition).
4. Jennings. A., Matrix Computation for Engineers and Scientists. John Wiley and Sons, 1992.
5. Prem.K.Kythe, Pratap Puri, Michael R.Schaferkotter, Introduction to Partial Differential Equations and Boundary Value problems with Mathematics, CRC Press, 2002.
6. Kreyszig, Erwin, I.S., Advanced Engineering Mathematics, Wiley, 1999.
7. Ramamurthy. V., Computer Aided Design in Mechanical Engineering., Tata McGraw Hill Publishing Co., 1987
8. Fundamental Concepts in the Design of Experiments, 5th Ed., by Hicks and Turner
9. Devore, Jay L., Probability and Statistics for Engineering and the Sciences, 5th edition, Brooks- Cole (1999)

### Mini project

#### Teaching Scheme

Lectures: 2 hrs/week

#### Course Outcomes:

At the end of the course:

1. Students will get an opportunity to work in actual industrial environment if they opt for internship.
2. In case of mini project, they will solve a live problem using software/analytical/computational tools.
3. Students will learn to write technical reports.
4. Students will develop skills to present and defend their work in front of technically

qualified audience.

**Syllabus Contents:**

- Students can take up small problems in the field of design engineering as mini project. It can be related to solution to an engineering problem, verification and analysis of experimental data available, conducting experiments on various engineering subjects, material characterization, studying a software tool for the solution of an engineering problem etc.

**Thermal Engineering Lab Practice – I and II**

**Teaching Scheme**

Practical: 4 hrs/week

**Course Outcomes:**

At the end of the course:

1. Students will acquire hands on experience on the various test-rigs, Experimental set up.
2. Students should able to measure the various technical parameters by instrument and by mathematical relationship.
3. Students will able to identify the effect of various parameters on the system and able to co-relate them.

**Syllabus Contents:**

- The lab practice consists of the tutorials and experiments as decided by the course supervisors of the Program Core Courses (PCC) namely Fluid Dynamics, Advanced Heat Transfer, Thermodynamics and Combustion, Refrigeration and Cryogenics.

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**Lab Practice III and IV - Thermal Engineering**

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**Teaching Scheme**

Practical: 4 hrs/week

**Course Outcomes:**

At the end of the course:

1. Students will acquire hands on experience on the various test-rigs, Experimental set up.
2. Students should able to measure the various technical parameters by instrument and by mathematical relationship.
3. Students will able to identify the effect of various parameters on the system and able to co- relate them.

#### **Syllabus Contents:**

- The lab practice consists of the tutorials and experiments as decided by the course supervisors of the Program Core Courses (PCC) namely Design of Heat Exchangers and Computational Fluid Dynamics, Modelling of I C Engine.

### **(Dissertation) Dissertation Phase-1**

#### **Teaching Scheme**

Lectures: 20 hr/week

#### **Course Outcomes:**

At the end of the course:

1. Students will be exposed to self-learning various topics.
2. Students will learn to survey the literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.
3. Students will learn to write technical reports.
4. Students will develop oral and written communication skills to present and defend their work in front of technically qualified audience.

#### **Guidelines:**

- The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. Seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by Head and PG coordinator. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

### **Dissertation Phase- II**

#### **Teaching Scheme**

Lectures: 32 hr/week

### **Course Outcomes:**

At the end of the course:

1. Students will be able to use different experimental techniques.
2. Students will be able to use different software/ computational/analytical tools.
3. Students will be able to design and develop an experimental set up/ equipment/test rig.
4. Students will be able to conduct tests on existing set ups/equipments and draw logical conclusions from the results after analyzing them.
5. Students will be able to either work in a research environment or in an industrial environment.
6. Students will be conversant with technical report writing.
7. Students will be able to present and convince their topic of study to the engineering community.

### **Guidelines:**

- It is a continuation of Project work started in semester III. He has to submit the report in prescribed format and also present a seminar. The dissertation should be presented in standard format as provided by the department. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study. . The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc. as decided by the Head and PG coordinator. The candidate has to be in regular contact with his guide.

## **OPEN ELECTIVES**

### **Business Analytics**

## Teaching scheme

**Lecture: - 3 h/week**

|                      |                           |
|----------------------|---------------------------|
| <b>Course Code</b>   |                           |
| <b>Course Name</b>   | <b>Business Analytics</b> |
| <b>Credits</b>       |                           |
| <b>Prerequisites</b> |                           |

Total Number of Lectures: 48

| <b>Course objective</b>   |
|---|
| <ol style="list-style-type: none"> <li>1. Understand the role of business analytics within an organization.</li> <li>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.</li> <li>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.</li> <li>4. To become familiar with processes needed to develop, report, and analyze business data.</li> <li>5. Use decision-making tools/Operations research techniques.</li> <li>6. Manage business process using analytical and management tools.</li> <li>7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.</li> </ol> |

| <b>LECTURE WITH BREAKUP</b>   | <b>NO. OF LECTURES</b> |
|---|------------------------|
| <p><b>Unit1:</b></p> <p>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.</p> <p>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p> | 9                      |
| <p><b>Unit 2:</b></p> <p>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.</p> <p>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.</p>  | 8                      |

|  |           |
|--|-----------|
| <p><b>Unit 3:</b></p> <p>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.</p> <p>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.</p>   | <p>9</p>  |
| <p><b>Unit 4:</b></p> <p>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.</p> <p>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.</p> | <p>10</p> |
| <p><b>Unit 5:</b></p> <p>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.</p>  | <p>8</p>  |
| <p><b>Unit 6:</b></p> <p>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.</p>   | <p>4</p>  |

| <b>COURSE OUTCOMES</b>   |  |
|--|--|
| <ol style="list-style-type: none"> <li>1. Students will demonstrate knowledge of data analytics.</li> <li>2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.</li> <li>3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.</li> <li>4. Students will demonstrate the ability to translate data into clear, actionable insights.</li> </ol> |  |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.



## OPEN ELECTIVES

### Industrial Safety

#### Teaching scheme

**Lecture: - 3 h/week**

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**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

#### Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

## OPEN ELECTIVES

## Operations Research

### Teaching Scheme

Lectures: 3 hrs/week

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**Course Outcomes:** At the end of the course, the student should be able to

1. Students should be able to apply the dynamic programming to solve problems of discrete and continuous variables.
2. Students should be able to apply the concept of non-linear programming
3. Students should be able to carry out sensitivity analysis
4. Student should be able to model the real world problem and simulate it.

### Syllabus Contents:

#### Unit 1:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

#### Unit 2

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

#### Unit 3:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

#### Unit 4

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

#### Unit 5

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

### References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

### Open Elective

## **Cost Management of Engineering Projects**

### **Teaching scheme**

**Lecture: - 3 h/week**

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#### Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

### **References:**

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

### **Open Elective**

#### **Composite Materials**

### **Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT-IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

**Open Elective**

**Waste to Energy**

## Teaching scheme

**Lecture: - 3 h/week**

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**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

## References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

## AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

### Course objectives:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title

| Ensure the good quality of paper at very first-time submission |  |              |
|--|--|--------------|
| <b>Syllabus</b>  |  |              |
| <b>Units</b>   | <b>CONTENTS</b>  | <b>Hours</b> |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4            |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4            |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4            |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4            |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4            |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4            |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

**AUDIT 1 and 2: DISASTER MANAGEMENT**

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|--|
| <p><b>Course Objectives:</b> -Students will be able to:</p> <ol style="list-style-type: none"> <li>1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.</li> <li>2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.</li> <li>3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.</li> <li>4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in</li> </ol> |
| <b>Syllabus</b>  |

| Units | CONTENTS   | Hours |
|-------|--|-------|
| 1     | <p><b>Introduction</b></p> <p>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.</p>  | 4     |
| 2     | <p><b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.</p> <p>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.</p> | 4     |
| 3     | <p><b>Disaster Prone Areas In India</b></p> <p>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics</p>  | 4     |
| 4     | <p><b>Disaster Preparedness And Management</b></p> <p>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.</p>   | 4     |
| 5     | <p><b>Risk Assessment</b></p> <p>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.</p>   | 4     |
| 6     | <p><b>Disaster Mitigation</b></p> <p>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.</p>   | 4     |

### SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.

3. Goel S. L. , Disaster Administration And Management Text And Case Studies” ,Deep &Deep Publication Pvt. Ltd., New Delhi.

### **AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE**

#### ***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

#### ***Syllabus***

| <b>Unit</b> | <b>Content</b>  | <b>Hours</b> |
|-------------|---|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul>          | 8            |
| 2           | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8            |
| 3           | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8            |

#### ***Suggested reading***

1. “Abhyaspustakam” – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

#### ***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

### **AUDIT 1 and 2: VALUE EDUCATION**



### **Course Objectives**

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

### **Syllabus**

| <b>Unit</b> | <b>Content</b>   | <b>Hours</b> |
|-------------|--|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul>  | 4            |
| 2           | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty, Humanity. Power of faith, National Unity.</li> <li>• Patriotism. Love for nature ,Discipline</li> </ul>   | 6            |
| 3           | <ul style="list-style-type: none"> <li>• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> <li>• Doing best for saving nature</li> </ul> | 6            |
| 4           | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality, Nonviolence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind, Self-control.</li> <li>• Honesty, Studying effectively</li> </ul>  | 6            |

**Suggested reading**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

**Course outcomes**

Students will be able to

- 1.Knowledge of self-development
- 2.Learn the importance of Human values
- 3.Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

| <b>Course Objectives:</b><br>Students will be able to:  |   |       |
|---|---|-------|
| <ol style="list-style-type: none"> <li>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>2. To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</li> <li>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ol> |   |       |
| <b>Syllabus</b>   |   |       |
| Units   | Content   | Hours |
| 1   | <ul style="list-style-type: none"> <li>• <b>History of Making of the Indian Constitution:</b></li> <li>History</li> <li>Drafting Committee, ( Composition &amp; Working)</li> </ul>   | 4     |
| 2   | <ul style="list-style-type: none"> <li>• <b>Philosophy of the Indian Constitution:</b></li> <li>Preamble</li> <li>Salient Features</li> </ul>   | 4     |
| 3   | <ul style="list-style-type: none"> <li>• <b>Contours of Constitutional Rights &amp; Duties:</b></li> <li>• Fundamental Rights</li> <li>• Right to Equality</li> <li>• Right to Freedom</li> <li>• Right against Exploitation</li> <li>• Right to Freedom of Religion</li> <li>• Cultural and Educational Rights</li> <li>• Right to Constitutional Remedies</li> <li>• Directive Principles of State Policy</li> <li>• Fundamental Duties.</li> </ul> | 4     |
| 4   | <ul style="list-style-type: none"> <li>• <b>Organs of Governance:</b></li> <li>• Parliament</li> <li>• Composition</li> <li>• Qualifications and Disqualifications</li> <li>• Powers and Functions                             <ul style="list-style-type: none"> <li>• Executive</li> </ul> </li> <li>• President</li> <li>• Governor</li> <li>• Council of Ministers</li> </ul>   | 4     |

|   |  |   |
|---|--|---|
|   | <ul style="list-style-type: none"> <li>• Judiciary, Appointment and Transfer of Judges, Qualifications</li> <li>• Powers and Functions</li> </ul>  |   |
| 5 | <ul style="list-style-type: none"> <li>• <b>Local Administration:</b></li> <li>• District's Administration head: Role and Importance,</li> <li>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.</li> <li>• Pachayati raj: Introduction, PRI: Zila Pachayat.</li> <li>• Elected officials and their roles, CEO Zila Pachayat: Position and role.</li> <li>• Block level: Organizational Hierarchy (Different departments),</li> <li>• Village level: Role of Elected and Appointed officials,</li> <li>• Importance of grass root democracy</li> </ul> | 4 |
| 6 | <ul style="list-style-type: none"> <li>• <b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul>   | 4 |

### Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

### Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGY STUDIES

| <b>Course Objectives:</b>  |  |       |
|--|--|-------|
| Students will be able to:  |  |       |
| 4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers. |  |       |
| 5. Identify critical evidence gaps to guide the development.   |  |       |
| Syllabus   |  |       |
| Units  | Content  | Hours |
| 1  | <ul style="list-style-type: none"> <li>• <b>Introduction and Methodology:</b></li> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> </ul> | 4     |

|   |   |   |
|---|---|---|
|   | <ul style="list-style-type: none"> <li>• Overview of methodology and Searching.</li> </ul>  |   |
| 2 | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>  | 2 |
| 3 | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers' attitudes and beliefs and Pedagogic strategies.</li> </ul> | 4 |
| 4 | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul>  | 4 |
| 5 | <ul style="list-style-type: none"> <li>• <b>Research gaps and future directions</b></li> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> <li>• Dissemination and research impact.</li> </ul>   | 2 |

### Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal Educational Development*, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf).

### Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?
- 4.

## AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

### Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

### Syllabus

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> </ul> <p>Do`s and Don`t`s in life.</p> <p>i) Ahinsa, satya, astheya, bramhacharya and aparigraha</p> | 8     |

|   |  |   |
|---|--|---|
|   | ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan  |   |
| 3 | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> </ul> i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-<br>Types of pranayam | 8 |

***Suggested reading***

1. ‘Yogic Asanas for Group Training-Part-I’ : Janardan Swami Yogabhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

**AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**

***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

***Syllabus***

| Unit | Content  | Hours |
|------|--|-------|
| 1    | Neetisatakam-Holistic development of personality <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont’s)</li> <li>• Verses- 71,73,75,78 (do’s)</li> </ul> | 8     |

|   |  |   |
|---|--|---|
| 2 | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>  | 8 |
| 3 | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8 |

### ***Suggested reading***

1. “Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

### ***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

**Model Curriculum for PG Programme in Mechanical Engineering**  
**Specialization: Design Engineering**

L – Theory lecture, T – Tutorial; P – lab work: Numbers under ting scheme indicate contact clock hours

Curriculum Structure – Semester-wise

| <b>Semester I</b> |                                     |   |             |           |          |           |
|-------------------|-------------------------------------|---|-------------|-----------|----------|-----------|
| Sr. No.           | Course Type/Code                    | Course Name   | Ting Scheme |           |          | Credits   |
|                   |                                     |   | L           | T         | P        |           |
| 1.                | Core-I                              | Advanced Stress Analysis  | 3           | --        | --       | 3         |
| 2.                | Core-II                             | Advanced Vibrations and Acoustics   | 3           | --        | --       | 3         |
| 3.                | Programme Elective-I<br>*See Notes  | 1. Advanced Machine Design<br>2. Design for Manufacturing and Assembly<br>3. Mathematical Methods in Engineering    | 3           | --        | --       | 3         |
| 4.                | Programme Elective-II<br>*See Notes | 1. Advanced Engineering Materials<br>2. Mechanics of Composite Materials<br>3. Analysis and Synthesis of Mechanisms | 3           | --        | --       | 3         |
| 5.                | Core                                | Lab-I   | --          | --        | 4        | 2         |
| 6.                | Core                                | Lab-II  | --          | --        | 4        | 2         |
| 7.                | Core                                | Research Methodology and IPR  | 2           | --        | --       | 2         |
| 8.                | Audit                               | Audit Course - 1  | 2           | --        | --       | 0         |
| <b>Total</b>      |                                     |   | <b>16</b>   | <b>--</b> | <b>8</b> | <b>18</b> |



| Semester II  |                                      |   |             |           |           |           |
|--------------|--------------------------------------|---|-------------|-----------|-----------|-----------|
| Sr. No.      | Course Code/Type                     | Course Name   | Ting Scheme |           |           | Credits   |
|              |                                      |   | L           | T         | P         |           |
| 1.           | Core-III                             | Finite Element Method   | 3           | --        | --        | 3         |
| 2.           | Core-IV                              | Computer Aided Design   | 3           | --        | --        | 3         |
| 3.           | Programme Elective-III<br>*See Notes | 1. Tribology in Design<br>2. Robotics<br>3. Fracture Mechanics                                  | 3           | --        | --        | 3         |
| 4.           | Programme Elective-IV<br>*See Notes  | 1. Multi-body Dynamics<br>2. Condition Based Monitoring<br>3. Optimization Techniques in Design | 3           | --        | --        | 3         |
| 5.           | Core                                 | Lab-III   | --          | --        | 4         | 2         |
| 6.           | Core                                 | Lab-IV  | --          | --        | 4         | 2         |
| 7.           | Audit                                | Audit -2  | 2           | --        | --        | 0         |
| 8.           | Core                                 | Mini-Project  | --          | --        | 4         | 2         |
| <b>Total</b> |                                      |   | <b>14</b>   | <b>--</b> | <b>12</b> | <b>18</b> |

| Semester III |                                     |   |             |    |    |         |
|--------------|-------------------------------------|---|-------------|----|----|---------|
| Sr. No.      | Course Code                         | Course Name   | Ting Scheme |    |    | Credits |
|              |                                     |   | L           | T  | P  |         |
| 1.           | Programme-Elective-V<br>* See Notes | 1. Advanced Finite Element Method<br>2. Advanced Metallurgy   | 3           | -- | -- | 3       |
| 2.           | Open Elective                       | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3           | -- | -- | 3       |
| 3.           | Dissertation                        | Dissertation Phase – I  | --          | -- | 20 | 10      |

|                    |              | <b>Total</b>            | 6           | -- | --        | <b>16</b> |
|--------------------|--------------|-------------------------|-------------|----|-----------|-----------|
| <b>Semester-IV</b> |              |                         |             |    |           |           |
| Sr. No.            | Course Code  | Course Name             | Ting Scheme |    |           | Credits   |
|                    |              |                         | L           | T  | P         |           |
| 1.                 | Dissertation | Dissertation Phase - II | --          | -- | 32        | 16        |
| <b>Total</b>       |              |                         | --          | -- | <b>32</b> | <b>16</b> |

Total Credits for the programme = 18 + 18 + 16 + 16 = **68**

\*Notes:

1. List of programme electives is indicative. The University may decide this depending on facilities and expertise available with them. But the number of courses under this list must be as large as possible with minimum three being offered at beginning of any semester out of which a student would choose any one.
2. Lab sessions may be conducted for core courses of individual semesters as shown in the structure but of evaluation will be reported as consolidated under single head.

Contents of the courses listed in the structure are given on following pages

#### **Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

|   |  |
|---|--|
| <b>Advanced StressAnalysis</b>  |  |
| <b>Ting Scheme</b><br>Lectures: 3Hrs/week   |  |
| <b>Course Outcomes:</b><br>At the end of the course:  |  |
| <ol style="list-style-type: none"> <li>1. Students will understand the tonsorial approach of continuum mechanics and comprehend modern research material.</li> <li>2. Student will learn basic field equations such as equilibrium equations, compatibility and constitutive relationship.</li> <li>3. Students will be able to apply basic field equations to torsion, bending and two dimensional elasticity problems, and energy methods.</li> <li>4. Students will be able to solve problems in unsymmetrical bending and shear center, contact stresses and pressurized cylinders and rotating discs.</li> </ol> |  |

## Syllabus Contents

### Unit 1: Theory of Elasticity

Analysis of stress, Analysis of strain, Elasticity problems in two dimension and three dimensions, Mohr's circle for three dimensional stresses. Stress tensor, Air's stress function in rectangular and polar coordinates.

### Unit 2. Energy Methods

Energy method for analysis of stress, strain and deflection The three theorem's -theorem of virtual work, theorem of least work, Castiglioni's theorem, Rayleigh Ritz method, Galekin's method, Elastic behavior of anisotropic materials like fiber reinforced composites.

### Unit 3. Theory of Torsion

Torsion of prismatic bars of solid section and thin walled section. Analogies for torsion, membrane analogy, fluid flow analogy and electrical analogy. Torsion of conical shaft, bar of variable diameter, thin walled members of open cross section in which some sections are prevented from warping, Torsion of noncircular shaft.

### Unit 4. Unsymmetrical Bending and Shear Centre

Concept of shear center in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear center for thin wall beam cross section, open section with one axis of symmetry, general open section, and closed section. .

### Unit 5. Pressurized Cylinders and Rotating Disks

Governing equations, stress in thick walled cylinder under internal and external pressure, shrink fit compound cylinders, stresses in rotating flat solid disk, flat disk with central hole, disk with variable thickness, disk of uniform strength, Plastic action in thick walled cylinders and rotating disc.

### Unit 6. Contact stresses

Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area. Introduction to Analysis of low speed impact.

### References:

1. Sadd, Martin H., Elasticity: Theory, applications and Numeric, Academic Press 05 (Text Book)
2. Boresi, A.P. and K. P. Chong, Elasticity in Engineering Mechanics, Second Edition, John Wiley & Sons, 00
3. Budynas, R. G. Advance strength and Applied Stress Analysis, Second Edition, WCB/McGraw Hill 1999
4. Dally, J. W. and W.F. Riley, Experimental Stress Analysis, McGraw Hill International, Third Edition, 1991
5. Theory of Elasticity – Timoshenko and Goodier, Mc Graw Hill
6. Advanced Strength of Materials, Vol. 1,2 – Timoshenko, CBS
7. Advanced Strength of Materials – Den Harteg

## Advanced Vibrations and Acoustics

|  |  |
|--|--|
| <b>Ting Scheme</b><br>Lectures: 3 hrs/week   |  |
| <b>Course Outcomes:</b><br>At the end of the course: <ol style="list-style-type: none"> <li>1. The student will be able to predict response of a SDOF system, damped or undamped, subjected to simple arbitrary base or force excitations. They will be able to obtain Shock Response Spectrum of SDOF systems for such excitations and understand use of the SRS.</li> <li>2. The students will be able to write differential equations of motion for MDOF systems, and through the technique of decoupling and orthogonal properties of natural modes, should be able to obtain the Eigen-values and mode shapes of natural vibrations and response to harmonic and arbitrary excitations.</li> <li>3. The students will be able to obtain the Eigen-values and mode shapes of natural vibrations of beams and response to harmonic excitations using orthogonal properties of natural modes.</li> <li>4. Student will be able to obtain natural frequencies and mode shapes of MDOF and continuous systems using computational methods such as Rayleigh-Ritz method, Holzer method, Dunckerley's method, and Stodola's method.</li> <li>5. Student will know various terminologies used in acoustics and acoustic wave transmission, derive plane and spherical wave equations, and obtain sound pressure level at a given distance from a simple sound source of known strength.</li> <li>6. Students should understand the basics of psychoacoustics, equal loudness contours, dBA scale, loudness, pitch and timbre.</li> </ol>  |  |
| <b>Syllabus Contents:</b><br><p><b>Unit 1:</b> Transient Vibrations, Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response function</p> <p><b>Unit 2:</b> Multi degree of freedom systems, Free, damped and forced vibrations of two degree of freedom systems, Eigen values and Eigen vectors, normal modes and their properties, mode summation method, use of Lagrange's equations to derive the equations of motion,</p> <p><b>Unit 3:</b> Continuous Systems, Natural Vibrations of beams – Differential equation of motion, solution by the method of separation of variables, frequency parameter, natural frequencies and mode shapes, forced vibration of simply supported beam subjected to concentrated harmonic force at a point, Mode summation method, discretized models of continuous systems and their solutions using Rayleigh – Ritz method</p> <p><b>Unit 4:</b> Vibration Control, Methods of vibration control, principle of superposition, Numerical and computer methods in vibrations: Rayleigh, Rayleigh-Ritz and Dunkerley's methods, matrix iteration method for Eigen-value calculations, Holzer's method,</p> <p><b>Unit 5</b><br/> Plane acoustic waves, Sound speed, characteristic acoustic impedance of elastic media, sound intensity, dB scale, Transmission Phenomena, transmission from one fluid medium to another, normal incidence, reflection at the surface of a solid, standing wave patterns, Symmetric Spherical waves, near and far fields, simple models of sound sources, sound power, determination of sound power and intensity levels at a point due to a simple source.</p> <p><b>Unit 6</b><br/> Psychoacoustics, Speech, mechanism of hearing, thresholds of the ear – sound intensity and frequency, loudness, equal loudness levels, loudness, pitch and timbre, beats, masking by pure tones, masking by noise.</p> |  |

**References:**

1. Thomson W.T., “Theory of Vibrations with applications”, George Allen and Unwh Ltd. London, 1981.
2. S.S. Rao, Addison, “Mechanical Vibrations”, Wesley Publishing Co., 1990.
3. Leonard Meirovitch, “Fundamentals of vibrations”, McGraw Hill International Edition.
4. S. Timoshenko, “Vibration problems in Engineering”, Wiley, 1974.
5. Lawrence E. Kinsler and Austin R.Frey, “Fundamentals of acoustics”, Wiley Eastern Ltd., 1987.
6. Michael Rettinger, “Acoustic Design and Noise Control”, Vol. I & II. , Chemical Publishing Co., New York, 1977.

**AdvancedMachineDesign**

**Ting Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course:

1. Students will realize that creativity, manufacturability, assembly, maintainability, emotions, reliability are also important aspects of design other than finding dimensions and stresses in the highly competitive, dynamic and customer centered market.
2. Students will demonstrate the ability to identify needs of the customer and convert them in to technical specifications of a product.
3. Students will be able to generate different ideas after identifying the need and determining the specifications and constraints of a product for a particular purpose.
4. Students will understand the principals used while designing for manufacture, assembly, emotions and maintenance.
5. Students will know various methods of rapid prototyping the products to test and modify the designs.
6. Students will be able to design the components considering strength based reliability.

**Syllabus Contents:**

**Unit 1:** Development processes and organizations, Product Planning

**Unit 2:** Need Identification and problem definition, product specification, concept generation and selection, evaluation, creativity methods, Concept testing

**Unit 3:** Design for manufacture, assembly, maintenance, casting, forging,

**Unit 4:** Design for Reliability, strength based reliability, parallel and series systems, robust design,

**Unit 5:** Industrial design: Design for Emotion and experience, Introduction to retrofit and Eco design, Human behavior in design

**Unit 6:** Rapid Prototyping

**References:**

1. George E Dieter, “Engineering Design”, McGraw Hill Company, 00.

2. Prashant Kumar, “Product Design, Creativity, Concepts and Usability”, Eastern Economy Edition, PHI New Delhi. 12
3. Woodson T.T., “Introduction to Engineering Design”, McGraw Hill Book Company, 1966.
4. John J.C. “Design Methods”, Wiley Inter science, 1970.
5. Averill M. Law and W. David Kelton “Simulation, modelling and analysis”, McGraw Hill Book Company, 1991.
6. Pahl, G.and W.Beitz, *Engineering Design–A Systematic Approach* – Springer, 2nd Ed., 1996.
7. Product Design and development Karl T. Ulrich, Steven Eppinger

### Design for Manufacturing and Assembly

#### Ting Scheme

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, the student should be able to

1. Understand the product development cycle
2. Know the manufacturing issues that must be considered in the mechanical engineering design process
3. Know the principles of assembly to minimize the assembly time
4. Know the effect of manufacturing process and assembly operations on the cost of product (not included by others)
5. Be familiar with tools and methods to facilitate development of manufactural mechanical designs

#### Syllabus Contents:

**Unit 1:** Introduction Need Identification and Problem Definition, Concept Generation and Evaluation, Embodiment Design, Selection of Materials and Shapes

**Unit 2:** Properties of Engineering Materials, Selection of Materials – I, Selection of Materials – II, Case Studies – I, Selection of Shapes, Co-selection of Materials and Shapes, Case Studies – II,

**Unit 3:** Selection of Manufacturing Processes, Review of Manufacturing Processes, Design for Casting, Design for Bulk Deformation Processes, Design for Sheet Metal Forming Processes, Design for Machining, Design for Powder Metallurgy, Design for Polymer Processing, Co-selection of Materials and Processes, Case-Studies – III

**Unit 4:** Design for Assembly, Review of Assembly Processes, Design for Welding – I, Design for Welding – II, Design for Brazing and Soldering, Design for Adhesive Bonding, Design for Joining of Polymers, Design for Heat Treatment, Case-Studies - IV

**Unit 5:** Design for Reliability, Failure Mode and Effect Analysis and Quality, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization,

#### References:

1. M F Ashby and K Johnson, Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 03.
2. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 00.

3. M F Ashby, Material Selection in Mechanical Design, Butterworth-Heinemann, 1999.
4. T H Courtney, Mechanical Behavior of Materials, McGraw Hill, NY, 00.
5. K G Swift and J D Booker, Process selection: from design to manufacture, London: Arnold, 1997.
6. S S Rao, Engineering Optimization: theory and practice, John Wiley, NY, 1996.
7. G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 1994.
8. J G Bralla, Handbook for Product Design for Manufacture, McGraw Hill, NY, 1998.
9. Houldcroft, Which Process – an introduction to welding and related processes and guide to their selection, Cambridge, Abington Pub., 1990.
10. ASTM Design handbook.

| <b>Advanced Engineering Materials</b>   |  |
|---|--|
| <b>Ting Scheme</b>  |  |
| Lectures: 3 hrs/week  |  |
| <b>Course Outcomes:</b>   |  |
| At the end of the course the student will   |  |
| <ol style="list-style-type: none"> <li>1. Demonstrate an understanding of mechanics, physical and chemical properties of materials including metals, ceramics, polymers and composites</li> <li>2. Understand existence of imperfections and their effects on mechanical properties of materials and cause of failure</li> <li>3. Demonstrate understanding of phase diagrams and their use in predicting phase transformation and microstructure</li> <li>4. Understand and predict various types of failures using concept of fracture mechanics, creep and effect of impact</li> <li>5. Know Electrical, Thermal, Optical and Magnetic Properties of metals, ceramics, polymers and composites</li> <li>6. Understand the economic considerations in usage and recycling of materials in human use</li> </ol>  |  |
| <b>Syllabus Contents</b>  |  |
| <p><b>Unit 1. Introduction, Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids:</b><br/>           Historical perspective of Materials Science. Why study properties of materials? Classification of materials. Advanced Materials, Future materials and modern materials, Atomic structure. Atomic bonding in solids, Crystal structures, Crystalline and noncrystalline materials. Miller indices. Anisotropic elasticity. Elastic behaviour of composites. Structure and properties of polymers. Structure and properties of ceramics.</p> <p><b>Unit 2: Imperfections in Solids and Mechanical Properties of Metals, Diffusion, Dislocations and Strengthening Mechanisms:</b><br/>           Point defects. Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations; Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves Yielding under multiaxial stress. Yield criteria and macroscopic aspects of plastic deformation. Property variability and design factors, Diffusion mechanisms. Steady and non-steady state diffusion. Factors that influence diffusion. Non-equilibrium transformation and microstructure, Dislocation and plastic deformation. Mechanisms of strengthening in metals. Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion.</p> <p><b>Unit 3: Phase Diagrams</b><br/>           Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Kinetics of nucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure and property changes in iron-carbon system</p> <p><b>Unit 4: Failure:</b><br/>           Fracture. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiation and propagation. Crack propagation rate. Creep. Generalized creep behaviour. Stress and temperature effects</p> |  |



**Unit 5: Applications and Processing of Metals and Alloys, Polymers, Ceramics, and composites:**

Types of metals and alloys. Fabrication of metals. Thermal processing of metals. Heat treatment. Precipitation hardening. Types and applications of ceramics. Fabrication and processing of ceramics, Mechanical behaviour of polymers. Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition. Polymer types. Polymer synthesis and processing, Particle reinforced composites. Fibre reinforced composites. Structural composites

**Unit 6. Electrical, Thermal, Optical and Magnetic Properties and economic Considerations:**

Electrical conduction. Semi conductivity. Super conductivity. Electrical conduction in ionic ceramics and in polymers. Dielectric behaviour. Ferroelectricity. Piezoelectricity

Heat capacity. Thermal expansion. Thermal conductivity. Thermal stresses

Diamagnetism and Para magnetism. Ferromagnetism. Antiferromagnetism and ferrimagnetism.

Influence of temperature on magnetic behaviour. Domains and Hysteresis,

Basic concepts. Optical properties of metals. Optical properties of non-metals. Application of optical phenomena.

Economic, Environmental and Social Issues of Material Usage - Economic considerations.

Environmental and societal considerations. Recycling issues. Life cycle analysis and its use in design

**References:**

8. Materials Science and Engineering, William D. Callister, Jr, John Wiley & sons, 07
9. Modern Physical Metallurgy and Material Engineering, Science, Process, application, Smallman R.E., Bishop R J, Butterworth Heinemann, Sixth Ed., 1999.

**Mathematical Methods in Engineering**

**Ting Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course, students will demonstrate their ability to:

1. apply statistical techniques to analyze multivariate functions.
2. identify and solve engineering problems by applying the knowledge of ordinary and partial differential equations.
3. Identify nature of a given wave equation and solve by applying D'Alembert solution and/or method of solution of method of separation of variables

**Course Contents**

**Unit 1 : Introduction to Probability Theory**

Probability Theory and Sampling Distributions. Basic probability theory along with examples. Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc. Central Limit Theorem and its significance. Some sampling distributions like  $\chi^2$ , t, F.

**Unit 2 : Testing of Statistical Hypothesis**

Testing a statistical hypothesis, tests on single sample and two samples concerning means and variances. ANOVA: One – way, Two – way with/without interactions.

**Unit 3 : Ordinary Differential Equations:**

Ordinary linear differential equations solvable by direct solution methods; solvable nonlinear ODE's;

**Unit 4: Partial Differential Equations and Concepts in Solution to Boundary Value Problems:**

First and second order partial differential equations; canonical forms

**Unit 5: Major Equation Types Encountered in Engineering and Physical Sciences**

Solution methods for wave equation, D'Alembert solution, potential equation, properties of harmonic functions, maximum principle, solution by variable separation method

**Text Books:**

1. Ronald E. Walpole, Sharon L. Myers, Keying Ye, *Probability and Statistics for Engineers and Scientists* (8<sup>th</sup> Edition), Pearson Prentice Hall, 07 (for Units I & II)
2. J. B. Doshi, *Differential Equations for Scientists and Engineers*, Narosa, New Delhi, 10 (for Units III & IV)

**Reference Books:**

1. Douglas C. Montgomery, *Design and Analysis of Experiments* (7<sup>th</sup> Edition), Wiley Student Edition, 09.
2. S. P. Gupta, *Statistical Methods*, S. Chand & Sons, 37<sup>th</sup> revised edition, 08
3. William W. Hines, Douglas C. Montgomery, David M. Goldsman, *Probability and Statistics for Engineering*, (4<sup>th</sup> Edition), Wiley Student edition, 06.
4. Advanced Engineering Mathematics (9<sup>th</sup> Edition), Erwin Kreyszig, Wiley India (13)

**Mechanics of Composite Materials**

**Ting Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

**The student should be able to**

1. Student will be able to understand the basic concepts and difference between composite materials with conventional materials.
2. Students will be able to understand role of constituent materials in defining the average properties and response of composite materials on macroscopic level.
3. Students will be able to apply knowledge for finding failure envelopes and stress-strain plots of laminates.
4. Students will be able to develop a clear understanding to utilize subject knowledge using computer programs to solve problems at structural level.

**Syllabus Contents:**

**Unit 1. Introduction**

Definition and

characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus

**Unit 2. Basic Concepts and Characteristics**

Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials

**Unit 3. Elastic Behavior of Unidirectional Lamina**

Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters

**Unit 4. Strength of Unidirectional Lamina**

Micromechanics of failure; failure mechanisms, Macro-mechanical strength parameters, Macro-mechanical failure theories, Applicability of various failure theories

**Unit 5. Elastic Behavior of Laminate**

Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates

**Unit 6. Stress and Failure Analysis of Laminates**

Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials

**References:**

1. Isaac M. Daniels, Ori Ishai, “Engineering Mechanics of Composite Materials”, Oxford University Press, 1994.
2. Bhagwan D. Agarwal, Lawrence J. Broutman, “Analysis and Performance of fiber composites”, John Wiley and Sons, Inc. 1990.
3. Mathews, F. L. and Rawlings, R. D., “Composite Materials: Engineering and Science”, CRC Press, Boca Raton, 03.
4. Madhujit Mukhopadhyay, “Mechanics of Composite Materials and Structures”, University Press, 04.
5. Mazumdar S. K., “Composite Manufacturing – Materials, Product and Processing Engineering”, CRC Press, Boca Raton, 02.
1. Robert M. Jones, “Mechanics of Composite Materials”, Taylor and Francis, Inc., 1999.

**Analysis and Synthesis of Mechanisms**

**Ting Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course:

1. To develop analytical equations describing the relative position, velocity and acceleration of all moving links.

2. To select, configure, and synthesize mechanical components into complete systems.
3. Use kinematic geometry to formulate and solve constraint equations to design linkages for specified tasks.
4. Formulate and solve four position synthesis problems for planar and spherical four-bar linkages by graphical and analytical methods.
5. Analyze and animate the movement of planar and spherical four-bar linkages.
6. students will be able to apply modern computer-based techniques in the selection, analysis, and synthesis of components and their integration into complete mechanical systems.
7. Finally Students will demonstrate ability to think creatively, participate in design challenges, and present logical solutions.

**Syllabus Contents:**

**Unit 1**

Basic Concepts; Definitions and assumptions; planar and spatial mechanisms; kinematic pairs; degree of freedom; equivalent mechanisms; Kinematic Analysis of Planar Mechanisms. Review of graphical and analytical methods of velocity and acceleration analysis of kinematically simple mechanisms, velocity-acceleration, analysis of complex mechanisms by the normal acceleration and auxiliary-point methods.

**Unit 2**

Curvature Theory: Fixed and moving centrodes, inflection circle, Euler-Savary equation, Bobillier constructions, cubic of stationary curvature, Ball's point, Applications in dwell mechanisms.

**Unit 3**

Kinematic Synthesis of planar mechanisms, accuracy (precision) points, Chebyshev spacing, types of errors, Graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, centre and circle point curves, Analytical synthesis of four-bar and slider-crank mechanisms.

**Unit 4**

Freudenstein's equation, synthesis for four and five accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers, three accuracy point synthesis using complex numbers.

**Unit 5**

Coupler Curves : Equation of coupler curve, Robert-Chebyshev theorem, double points and symmetry.

**Unit 6**

Kinematic Analysis of Spatial Mechanisms, Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms

**References:**

1. R.S. Hartenberg and J. Denavit, "Kinematic Synthesis of Linkages", McGraw-Hill, New York, 1980.
2. Robert L.Nortan, "Design of Machinery", Tata McGraw Hill Edition
3. Hamilton H.Mabie, "Mechanisms and Dynamics of Machinery", John Wiley and sons New York
4. S.B.Tuttle, "Mechanisms for Engineering Design" John Wiley and sons New York

5. A. Ghosh and A.K. Mallik, "Theory of Machines and Mechanisms", Affiliated East-West Press, New Delhi, 1988.
6. A.G. Erdman and G.N. Sandor, "Mechanism Design – Analysis and Synthesis", (Vol. 1 and 2), Prentice Hall India, 1988.
7. A.S. Hall, "Kinematics and Linkage Design", Prentice Hall of India.
8. J.E. Shigley and J.J. Uicker, "Theory of Machines and Mechanisms", 2<sup>nd</sup> Edition, McGraw-Hill, 1995.

### Lab – I and Lab-II

**Ting Scheme**

**Lectures: 4 hrs/week**

**Course Outcomes:**

At the end of the course:

1. Students will be able to use various experimental techniques relevant to the subject.
2. Students will acquire hands on experience on the various test-rigs, Experimental set up.
3. Students will be able to function as a team member
4. Students will develop communication skills.
5. Students will be able to write technical reports.
6. Students will be able to use different software's.

**Syllabus Contents:**

The lab practice consists of experiments, tutorials and assignments decided by the course supervisors of the program core courses and program specific elective courses.

### Finite Element Method

**Ting Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course,

For one and two dimensional, linear, static and dynamic problems in Structural Mechanics and Heat Transfer, the student will be able to demonstrate the learning outcomes as mentioned below:

1. The student will be able to classify a given problem on the basis of its dimensionality as 1-D, 2-D, or 3-D, time-dependence as Static or Dynamic, Linear or Non-linear.
2. The students will be able to develop system level matrix equations from a given mathematical model of a problem following the Galerkin weighted residual method or principle of stationary potential.
3. While demonstrating the process mentioned in 2 above, he will be able to identify the primary and secondary variables of the problem and choose correct nodal degrees of freedom and develop suitable shape functions for an element, implement Gauss-Legendre scheme of numerical integration to evaluate integrals at element level, and assemble the element level equations to get the system level matrix equations. He will also be able to

|   |
|---|
| <p>substitute the essential boundary conditions correctly and obtain the solution to system level matrix equations to get the values of the field variable at the global nodes.</p> <ol style="list-style-type: none"> <li>4. The student will be able to state three sources of errors in implementing FEM and suggest remedies to minimize the same for a given problem, viz. Modeling errors, Approximation errors, and numerical errors.</li> <li>5. The student will be able to obtain consistent and lumped mass matrices for axial vibration of bars and transverse vibration of beams and obtain fundamental frequency of natural vibration using the methods mentioned in the curricula.</li> <li>6. The students will be able use MATLAB for implementation of FEM to obtain elongations at nodes of a bar subjected to traction and concentrated loads and prescribed boundary conditions</li> <li>7. The students will be able to use commercial software like ANSYS or ABAQUS for implementation of FEM to obtain stress concentration due to a small hole in a rectangular plate subjected to traction on edges and concentrated loads at points on the edges and prescribed boundary conditions</li> </ol> |
|---|

**Syllabus Contents:**

**Unit 1: Introduction**, Classification of problems – Dimensionality, time dependence, Boundary Value problems, Initial value problems, Linear/Non-linear, etc,

**Unit 2:** Differential equation as the starting point for FEM, steps in finite element method, discretization, types of elements used, Shape functions, Linear Elements, Local and Global coordinates, Coordinate transformation and Gauss-Legendre scheme of numerical integration, Nodal degrees of freedom,

**Unit 3:** Finite element formulation, variational, weighted residual and virtual work methods,

**Unit 4:** 1-D and 2-D problems from Structural Mechanics – Bar, Beam, Plane stress and plane strain problems, Axisymmetric problems – Axi-symmetric forces and geometry,

**Unit 5:** computer implementation, higher order elements, iso-parametric formulation,

**Unit 6:** Eigen-value problems, Natural vibration of bars and beams, Methods to find eigen-values and eigen-vectors.

**References:**

1. Chandrupatla and Belegundu “Introduction to Finite Elements in Engineering”, Prentice Hall of India Pvt. Ltd. New Delhi, Ed.4, 11.
2. Logan Deryl L., “A First Course in Finite Element Method”, Thomson Brook/Cole, 5<sup>th</sup> Ed. 12
3. Cook R.D. “Concepts and applications of finite element analysis” Wiley, New York, 4<sup>th</sup> Ed. 02.
4. Reddy J N, “Finite element Method”, Tata McGraw Hill publishing Co Ltd, New Delhi, 3<sup>rd</sup> Ed., 05
5. Bathe K.J., Cliffs, N.J. “Finite Element Procedures in Engineering Analysis”, PHI Learning, Eastern Economy Editions, 09.

**Research Methodology and IPR**

**Teaching Scheme**

Lectures: 1hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics

- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasize the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

### Syllabus Contents:

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

### References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.

- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

## ComputerAidedDesign

### Ting Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of the course:

1. Have a conceptual understanding of the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems.
2. Understand 2D, 3D transformations and projection transformations
3. Get knowledge of various approaches of geometric modeling
4. Understand mathematical representation of 2D and 3D entities
5. Understand basic fundamentals of FEM

### Syllabus Contents:

**Unit 1:** CAD Hardware and Software, Types of systems and system considerations, input and output devices, hardware integration and networking, hardware trends, Software modules,

**Unit 2:** Computer Communications, Principle of networking, classification networks, network wiring, methods, transmission media and interfaces, network operating systems,

**Unit 3:** Computer Graphics Introduction, transformation of geometric models: translation, scaling, reflection, rotation, homogeneous representation, concatenated transformations; mappings of geometric models, translational mapping rotational mapping, general mapping, mappings as changes of coordinate system; inverse transformations and mapping;

**Unit 4 :** Projections of geometric models, orthographic projections, Geometric Modeling, curve representation: Parametric representation of analytic curves, parametric representation of synthetic curves, curve manipulations. Surface representation,

**Unit 5 :** Fundamentals of solid modeling, boundary representation (B-rep), Constructive Solid Geometry (CSF), sweep representation, Analytic Solid Modeling (ASM), other representations; solid manipulations, solid modeling based applications: mass properties calculations, mechanical tolerancing, etc.

**Unit 6:** Finite Element Modeling and Analysis, Finite Element Analysis, finite element modeling, mesh generation mesh requirements, semiautomatic methods, fully automatic methods, design and engineering applications, System Simulation, Need of simulation, areas of applications, when simulation is appropriate tool / not appropriate, concept of a system, components of a system, discrete and continuous systems, model of a system, types of models, types of simulation approaches

### References:

1. Ibrahim Zeid, “CAD / CAM Theory and Practice”.
2. Jim Browne, “Computer Aided Engineering and Design”.
3. P. Radhakrishnan / V. Raju / S. Subramanyam, “CAD / CAM / CIM”.
4. P.N. Rao, “CAD / CAM principles and applications”, Tata Mcraw-Hill, 02.



5. Rogers / Adams, “Mathematical Elements for Computer Graphics”.
6. Rooney and Steadman, “Principles of Computer Aided Design”, Aug. 1993.
7. Jerry Banks / John Carson / Barry Nelson / David Nicol, “Discrete-Event System Simulation”

### Tribology in Design

#### Ting Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

##### At the end of the course:

1. The students will be able to apply theories of friction and wear to various practical situations by analysing the physics of the process.
2. They will understand the various surface measurement techniques and effect of surface texture on Tribological behavior of a surface.
3. They will be able to select materials and lubricants to suggest a tribological solution to a particular situation.
4. The students will be able to design a hydrodynamic bearing using various bearing charts.
5. The students will be able to understand the recent developments in the field and understand modern research material.

#### Syllabus Contents:

**Unit 1:** Friction, theories of friction, Friction control, Surface texture and measurement, genesis of friction, instabilities and stick-slip motion.

**Unit 2:** Wear, types of wear, theories of wear, wear prevention.

**Unit 3:** Tribological properties of bearing materials and lubricants.

**Unit 4:** Lubrication, Reynolds’s equation and its limitations, idealized bearings, infinitely long plane pivoted and fixed show sliders, infinitely long and infinitely short (narrow) journal bearings, lightly loaded infinitely long journal bearing (Petroff’s solution), FiniteBearings, Design of hydrodynamic journal bearings

**Unit 5:** Hydrostatic, squeeze film Circular and rectangular flat plates, variable and alternating loads, piston pin lubrications, application to journal bearings.

**Unit 6:** Elasto-hydrodynamic lubrication – pressure viscosity term in Reynolds’s equation, Hertz’ theory, Ertel-Grubin equation, lubrication of spheres, gear teeth and rolling element bearings, Air lubricated bearings, Tilting pad bearings,

#### References:

1. Cameron, “Basic Lubrication Theory”, Ellis Horwood Ltd, 1981.
2. Principles in Tribology, Edited by J. Halling, 1975
3. Fundamentals of Fluid Film Lubrication – B. J. Hamrock, McGraw Hill International, 1994

4. D.D. Fuller, "Theory and Practice of Lubrication for Engineers", John Wiley and Sons, 1984.
5. "Fundamentals of Friction and wear of Materials" American Society of Metals.
6. Introduction to Tribology of Bearings –B. C. Majumdar, A. H. Wheeler &co. Pvt. Ltd 1985.
7. T.A. Stolarski, "Tribology in Machine Design".

## Robotics

### Ting Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of the course students will be able to

1. understand basic terminologies and concepts associated with Robotics and Automation
2. demonstrate comprehension of various Robotic sub-systems
3. understand kinematics and dynamics to explain exact working pattern of robots
4. aware of the associated recent updates in Robotics

### Syllabus Contents

#### Unit 1 Introduction:

Basic Concepts such as Definition, three laws, DOF, Misunderstood devices etc., Elements of Robotic Systems i.e. Robot anatomy, Classification, Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device, etc. Automation - Concept, Need, Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, introduction to automation productivity.

#### Unit 2 Robot Grippers:

Types of Grippers , Design aspect for gripper, Force analysis for various basic gripper system. Sensors for Robots:- Characteristics of sensing devices, Selections of sensors, Classification and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot.

#### Unit 3 Drives and control systems:

Types of Drives, Actuators and its selection while designing a robot system. Types of transmission systems,

Control Systems -Types of Controllers, Introduction to closed loop control Control Technologies in Automation:- Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process and its Forms. Control System Components such as Sensors, Actuators and others.

#### Unit 4 Kinematics:

Transformation matrices and their arithmetic, link and joint description, Denavit - Hartenberg

parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics, solvability, algebraic and geometrical methods. Velocities and Static forces in manipulators:- Jacobians, singularities, static forces, Jacobian in force domain.

Dynamics:- Introduction to Dynamics , Trajectory generations

**Unit 5 Machine Vision System:**

Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques , Noise reduction methods, Edge detection, Segmentation. Robot Programming :- Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Introduction to various types such as RAIL and VAL II etc, Features of type and development of languages for recent robot systems.

**Unit 6 Modeling and Simulation for manufacturing Plant Automation:**

Introduction, need for system Modeling, Building Mathematical Model of a manufacturing Plant, Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing, Fuzzy decision and control, robots and application of robots for automation.

Artificial Intelligence:- Introduction to Artificial Intelligence, AI techniques, Need and application of AI. Other Topics in Robotics:- Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and associated mass, New Trends & recent updates in robotics

**References:**

**Text Books:**

1. John J. Craig, Introduction to Robotics (Mechanics and Control), Addison-Wesley, 2<sup>nd</sup> Edition, 04
2. Mikell P. Groover et. Al., Industrial Robotics: Technology, Programming and Applications, McGraw – Hill International, 1986.
3. Shimon Y. Nof , Handbook of Industrial Robotics , John Wiley Co, 01.
4. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
5. Industrial Automation: W.P. David, John Wiley and Sons.

**Reference Books:**

1. Richard D. Klafter , Thomas A. Chmielowski, Michael Negin, Robotic Engineering : An Integrated Approach , Prentice Hall India, 02.
2. Handbook of design, manufacturing & Automation: R.C. Dorf, John Wiley and Sons.

**Fracture Mechanics**

**Ting Scheme**

**Lectures: 3 hrs/week**

**Course Outcomes:**

**At the end of the course:**

1. Students will be able to use any one of the four parameters for finding out damage tolerance: stress intensity factor, energy release rate, J integral, Crack tip opening displacement.
2. Students will be able to manage singularity at crack tip using complex variable.
3. Students will understand important role played by plastic zone at the crack tip.
4. Students will learn modern fatigue and will able to calculate the fatigue life of a component with or without crack in it.
5. Students will learn modern sophisticated experimental techniques to determine fracture toughness and stress intensity factor.
- 6.

**Syllabus Contents:**

**Unit 1:** Modes of fracture failure, Brittle and ductile fracture,

**Unit 2:** Energy release rate: crack resistance, stable and unstable crack growth.

**Unit 3:** Stress intensity factor: Stress and displacement fields, edge cracks, embedded cracks.

**Unit 4:** Crack tip plasticity: Shape and size of plastic zone, effective crack length, effect of plate thickness, J-Integral. Crack tip opening displacement.

**Unit 5:** Test methods for determining critical energy release rate, critical stress intensity factor, J-Integral.

**Unit 6:** Fatigue failure: Crack propagation, effect of an overload, crack closure, variable amplitude fatigue load. Environment-assisted cracking. Dynamic mode crack initiation and growth, various crack detection techniques.

**References:**

1. Brook D, "Elementary engineering fracture mechanics".
2. Liebowitz H., "Fracture" Volume I to VII.
3. A Nadai, W. S. Hemp, "Theory of flow and fracture of solids", McGraw Hill Book Company, 1950.

**Multi-body Dynamics**

**Ting Scheme**

Lectures: 3 hrs/week

**Course Outcomes:** At the end of this course, the students will be able to:

1. Derive equations of motion for interconnected bodies in multi-body systems with three-dimensional motion.
2. Implement and analyze methods of formulating equations of motion for interconnected bodies.
3. Write programs to solve constrained differential equations for analyzing multi-body systems.
4. Simulate and analyze all types of static and dynamic behaviors of the multi-body systems including the kineto-static analysis.
5. Lead team projects in academic research or the industry that require modeling and simulation of multi-body systems.
6. Demonstrate an improved technical writing and presentation skills.

## Syllabus Contents

### Unit 1. Introduction:

The method of constraints for planar kinematic analysis. Revolute, prismatic, gear and cam pairs are considered together with other 2 degrees-of-freedom types of constraints.

### Unit 2. Basic principles for analysis of multi-body systems:

The automatic assembly of the systems of equations for position, velocity and acceleration analysis. Iterative solution of systems of non linear equations. Geometry of masses. The principle of virtual work and Lagrange's equations.

### Unit 3. Dynamics of Planar Systems:

Dynamics of planar systems. Systematic computation and assembly of mass matrix. Computation of planar generalized forces for external forces and for actuator-spring-damper element. Simple applications of inverse and forward dynamic analysis. Numerical integration of first-order initial-value problems. The method of Baumgarte for the solution of mixed differential-algebraic equations of motion. The use of coordinates partitioning, QR and SVD decomposition for the orthogonalization of constraints.

### Unit 4. Kinematics of rigid bodies in space:

Reference frames for the location of a body in space. Euler angles and Euler parameters. The formula of Rodrigues. Screw motion in space. Velocity, acceleration and angular velocity. Relationship between the angular velocity vector and the time derivatives of Euler parameters.

### Unit 5. Kinematic analysis of spatial systems:

Basic kinematic constraints. Joint definition frames. The constraints required for the description in space of common kinematic pairs (revolute, prismatic, cylindrical, spherical). Equations of motion of constrained spatial systems.

### Unit 6. Computation of Forces:

Computation of spatial generalized forces for external forces and for actuator-spring-damper element. Computation of reaction forces from Lagrange's multipliers.

### References:

1. Wittenburg, J., *Dynamics of Systems of Rigid Bodies*, B.G. Teubner, Stuttgart, 1977.
2. Kane, T.R, Levinson, D.A., *Dynamics: Theory and Applications*, McGraw-Hill Book Co., 1985.
3. Nikravesh, P.E., *Computer Aided Analysis of Mechanical Systems*, Prentice-Hall Inc., Englewood Cliffs, NJ, 1988.
4. Roberson, R.E., Schwertassek, R., *Dynamics of Multibody Systems*, Springer-Verlag, Berlin, 1988.
5. Haug, E.J., *Computer-Aided Kinematics and Dynamics of Mechanical Systems-Basic Methods*, Allyn and Bacon, 1989.
6. Huston, R.L., *Multibody Dynamics*, Butterworth-Heinemann, 1990.
7. Schielen, W. ed., *Multibody Systems Handbook*, Springer-Verlag, Berlin, 1990.
8. de Jalon, J.C., Bayo, E., *Kinematic and Dynamic Simulation of Multibody Systems*, Springer-Verlag, 1994.

9. Shabana, A.A., *Computational Dynamics*, John Wiley & Sons, 1994.

Reference

Books:

1. "Why Do Multi-Body System Simulation?" by Rajiv Rampalli, Gabriele Ferrarotti & Michael Hoffmann, Published NAFEMS Publications, January 12
2. "Principles of Dynamics" by Donald T. Greenwood, 2nd ed., Prentice Hall

### Condition Based Monitoring

#### Ting Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

1. to know and be able to explain the aim and the basics of CM
2. be aware of some methods and procedures applied for general CM;
3. appreciate and understand the basic idea behind vibration-based structural health monitoring and vibration-based condition monitoring, know the general stages of CM;
4. be able to apply some basic techniques for analysis of random and periodic signals;
5. know the basics of Vibration of Linear Systems: time and frequency response, resonance;
6. be aware of some basic instrumentation used for machinery and structural vibration-based monitoring;
7. be aware of some basic faults in rotating machinery, their manifestation and methods for detection and recognition: low frequency, medium frequency and high frequency

#### Syllabus Contents

**Unit 1.** The basic idea of health monitoring and condition monitoring of structures and machines. Some basic techniques.

**Unit 2.** Basics of signal processing: Study of periodic and random signals, probability distribution, statistical properties, auto and cross correlation and power spectral density functions of commonly found systems, spectral analysis.

**Unit 3.** Fourier transform: the basic idea of Fourier transform, interpretation and application to real signals. Response of linear systems to stationary random signals: FRFs, resonant frequencies, modes of vibration,

**Unit 4.** Introduction to vibration-based monitoring, Machinery condition monitoring by vibration analysis: Use and selection of measurements, analysis procedures and instruments,

**Unit 5.** Typical applications of condition monitoring using vibration analysis to rotating machines,

**Unit 6.** Some other health monitoring techniques, acoustic emission, oil debris and temperature analysis, Applications.

#### References:

1. M.Adams, Rotating machinery analysis - from analysis to troubleshooting, Marcel Dekker, New York, 01, ISBN 0-8247-0258-1.
2. Cornelius Scheffer Paresh Girdhar, **Practical Machinery Vibration Analysis and Predictive Maintenance**, Newnes, 1st Edition, 04, **Paperback ISBN: 9780750662758**

| <b>Optimization Techniques in Design</b>   |  |
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| <b>Ting Scheme</b><br>Lectures: 3 hrs/week   |  |
| <b>Course Outcomes:</b><br>At the end of the course: <ol style="list-style-type: none"> <li>1. Students will know the principles of optimization.</li> <li>2. Students will have knowledge of algorithms for design optimization</li> <li>3. Students will be able to formulate an optimization problem.</li> <li>4. Students should be able to find the optimum solution of their problems using optimization techniques.</li> </ol>  |  |
| <b>Syllabus Contents:</b><br>Unit 1: Introduction to optimization, classification of optimisation problems, classical optimization techniques,<br>Unit 2: Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar’s methods,<br>Unit 3: Non-Linear Programming: - One dimensional minimization, unconstrained and constrained minimization, direct and indirect methods,<br>Unit 4: Geometric programming, Optimum design of mechanical elements like beams, columns, gears, shafts, etc.<br>Unit 5: Introduction to Genetic Algorithms, Operators, applications to engineering optimization problems.  |  |
| <b>References:</b> <ol style="list-style-type: none"> <li>1. S. S. Stricker, “Optimising performance of energy systems” Battelle Press, New York, 1985.</li> <li>2. R.C. Johnson, “Optimum Design of Mechanical Elements”, Willey, New York, 1980.</li> <li>3. J. S. Arora, “Introduction to Optimum Design”, McGraw Hill, New York, 1989.</li> <li>4. Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice Hall of India, New Delhi, 05</li> <li>5. L.C.W. Dixon, “Non-Linear Optimisation - Theory and Algorithms”, Birkhauser, Boston, 1980.</li> <li>6. R.J. Duffin, E.L. Peterson and C.Zener “Geometric Programming-Theory and Applications”, Willey, New York, 1967.</li> <li>7. G.B. Dantzig “Linear Programming and Extensions Princeton University Press”, Princeton, N. J., 1963.</li> <li>8. R. Bellman “Dynamic Programming-Princeton” University Press, Princeton, N.J. 1957.</li> </ol> |  |

| <b>Advanced Finite Element Method</b>   |  |
|---|--|
| <b>Ting Scheme</b><br>Lectures: 3 hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of the course, the students will be able to |  |

1. Demonstrate understanding of FE formulation for linear problems in solid mechanics
2. Understand behaviour of elastic-plastic materials and visco-plasticity, Use of Newton-Raphson method for solving nonlinear equations of equilibrium
3. Understand flow rules and strain hardening, loading and unloading conditions, Drucker's stability postulates, J2 flow of theory of plasticity
4. Demonstrate use of FE formulation to solve the problems of large deformation of structures under loads
5. Able to solve contact problems by using the techniques of non-linear FEM

### Syllabus Contents

#### Unit 1. Review of linear FEA:

FE formulation of 1D bar, 3D linear elastic continuum, 2D plane strain, plane stress, and axisymmetric elements; Iso-parametric mapping; numerical integration.

#### Unit 2. FE formulation for 1D plasticity:

Elastic-perfectly plastic material; Isotropic and kinematic hardening; Integration algorithms for 1D plasticity; FE formulation; Newton-Raphson method for solving nonlinear equilibrium equations; 1D visco-plasticity and integration algorithm.

#### Unit 3. Continuum theories of plasticity:

Review of tensor algebra; Yield condition, flow rule and hardening rules; loading and unloading conditions; Drucker's stability postulates; Convexity and normality; J2 flow theory of plasticity and visco-plasticity, Gurson model.

#### Unit 4. FE procedures for 2D and 3D plasticity:

Integration algorithms for rate independent plasticity—explicit forward Euler and implicit backward Euler; Return mapping algorithm; visco-plasticity; FE formulation; Consistent linearization; Algorithmic and consistent tangent moduli; Treatment of incompressible deformation (Locking); B-bar method.

#### Unit 5. FE procedures for large deformation problems:

Continuum mechanics—deformation gradient, polar decomposition, Green-Lagrange strain, rate of deformation, Cauchy stress, P-K stresses, Balance laws; Principle of objectivity and isotropy; Constitutive equations for hyperelasticity; Neo-Hookean model; FE formulation—Total Lagrangian and updated Lagrangian descriptions; Tangent Stiffness Matrix. Introduction to finite strain plasticity.

#### Unit 6. Contact Problems:

Condition of impenetrability; Gap elements for modelling contact; Tangent stiffness matrix and force vectors for 2D frictionless contact problems.

#### References:

- 1) K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi, 1996
- 2) J. C. Simo and T. J. R. Hughes, Computational Inelasticity, Springer-Verlag New York, Inc., New York, 1998
- 3) O. C. Zienkiewicz and R. L. Taylor, Finite Element Method: Volume 2 Solid Mechanics, Fifth Edition, Butterworth-Heinemann, Oxford, 00



- 4) T. Belytschko and W. K. Liu and B. Moran, Nonlinear Finite Elements for Continua and Structures, John Wiley & Sons Ltd., England, 00  
 5) D. R. J. Owen and E. Hinton, Finite Elements in Plasticity: Theory and Practice, Pineridge Press Ltd., 00

### Advanced Metallurgy

**Ting Scheme**  
**Lectures: 3 hrs/week**

**Course Outcomes:**

At the end of the course, the students will be able to:

1. Demonstrate understanding of various aspects of crystal and lattice structure and their imperfection
2. Understand importance of equilibrium diagrams and their uses in developing materials
3. Understand the process of heat treatment of different nonferrous alloys and tool steel and decide a heat treatment to acquire their desired properties
4. Demonstrate acquisition of knowledge of composites, ceramics, orthodontal and bio-materials

**Syllabus Contents:**

**Unit 1.** Aspects of Physical Metallurgy: Crystal structure, systems and Barvias lattices, Indexing of lattice planes (Miller's Indices), Indexing of lattice directions, Co-ordination Number (Ligency), Density calculations and imperfections in crystals

**Unit 2.** Study of Equilibrium diagrams for Fe-C systems, Cu - Bronze alloys i.e. Cu:Zn, Cu:Sn, Cu:Al etc., Developments in metallic materials like HSLA state, maraging steels, dual phased steels, creep resisting steels, materials for high and low temperature applications, Nimerics, Inconels, Haste Alloys etc., Al, Ni alloys, Ti, Mg alloys.

**Unit 3.** Heat Treatment of Nonferrous alloys, Heat Treatment of Tool steels

**Unit 4.** Orthodontal materials, Bio material, Prosthetic materials, Nano materials, super conducting materials, sports materials.

**Unit 5.** Composites, ceramics, cermets, shape memory alloys their manufacturing techniques, advantages and limitations.

**Unit 6.** Surface coatings and their tribological aspects. PVD, CVD, IVD ion implantation method.

**Reference Books**

1. Engineering Metallurgy, R. A. Higgins, Viva Books Pvt. Ltd.
2. Elements of Material Science and Engineering, Lawrence H., Van Vlack Addison-

Wesley Publishing Company

3. Principles of Material Science and Engineering, William F. Smith, McGraw-Hill Book Co.
4. Material Science, R. B. Gupta, Satya Publications, New Delhi.
5. A Text Book of Material Science and Metallurgy, O. P. Khanna, Dhanpat Rai and Sons, New Delhi.
6. Material Science and Engineering an Introduction, William D. Callister, Jr., John Wiley and Sons Inc.
7. Smithells Metals Reference Book, E. A. Brandes and G. B. Brook, Butterworth Heinemann.
8. Biomaterials and Bioengineering Handbook, Donald L. Wise, Marcel Dekker Inc.

### Dissertation (Phase-I)

#### Ting Scheme

Lectures: hr/week

#### Course Outcomes:

At the end of the course:

1. Students will learn to survey the relevant literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.
1. Students will be able to use different experimental techniques.
2. Students will be able to use different software/ computational/analytical tools.
3. Students will be able to design and develop an experimental set up/ equipment/test rig.
4. Students will be able to conduct tests on existing set ups/equipments and draw logical conclusions from the results after analyzing them.
5. Students will be able to either work in a research environment or in an industrial environment.

#### Syllabus Contents:

The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. Seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by Head and PG coordinator. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

### Dissertation (Phase- II)

|  |  |
|--|--|
| <b>Ting Scheme</b><br>Practical Hours: 32 per week   |  |
| <b>Course Outcomes:</b><br>At the end of the course:   |  |
| <ol style="list-style-type: none"> <li>1. Students will develop attitude of lifelong learning and will develop interpersonal skills to deal with people working in diversified field will.</li> <li>2. Students will learn to write technical reports and research papers to publish at national and international level.</li> <li>3. Students will develop strong communication skills to defend their work in front of technically qualified audience.</li> </ol>  |  |
| <b>Syllabus Contents:</b>  |  |
| <p>It is a continuation of Project work started in semester III. He has to submit the report in prescribed format and also present a seminar. The dissertation should be presented in standard format as provided by the department. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study. . The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc. as decided by the Head and PG coordinator. The candidate has to be in regular contact with his guide.</p> |  |

## OPEN ELECTIVES

### Business Analytics

#### Teaching scheme

**Lecture: - 3 h/week**

|                      |                           |
|----------------------|---------------------------|
| <b>Course Code</b>   |                           |
| <b>Course Name</b>   | <b>Business Analytics</b> |
| <b>Credits</b>       |                           |
| <b>Prerequisites</b> |                           |

Total Number of Lectures: 48

|   |
|---|
| <b>Course objective</b>   |
| <ol style="list-style-type: none"> <li>1. Understand the role of business analytics within an organization.</li> <li>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.</li> <li>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.</li> <li>4. To become familiar with processes needed to develop, report, and analyze business data.</li> <li>5. Use decision-making tools/Operations research techniques.</li> </ol> |

|    |  |
|----|--|
| 6. | Mange business process using analytical and management tools.  |
| 7. | Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| LECTURE WITH BREAKUP   | NO. OF LECTURES |
|--|-----------------|
| <p><b>Unit1:</b><br/>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br/>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p>  | 9               |
| <p><b>Unit 2:</b><br/>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br/>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.</p>   | 8               |
| <p><b>Unit 3:</b><br/>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br/>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.</p>   | 9               |
| <p><b>Unit 4:</b><br/>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br/>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.</p> | 10              |
| <p><b>Unit 5:</b><br/>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.</p>   | 8               |
| <p><b>Unit 6:</b><br/>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.</p>  | 4               |

|                        |  |
|------------------------|--|
| <b>COURSE OUTCOMES</b> |  |
|------------------------|--|

- |   |
|---|
| <ol style="list-style-type: none"><li>1. Students will demonstrate knowledge of data analytics.</li><li>2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.</li><li>3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.</li><li>4. Students will demonstrate the ability to translate data into clear, actionable insights.</li></ol> |
|---|

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

**OPEN ELECTIVES**  
**Industrial Safety**

**Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

**OPEN ELECTIVES**

**Operations Research**

**Teaching Scheme**

Lectures: 3 hrs/week

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**Course Outcomes:** At the end of the course, the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

### **Unit 5**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

### **References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

## **Open Elective**

### **Cost Management of Engineering Projects**

#### **Teaching scheme**

**Lecture: - 3 h/week**

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Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

**Open Elective**

**Composite Materials**

**Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III: Manufacturing of Metal Matrix Composites:** Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT-IV: Manufacturing of Polymer Matrix Composites:** Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V: Strength:** Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**



1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

### References:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## Open Elective

### Waste to Energy

#### Teaching scheme

**Lecture: - 3 h/week**

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**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

**AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING**

| <b>Course objectives:</b>  |  |       |
|--|--|-------|
| Students will be able to:  |  |       |
| <ol style="list-style-type: none"> <li>1. Understand that how to improve your writing skills and level of readability</li> <li>2. Learn about what to write in each section</li> <li>3. Understand the skills needed when writing a Title</li> </ol> |  |       |
| Ensure the good quality of paper at very first-time submission   |  |       |
| <b>Syllabus</b>  |  |       |
| Units  | CONTENTS   | Hours |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4     |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4     |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4     |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4     |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4     |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4     |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

**AUDIT 1 and 2: DISASTER MANAGEMENT**

| <b>Course Objectives:</b> -Students will be able to:  |   |       |
|---|---|-------|
| 1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.  |   |       |
| 2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.  |   |       |
| 3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.   |   |       |
| 4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in |   |       |
| <b>Syllabus</b>   |   |       |
| Units   | CONTENTS  | Hours |
| 1   | <b>Introduction</b><br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.  | 4     |
| 2   | <b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4     |
| 3   | <b>Disaster Prone Areas In India</b><br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics  | 4     |
| 4   | <b>Disaster Preparedness And Management</b><br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.   | 4     |
| 5   | <b>Risk Assessment</b><br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.   | 4     |
| 6   | <b>Disaster Mitigation</b><br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.   | 4     |

### **SUGGESTED READINGS:**

1. R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies” ,Deep &Deep Publication Pvt. Ltd., New Delhi.

### **AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE**

#### ***Course Objectives***

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

#### ***Syllabus***

| <b>Unit</b> | <b>Content</b>  | <b>Hours</b> |
|-------------|---|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul>          | 8            |
| 2           | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8            |
| 3           | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8            |

#### ***Suggested reading***

1. “Abhyaspustakam” – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

#### ***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

### AUDIT 1 and 2: VALUE EDUCATION

#### *Course Objectives*

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

#### *Syllabus*

| <b>Unit</b> | <b>Content</b>   | <b>Hours</b> |
|-------------|--|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul>  | 4            |
| 2           | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty, Humanity. Power of faith, National Unity.</li> <li>• Patriotism. Love for nature ,Discipline</li> </ul>   | 6            |
| 3           | <ul style="list-style-type: none"> <li>• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> <li>• Doing best for saving nature</li> </ul> | 6            |
| 4           | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality, Nonviolence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind, Self-control.</li> <li>• Honesty, Studying effectively</li> </ul>  | 6            |

|  |  |  |
|--|--|--|
|  |  |  |
|--|--|--|

**Suggested reading**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

**Course outcomes**

Students will be able to

- 1.Knowledge of self-development
- 2.Learn the importance of Human values
- 3.Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

|   |   |              |
|---|---|--------------|
| <b>Course Objectives:</b>   |   |              |
| Students will be able to:   |   |              |
| <ol style="list-style-type: none"> <li>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>2. To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</li> <li>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ol> |   |              |
| <b>Syllabus</b>   |   |              |
| <b>Units</b>  | <b>Content</b>  | <b>Hours</b> |
| <b>1</b>  | <ul style="list-style-type: none"> <li>• <b>History of Making of the Indian Constitution:</b></li> <li>History</li> <li>Drafting Committee, ( Composition &amp; Working)</li> </ul>   | 4            |
| <b>2</b>  | <ul style="list-style-type: none"> <li>• <b>Philosophy of the Indian Constitution:</b></li> <li>Preamble</li> <li>Salient Features</li> </ul>   | 4            |
| <b>3</b>  | <ul style="list-style-type: none"> <li>• <b>Contours of Constitutional Rights &amp; Duties:</b></li> <li>• Fundamental Rights</li> <li>• Right to Equality</li> <li>• Right to Freedom</li> <li>• Right against Exploitation</li> <li>• Right to Freedom of Religion</li> <li>• Cultural and Educational Rights</li> <li>• Right to Constitutional Remedies</li> <li>• Directive Principles of State Policy</li> <li>• Fundamental Duties.</li> </ul> | 4            |
| <b>4</b>  | <ul style="list-style-type: none"> <li>• <b>Organs of Governance:</b></li> </ul>  | 4            |

|          |  |   |
|----------|--|---|
|          | <ul style="list-style-type: none"> <li>• Parliament</li> <li>• Composition</li> <li>• Qualifications and Disqualifications</li> <li>• Powers and Functions                         <ul style="list-style-type: none"> <li>• Executive</li> </ul> </li> <li>• President</li> <li>• Governor</li> <li>• Council of Ministers</li> <li>• Judiciary, Appointment and Transfer of Judges, Qualifications</li> <li>• Powers and Functions</li> </ul>   |   |
| <b>5</b> | <ul style="list-style-type: none"> <li>• <b>Local Administration:</b></li> <li>• District's Administration head: Role and Importance,</li> <li>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.</li> <li>• Pachayati raj: Introduction, PRI: Zila Pachayat.</li> <li>• Elected officials and their roles, CEO Zila Pachayat: Position and role.</li> <li>• Block level: Organizational Hierarchy (Different departments),</li> <li>• Village level: Role of Elected and Appointed officials,</li> <li>• Importance of grass root democracy</li> </ul> | 4 |
| <b>6</b> | <ul style="list-style-type: none"> <li>• <b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul>   | 4 |

**Suggested reading**

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**Course Outcomes:**

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

**AUDIT 1 and 2: PEDAGOGY STUDIES**

**Course Objectives:**

| Students will be able to:  |   |              |
|--|---|--------------|
| 4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers. |   |              |
| 5. Identify critical evidence gaps to guide the development.   |   |              |
| <b>Syllabus</b>  |   |              |
| <b>Units</b>   | <b>Content</b>  | <b>Hours</b> |
| <b>1</b>   | <ul style="list-style-type: none"> <li>• <b>Introduction and Methodology:</b></li> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> <li>• Overview of methodology and Searching.</li> </ul>  | 4            |
| <b>2</b>   | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>  | 2            |
| <b>3</b>   | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers' attitudes and beliefs and Pedagogical strategies.</li> </ul> | 4            |
| <b>4</b>   | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul>  | 4            |
| <b>5</b>   | <ul style="list-style-type: none"> <li>• <b>Research gaps and future directions</b></li> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> <li>• Dissemination and research impact.</li> </ul>   | 2            |

### **Suggested reading**

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.



3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf).

### **Course Outcomes:**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?
- 4.

## **AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA**

### ***Course Objectives***

1. To achieve overall health of body and mind
2. To overcome stress

### ***Syllabus***

| <b>Unit</b> | <b>Content</b>   | <b>Hours</b> |
|-------------|--|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>  | 8            |
| 2           | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> </ul> Do`s and Don`t`s in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan  | 8            |
| 3           | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> </ul> i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-<br>Types of pranayam | 8            |

### ***Suggested reading***

1. ‘Yogic Asanas for Group Training-Part-I’ : Janardan Swami Yogabhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

### **Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

## **AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**

### ***Course Objectives***

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination

3. To awaken wisdom in students

**Syllabus**

| Unit | Content  | Hours |
|------|--|-------|
| 1    | Neetisatakam-Holistic development of personality <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont's)</li> <li>• Verses- 71,73,75,78 (do's)</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>  | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8     |

**Suggested reading**

1. “Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication

Department), Kolkata

2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath,Rashtriya Sanskrit Sansthanam, New Delhi.

**Course Outcomes**

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life

2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity

3. Study of Neetishatakam will help in developing versatile personality of students.

MODEL CURRICULUM  
of  
Engineering & Technology PG Courses

# CHEMICAL ENGINEERING



**ALL INDIA COUNCIL FOR TECHNICAL EDUCATION**  
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070  
[www.aicte-india.org](http://www.aicte-india.org)

# M.Tech.(Chemical Engineering)

## Semester I

| Sr. No. | Course Type/Code        | Course Name  |
|---------|-------------------------|--|
| 1       | Core 1                  | Mathematical and Statistical Methods in Chemical Engineering     |
| 2       | Core 2                  | Advanced Separation Processes                                    |
| 3       | Prog. Specific Elective | Elective I<br>One from the list Electives I                      |
| 4       | Prog. Specific Elective | Elective – II<br>One from the list of Electives II               |
| 5       | Lab1                    | <b>Laboratory 0I: Process Modeling and Simulation laboratory</b> |
| 6       | Lab2                    | <b>Laboratory II Advanced separation processes</b>               |
| 7       |                         | Research Methodology and IPR                                     |
| 8       | Audit 1                 | Audit course   |

## Semester II

| Sr. No. | Course Code               | Course Name   |
|---------|---------------------------|---|
|         |                           |   |
| 1       | Core 3                    | Advanced transport phenomena                                |
| 2       | Core 4                    | Advanced Reaction Engineering                               |
| 3       | Program Specific Elective | <b>Elective – III</b><br>One from the list of Electives III |
| 4       | Program Specific Elective | <b>Elective – IV</b><br>One from the list of Electives III  |
| 5       | Lab 3                     | Advanced Chemical Reaction Engineering laboratory           |
| 6       | Lab 4                     | Advanced Chemical Engineering Laboratory                    |
| 7       |                           | Mini Project  |
| 8       | Aud2                      | Audit course 2  |

## Semester III

| Sr. No. | Course Code               | Course Name   |
|---------|---------------------------|---|
| 1.      | Program Specific Elective | <b>Elective – V</b><br>One from the list Electives V  |
| 2.      | Open Elective             | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials |

|    |              |                        |
|----|--------------|------------------------|
|    |              | 6. Waste to Energy     |
| 3. | Dissertation | Dissertation Phase – I |

| Sr. No. | Course Code  | Course Name             |
|---------|--------------|-------------------------|
| 1.      | Dissertation | Dissertation Phase – II |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

### Semester I

| Sr. No. | Course Type/Code        | Course Name   | Teaching Scheme Hrs/Week |          |          | Credits   |
|---------|-------------------------|---|--------------------------|----------|----------|-----------|
|         |                         |   | L                        | T        | P        |           |
| 1       | Core 1                  | Mathematical and Statistical Methods in Chemical Engineering    | 3                        | 0        | 0        | 3         |
| 2       | Core 2                  | Advanced Separation Processes                                   | 3                        | 0        | 0        | 3         |
| 3       | Prog. Specific Elective | Elective I<br>One from the list Electives I                     | 3                        | 0        | 0        | 3         |
| 4       | Prog. Specific Elective | Elective – II<br>One from the list of Electives II              | 3                        | 0        | 0        | 3         |
| 5       | Lab1                    | <b>Laboratory 0I:Process Modeling and Simulation laboratory</b> | 0                        | 0        | 4        | 2         |
| 6       | Lab2                    | <b>Laboratory II Advanced separation processes</b>              | 0                        | 0        | 4        | 2         |
| 7       |                         | Research Methodology and IPR                                    | 2                        | 0        | 0        | 2         |
| 8       | Audit 1                 | Audit course  | 2                        | 0        | 0        | 0         |
|         |                         | <b>Total</b>  | <b>16</b>                | <b>0</b> | <b>8</b> | <b>18</b> |

### Semester II

| Sr. No. | Course Code               | Course Name   | Teaching Scheme Hrs/Week |   |   | Credits |
|---------|---------------------------|---|--------------------------|---|---|---------|
|         |                           |   | L                        | T | P |         |
| 1       | Core 3                    | Advanced transport phenomena                                | 3                        | 0 | 0 | 3       |
| 2       | Core 4                    | Advanced Reaction Engineering                               | 3                        | 0 | 0 | 3       |
| 3       | Program Specific Elective | <b>Elective – III</b><br>One from the list of Electives III | 3                        | 0 | 0 | 3       |
| 4       | Program Specific Elective | <b>Elective – IV</b><br>One from the list of Electives III  | 3                        | 0 | 0 | 3       |
| 5       | Lab 3                     | Advanced Chemical Reaction Engineering laboratory           | 0                        | 0 | 4 | 2       |
| 6       | Lab 4                     | Advanced Chemical Engineering Laboratory                    | 0                        | 0 | 4 | 2       |
| 7       |                           | Mini Project  | 0                        | 0 | 4 | 2       |
| 8       | Aud2                      | Audit course 2  | 2                        | 0 | 0 | 0       |

|  |  |              |           |          |           |           |
|--|--|--------------|-----------|----------|-----------|-----------|
|  |  | <b>Total</b> | <b>14</b> | <b>0</b> | <b>12</b> | <b>18</b> |
|--|--|--------------|-----------|----------|-----------|-----------|

**Semester-III**

| Sr. No. | Course Code               | Course Name   | Teaching Scheme |          |           | Credits   |
|---------|---------------------------|---|-----------------|----------|-----------|-----------|
|         |                           |   | Hrs/Week        |          |           |           |
| 1.      | Program Specific Elective | <b>Elective – V</b><br>One from the list Electives V  | 3               | 0        | 0         | 3         |
| 2.      | Open Elective             | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3               | 0        | 0         | 3         |
| 3.      | Dissertation              | Dissertation Phase – I  | 0               | 0        | 20        | 10        |
|         |                           | <b>Total</b>  | <b>06</b>       | <b>0</b> | <b>20</b> | <b>16</b> |

**Semester-IV**

| Sr. No. | Course Code  | Course Name             | Teaching Scheme |           |           | Credits   |
|---------|--------------|-------------------------|-----------------|-----------|-----------|-----------|
|         |              |                         | L               | T         | P         |           |
| 1.      | Dissertation | Dissertation Phase – II | --              | --        | 32        | 16        |
|         |              | <b>Total</b>            | <b>--</b>       | <b>--</b> | <b>--</b> | <b>16</b> |

Total

68

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies



7. Stress Management by Yoga

8. Personality Development through Life Enlightenment Skills.

**List of Electives**

[Elective – III] (a): Modern concepts in Catalysis and Surface Phenomenon III

[Elective – III] (b): Advanced Downstream Processes

[Elective – III] (c): Computational Fluid Dynamics

[Elective – III] (d): Bioprocess Engineering

[Elective – IV] (a): Process Intensification I

[Elective – IV] (b): Phase transitions in Process Equipment II

[Elective – IV] (c): Micro and Nano fluidics III

[Elective – IV] (d): Process Integration IV

[Elective – IV] (e): Transport in porous Media V

[Elective – IV] (f): Micro Flow Chemistry and Process Technology VI

[Elective – IV] (g): Process Plant Design & Flow sheeting VII

[Elective – I] (a): Process Design and Synthesis I

[Elective – I] (b): Chemical Reactor Analysis

[Elective – I] (c): Fluidization Engineering

[Elective – II] (a): Industrial Pollution Control II

[Elective – II] (b): Application of Nanotechnology in Chemical Engineering

[Elective – II] (c): Chemoinformatics

[Elective – V] (a): Design of Experiments and Parameter Estimation

[Elective – V] (b): Computer Aided Design

[Elective – V] (c): Cleaner Production

## Semester-I

### 1). Mathematical and Statistical Methods in Chemical Engineering

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives:

1. To give students an insight in various Chemical Engineering Processes using advanced Numerical and Statistical Methods.
2. To provide adequate background of Mathematics to deal with Chemical Engineering Problems
3. To understand research papers on relevant topics involving advanced Mathematics.
4. To study correlation and regression of multivariate data.
5. To evaluate Experimental design methods and statistical quality control measures.

#### Outcomes:

At the end of the course, the student will be able to:

1. Students should be able to solve system of linear algebraic equations
2. Students should be able to do numerical integrations of functions.
3. Students should be able to fit relationship between two data sets using linear, non-linear regression.
4. Students should be able to calculate maxima/minima and functions.

**Unit-1:** Equation Forms in Process Modeling, Introduction and Motivation, Linear and Nonlinear Algebraic Equation, Optimization based Formulations, ODE-IVPs and Differential Algebraic Equations, ODE-BVPs and PDEs, Abstract model forms. Fundamentals of Vector Spaces, Generalized concepts of vector space, sub-space, linear dependence, Concept of basis, dimension, norms defined on general vector spaces, Examples of norms defined on different vector spaces, Cauchy sequence and convergence, introduction to concept of completeness and Banach spaces, Inner product in a general vector space, Inner-product spaces and their examples, Cauchy-Schwartz inequality and orthogonal sets, Gram-Schmidt process and generation of orthogonal basis, well known orthogonal basis Matrix norms.

**Unit-2:** Problem Discretization Using Approximation Theory, Transformations and unified view of problems through the concept of transformations, classification of problems in numerical analysis, Problem discretization using approximation theory, Weierstrass theorem and polynomial approximations, Taylor series approximation, Finite difference method for solving ODE-BVPs with examples, Finite difference method for solving PDEs with examples, Newton's Method for solving nonlinear algebraic equation as an application of multivariable Taylor series, Introduction to polynomial interpolation, Polynomial and function interpolations, Orthogonal Collocations method for solving ODE-BVPs, Orthogonal Collocations method for solving ODE-BVPs with examples, Orthogonal Collocations method for solving PDEs with examples, Necessary and sufficient

conditions for unconstrained multivariate optimization, Least square approximations, Formulation and derivation of weighted linear least square estimation, Geometric interpretation of least squares Projections and least square solution, Function approximations and normal equation in any inner product space, Model Parameter Estimation using linear least squares method, Gauss Newton Method, Method of least squares for solving ODE-BVP, Gelarkin's method and generic equation forms arising in problem discretization, Errors in Discretization, Generic equation forms in transformed problems.

**Unit-3:** Solving Linear Algebraic Equations, System of linear algebraic equations, conditions for existence of solution - geometric interpretations (row picture and column picture), review of concepts of rank and fundamental theorem of linear algebra, Classification of solution approaches as direct and iterative, review of Gaussian elimination, Introduction to methods for solving sparse linear systems: Thomas algorithm for tridiagonal and block tridiagonal matrices, Block-diagonal, triangular and block-triangular systems, solution by matrix decomposition, Iterative methods: Derivation of Jacobi, Gauss-Seidel and successive over-relaxation methods, Convergence of iterative solution schemes: analysis of asymptotic behavior of linear difference equations using Eigen values, Convergence of iterative solution schemes with examples, Convergence of iterative solution schemes, Optimization based solution of linear algebraic equations, Matrix conditioning, examples of well conditioned and ill-conditioned linear systems.

**Unit-4:** Solving Nonlinear Algebraic Equations, Method of successive substitutions derivative free iterative solution approaches Secant method, regula-falsi method and Wegstein iterations, Modified Newton's method and quasi-Newton method with Broyden's update, Optimization based formulations and Levenberg-Marquardt method, Contraction mapping principle and introduction to convergence analysis.

**Unit-5:** Solving Ordinary Differential Equations, Initial Value Problems (ODE-IVPs), Introduction, Existence of Solutions (optional topic), Analytical Solutions of Linear ODE-IVPs, Analytical Solutions of Linear ODE-IVPs (contd.), Basic concepts in numerical solutions of ODE-IVP: step size and marching, concept of implicit and explicit methods, Taylor series based and Runge-Kutta methods: derivation and examples Runge-Kutta methods, Multi-step (predictor-corrector) approaches: derivations and examples, Multi-step (predictor-corrector) approaches: derivations and examples, Stability of ODE-IVP solvers, choice of step size and stability envelopes, Stability of ODE-IVP solvers (contd.), stiffness and variable step size implementation, Introduction to solution methods for differential algebraic equations (DAEs), Single shooting method for solving ODE-BVPs.

### References

- Gilbert Strang, Linear Algebra and Its Applications (4th Ed.), Wellesley Cambridge Press (2009).  
 Philips, G. M., Taylor, P. J. ; Theory and Applications of Numerical Analysis (2nd Ed.), Academic Press, 1996.  
 Gourdin, A. and M Boumhrat; Applied Numerical Methods. Prentice Hall India, New Delhi, (2000).  
 Gupta, S. K.; Numerical Methods for Engineers. Wiley Eastern, New Delhi, 1995.  
 Linz, P.; Theoretical Numerical Analysis, Dover, New York, (1979).  
 Gilbert Strang , Introduction to Applied Mathematics, Wellesley Cambridge Press (2009)

## 2). Advanced Separation Processes

### Teaching Scheme:

Lecture: 3 hrs/week

Objectives:

1. To familiarize students with various advanced aspects of separation processes and the selection of separation processes.
2. To enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design an absorber or a membrane unit to achieve a specified separation.
3. To introduce them to new trends used in the separation technologies.

Outcomes: At the end of the course, the student will be able to:

1. List situations where liquid–liquid extraction might be preferred to distillation, make a preliminary selection of a solvent using group-interaction rules, Size simple extraction equipment.
2. Differentiate between chemisorption and physical adsorption, List steps involved in adsorption of a solute, and which steps may control the rate of adsorption, Explain the concept of breakthrough in fixed-bed adsorption.
3. Explain how crystals grow, Explain the importance of supersaturation in crystallization. Describe effects of mixing on supersaturation, mass transfer, growth, and scale-up of crystallization.
4. Explain membrane processes in terms of the membrane, feed, sweep, retentate, permeate, and solute membrane interactions. Distinguish among microfiltration, ultrafiltration, nanofiltration, virus filtration, sterile filtration, filter-aid filtration, and reverse osmosis in terms of average pore size. Explain common idealized flow patterns in membrane modules.

**Unit-1:** Introduction: Conventional separation processes - Absorption, Adsorption, Conventional separation processes - Distillation, Drying, Conventional separation processes - Extraction, Diffusion, Conventional separation processes - Leaching, Crystallisation, Advances in separation techniques based on size, Advances in separation techniques based on surface properties, Advances in separation techniques based on ionic properties, Cross flow filtration, Electro filtration, Dual functional filter, Surface based solid-liquid separations involving a second liquid, Sirofloc filter

**Unit-2:** Bubble and Foam Fractionation: Nature of bubbles and foams, stability of foams, foam fractionation techniques, batch, continuous, single stage and multistage columns. Types and choice of membranes, Plate and frame, spiral wound membranes, Tubular and hollow fibre membrane reactors, Membrane Permeates: Dialysis, Reverse osmosis, Nanofiltration, ultrafiltration, microfiltration, Donnan dialysis, Ceramic membranes

**Unit-3:** Membrane Separation: Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, macro-filtration, ultra-filtration, reverse osmosis, electro-dialysis. Industrial applications.

**Unit-4:** Special Processes: Liquid membrane separation, super-critical extraction, adsorptive separation-pressure, vacuum and thermal swing, pervaporation and permeation, nano-separation.

**Unit-5:** Chromatographic Methods of Separation: Gel, solvent, ion and high performance liquid chromatography.

King C.J., “Separation Processes”, Tata McGraw Hill. 1982.

Nakagawa, O. V., “Membrane Science and Technology”, Marcel Dekker, 1992.

Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997  
Khoury F.M., "Multistage Separation Processes", 3rd Ed., CRC Press. 2004.  
Wankat P.C., "Separation Process Engineering", 2nd Ed., Prentice Hall.2006.  
Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed., Wiley.2006  
Basmadjian D., "Mass Transfer and Separation Processes: Principles and Applications", 2nd Ed., CRC Press.2007.  
Phillip C. Wankat , Separation Process Engineering (2nd Edition), Printice Hall,2007  
Rousseau, R. W., "Handbook of Separation Process Technology", John Wiley, New York, 2009.

### [Elective – I] (a): Process Design and Synthesis

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives:

1. To understand the systematic approaches for the development of conceptual chemical process designs
2. To learn the advances in problem formulation and software capabilities which offer the promise of a new generation of practical process synthesis techniques based directly on structural optimization.
3. Learning chemical process synthesis, analysis, and optimization principles
4. Product design and development procedure and Process life cycle assessment.

**Outcomes:** At the end of the course, the student will be able to:

1. Analyze alternative processes and equipment
2. Synthesize a chemical process flow sheet that would approximate the real process
3. Design best process flow sheet for a given product
4. Perform economic analysis related to process design and evaluate project profitability

#### Introduction

Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist process design. Process Flow sheet Models: An Introduction to Design, Chemical process synthesis, analysis and optimization. Introduction to commercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software

#### Product design and developments

Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety.

#### Reactor Networks

Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps

### **Synthesis of Separation Trains**

Criteria for selection of separation methods, selection of equipment: Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation - Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor flow rates for single columns, Residue curve basics, Non-ideal Distillation - Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns, Binary VLLE and pressure-swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interior structure

### **Heat Exchanger Network Synthesis**

Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming

### **References**

1. Douglas, J. "Conceptual Design of Chemical Processes", New York, NY: McGraw-Hill Science/Engineering/Math, 1988. ISBN: 0070177627.
2. Seider, W. D., J. D. Seader, and D. R. Lewin. "Product and Process Design Principles: Synthesis, Analysis, and Evaluation", 2nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.
3. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., "Analysis, Synthesis, and Design of Chemical Processes", 2nd Edition, 2002, Prentice Hall ISBN-10: 0-13-064792-6
4. Biegler L.T., Grossmann I.E. and Westerberg A.W., "Systematic Methods of Chemical Process Design", Prentice Hall, 1997.

### **[Elective – I] (b): Chemical Reactor Analysis**

#### **Teaching Scheme:**

Lecture: 3 hrs/week

#### **Objectives:**

1. To learn the heterogeneous catalyzed reactions and the models involved in reactor design
2. To study mass and heat transfer mechanisms in the different reactors
3. To appreciate the importance of both external and internal transport effects in gas-solid and liquid-solid systems
4. To design isothermal and non-isothermal reactors for heterogeneous catalytic reactions

**Course Outcomes:** At the end of the course, the student will be able to:

1. Evaluate heterogeneous reactor performance considering mass transfer limitations
2. Perform the energy balance and obtain concentration profiles in multiphase reactors.
3. Estimate the performance of multiphase reactors under non-isothermal conditions

**Unit-I:** Chemical factor affecting the choice of the reactor, fundamental mass, energy and momentum balance, Model for a semi-batch reactor, optimum operation policies and control strategies, optimal batch operation time, optimal temperature policies, stability of operation and transient behavior for mixed flow reactor. Transient CSTR analysis, Hot spot equation; Optimization using Lagrange multiplier, Poynting's maximum principle.

**Unit-II:** Fixed bed catalytic reactor: The importance and scale of fixed bed catalytic processes, factors in preliminary design, modeling of fixed bed reactor. Pseudo-homogeneous model, the multi-bed adiabatic reactor, auto-thermal operation, non-steady-state model with axial mixing, two dimensional pseudo-homogeneous models, heterogeneous models, global and intrinsic rates, Mechanism of catalytic reactions, Engineering properties of catalysts - BET surface area, pore volume, pore size, pore size distribution, one dimensional and two dimensional model equation.

**Unit-III:** Multiphase flow reactor: Types of multiphase flow reactors, packed columns, plate columns, empty columns, stirred vessel reactors. Development of rate equations for solid catalyzed fluid phase reactions; Estimation of kinetic parameters. External mass and heat transfer in catalyst particles. Stability and selectivity, Packed bed reactor, slurry reactor; Trickle bed reactor and fluidized bed reactor. Intra-particle heat and mass transfer - Wheeler's parallel pore model, random pore model of Wakao and Smith. deactivation of catalyst, Ideal and non-ideal flow in reactors.

**Unit-IV:** Design model for multiphase flow reactors, gas and liquid phase in completely mixed and plug flow, gas phase in plug flow and liquid phase in completely mixed flow, effective diffusion model, two zone model, specific design aspects, packed absorber, two-phase fixed bed reactor, plate column, spray tower, bubble reactor, stirred vessel reactor. Computer - aided reactor design.

**Unit-V:** Temperature effects in reactor: Introduction, well mixed system with steady feed, the stability and start-up of CSTR, limit cycles and oscillatory reactions, the plug flow reactors, tubular reactor, diffusion control, propagation of reaction zone.

Reference Books:

1. Froment G. F. and K.B. Bischoff, "Chemical Reactor Analysis and Design", John Wiley & Sons
2. Denbigh K. G. and J.C. Turner, "Chemical Reactor and Theory – an Introduction", 3<sup>rd</sup> edition Cambridge University Press.
3. Bruce Nauman, "Chemical Reactor Design", John Wiley & Sons
4. Elements of Chemical Reaction Engineering by H. Scott Fogler
5. Chemical Engineering Kinetics by J. M. Smith.
6. Chemical Reactor Design and Operation by K. R. Westerterp, W. P. M. Van Swaaij and A. A. C. M. Beenackers Reference
7. Chemical Reactor Analysis and Design by G. F. Froment and K. B. Bischoff

**[Elective – I] (c): Fluidization Engineering**

**Teaching Scheme:**

Lecture: 3 hrs/week

## Objectives

1. To study the phenomenon of fluidization with industrial processing objective
2. To study the various regimes of fluidization and their mapping.
3. To study the design of equipments based on fluidization technique

**Course Outcomes:** At the end of the course, the student will be able to:

1. Performing and understanding the behavior fluidization in fluidized bed
2. Evaluate the characterization of particles and power consumption in fluidization regimes
3. Understanding the applicability of the fluidized beds in chemical industries

## Introduction to fluidization and applications

Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons

## Mapping of fluidization regimes

characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

## Bubbling fluidized beds

Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

## Solids movement and Gas dispersion

Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds

Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems - measurements and models.

## Fluidized bed reactors

Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds.

Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size



## References

1. Levenspiel O. and Kunii D., "Fluidization Engineering", John Wiley, 1972
2. Liang-Shih Fan, "Gas-Liquid-Solid Fluidization Engineering", Butterworths, 1989

### [Elective – II] (a): Industrial Pollution Control

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives

1. To understand the importance of industrial pollution and its abatement
2. To study the underlying principles of industrial pollution control
3. To acquaint the students with case studies
4. Student should be able to design complete treatment system

**Course Outcomes:** At the end of the course, the student will be able to:

1. Recognize the causes and effects of environmental pollution
2. Analyze the mechanism of proliferation of pollution
3. Develop methods for pollution abatement and waste minimization
4. Design treatment methods for gas, liquid and solid wastes

#### Industries & Environment

Industrial scenario in India - Industrial activity and Environment - Uses of Water by industry - Sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey - Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests.

#### Industrial Noise pollution

Sources of noise pollution, characterization of noise pollution prevention & control of noise pollution, Factories Act 1948 for regulatory aspects of noise pollution.

#### Air Pollutant Abatement

Air pollutants scales of concentration, lapse rate and stability, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and its solutions, Gaussian plume models. Air pollution control methods, Source correction methods, Design concepts for pollution abatement systems for particulates and gases. Such as gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.

#### Waste water treatment processes

Design concepts for primary treatment, grid chambers and primary sedimentation basins, selection of treatment process flow diagram, elements of conceptual process design, design of thickener, biological treatment Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and analysis, determination of kinetic coefficients, activated sludge process. Design, trickling filter design considerations, advanced treatment processes, Study of environment pollution from process industries and their abatement:

Fertilizer, paper and pulp, inorganic acids, petroleum and petrochemicals, recovery of materials from process effluents.

### **Solid waste and Hazardous waste management**

Sources and classification, properties, public health aspects, Sanitary land fill design, Hazardous waste classification and rules, management strategies, Nuclear waste disposal Treatment methods – component separation, chemical and biological treatment, incineration, solidification and stabilization, and disposal methods, Latest Trends in solid waste management.

### **References**

1. Rao C.S., “Environmental Pollution Control Engineering”, 2nd edition
2. Mahajan S.P., “Pollution Control in Process Industries”.
3. Nemerow N.L., “Liquid waste of industry- theories, Practices and Treatment”, Addison Wesley, New York, 1971
4. Weber W.J., “Physico-Chemical Processes for water quality control”, Wiley Interscience New York, 1969
5. Strauss W., “Industrial Gas Cleaning”, Pergamon, London, 1975
6. Stern A.C., “Air pollution”, Volumes I to VI, academic Press, New York, 1968
7. Peterson and Gross .E Jr., “Hand Book of Noise Measurement”, 7th Edn, 2003.
8. Antony Milne, “Noise Pollution: Impact and Counter Measures”, David & Charles PLC, 2009.

### **[Elective – II] (b): Application of Nanotechnology in Chemical Engineering**

#### **Teaching Scheme:**

Lecture: 3 hrs/week

#### **Objectives**

1. To understand the fundamentals of the preparation and properties of nanomaterials from a chemical engineering perspective.
2. To gain knowledge of structure, properties, manufacturing, and applications of various nanomaterials and characterization methods in nanotechnology
3. To give a survey of the key processes, principles, and techniques used to build novel nanomaterials and assemblies of nanomaterials

**Course Outcomes:** At the end of the course, the student will be able to:

1. Understanding the different top down and bottom up approaches for nanoparticles
2. Get to know the different applications of nanoparticles in chemical engineering field.
3. Learning the characterization techniques for nanoparticles.

#### **Introduction**

Introduction to nanotechnology, Feynman’s Vision-There’s Plenty of Room at the Bottom, Classification of nanostructures, Nanoscale architecture, Chemical interactions at nanoscale, Types of carbon based nanomaterials, Synthesis of fullerenes, Graphene, Carbon nanotubes, Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography.

## **Approaches to Synthesis of Nanoscale Materials and characterization**

Top down approach, Bottom up approach Bottom-up vs. top-down fabrication; Top-down: Atomization, Sol gel technique, Arc discharge, Laser ablation, RF sputtering; Bottom-up: Chemical Vapor Deposition (CVD), Metal Oxide Chemical Vapor Deposition (MOCVD), Atomic layer deposition (ALD), Molecular beam Molecular self-assembly; Ultrasound assisted, microwave assisted, Mini, micro and nanoemulsion. Wet grinding method, Spray pyrolysis, Ultrasound assisted pyrolysis, atomization techniques. Surfactant based synthesis procedures, Types of molecular modeling methods. Size, shape, crystallinity, topology, chemistry analysis using X-ray imaging, Transmission Electron Microscopy, HRTEM, Scanning Electron Microscopy, SPM, AFM, STM, PSD, Zeta potential, DSC and TGA.

## **Semiconductors and Quantum dots**

Intrinsic semiconductors, Extrinsic semiconductors, Review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function, Applications: quantum well, wire, dot, Quantum cryptography

## **Polymer-based and Polymer-filled Nanocomposites**

Nanoscale Fillers, Nanofiber or Nanotube Fillers, Plate-like Nanofillers, Equi-axed Nanoparticle Fillers, Inorganic Filler Polymer Interfaces, Processing of Polymer Nanocomposites, Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing, Nanoparticle/Polymer Composite Processing: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, In-Situ Particle Processing Metal/Polymer Nanocomposites, Properties of nanocomposites.

### **Applications to Safety, Environment and Others**

Chemical and Biosensors- Classification and Main Parameters of Chemical and Biosensors, Nanostructured Materials for Sensing, Waste Water Treatment, Nanobiotechnology, Drug Delivery, Nanocoatings, Self cleaning Materials, Hydrophobic Nanoparticles, Photocatalysts, Biological nanomaterials, Nanoelectronics, Nanomachines & nanodevices, Societal, Health and Environmental Impacts.

## **References**

1. Louis Hornyak G., Dutta Joydeep, Tibbals Harry F. and Rao Anil K., "Introduction to Nanoscience", (CRC Press of Taylor and Francis Group LLC), May 2008, 856pp, ISBN-13: 978142004805
2. Ajayan P. M., Schadler L. S., Braun P. V., "Nanocomposite Science and Technology", Edited by WILEY-VCH Verlag GmbH Co. KGaA, Weinheim ISBN: 3-527-30359-6, 2003.
3. Kelsall Robert W., Hamley Ian W., GeogheganMark, "Nanoscale Science and Technology", John Wiley & Sons, Ltd, 2006.

4. Kal Ranganathan Sharma, "Nanostructuring Operations in Nanoscale Science and Engineering", McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010.
5. "Organic and inorganic nanostructures"-(Artech House MEMS series), Nabok, Alexei, ISBN 1-58053-818-5, 2005.

### [Elective – II] (c): Chemoinformatics

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives

1. To give students a concept of Chemo-informatics related to chemical structure databases and database search methods
2. To understand the quantum methods and models involved in drug discovery and targeted drug delivery
3. To study the application of Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties

**Course Outcomes:** At the end of the course, the student will be able to:

1. The course will introduce the students preparing for professional work in chemistry must learn how to retrieve specific information from the enormous and rapidly expanding chemical literature.
2. The course will provide a broad overview of the computer technology to chemistry in all of its manifestations.
3. The course will expose the student to current and relevant applications in QSAR and Drug Design.

#### Chemo-informatics

Introduction, scope and application, Basics of Chemo-informatics, Current Chemo-informatics resources for synthetic polymers, pigments. Primary, secondary and tertiary sources of chemical information, Databases: Chemical Structure Databases (PubChem, Binding database, Drugbank), Database search methods:chemical indexing, proximity searching, 2D and 3D structure and substructure searching. Drawing the Chemical Structure: 2D & 3D drawing tools (ACD Chems sketch) Structure optimization.

#### Introduction to quantum methods

Combinatorial chemistry (library design, synthesis and deconvolution), spectroscopic methods and analytical techniques,Representation of Molecules and Chemical Reactions:Different types of

Notations, SMILES Coding, Structure of Mol files and Sd files (Molecular converter, SMILES Translator).

### **Analysis and use of chemical reaction information**

Chemical property information, spectroscopic information, analytical chemistry information, chemical safety information, Drug Designing: Prediction of Properties of Compounds, QSAR Data Analysis, Structure-Activity Relationships, Electronic properties, Lead Identification, Molecular Descriptor Analysis.

### **Target Identification**

Molecular Modeling and Structure Elucidation: Homology Modelling (Modeller 9v7, PROCHECK), Visualization and validation of the Molecule (Rasmol, Pymol Discovery studio), Applications of Chemoinformatics in Drug Research - Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties.

### **Drug Discovery**

Structure based drug designing, Docking Studies (Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking, Structure based design of lead compounds, Library docking), Pharmacophore - Based Drug Design, Pharmacophore Modeling (Identification of pharmacophore features, Building 2D/3D pharmacophore hypothesis), Toxicity Analysis-Pharmacological Properties (Absorption, Distribution and Toxicity), Global Properties (Oral Bioavailability and Drug-Likeness) (ADME, OSIRIS, and MOLINSPIRATION)

### **References**

1. Bajorath J (2004), "Chemoinformatics: Concepts, Methods and Tools for Drug Discovery" Humana Press
2. Leach A, Gillet V, "An Introduction to Chemoinformatics" Revised edition, Springer
3. Gasteiger J. Engel T. "A textbook of Chemoinformatics" Wiley- VCH GmbH & Co. KGaA
4. Bunin B. Siesel B. Guillermo M. "Chemoinformatics: Theory, Practice & Products", Springer
5. Lavine B. (2005), "Chemometrics and Chemoinformatics", American Chemical Society
6. Casteiger J. and Engel T (2003) "Chemoinformatics" Wiley-VCH
7. Bunin Barry A. Siesel Brian, Morales Guillermo, Bajorath Jürgen. Chemoinformatics: Theory, Practice, & Products Publisher: New York, Springer. 2006.
8. Leach Andrew R., Valerie J. Gillet, "An introduction to Chemoinformatics", Publisher: Kluwer academic, 2003. ISBN: 1402013477
9. Gasteiger Johann, Handbook of Chemoinformatics: From Data to Knowledge (4 Volumes), 2003. Publisher: Wiley-VCH.

## Laboratory I Modeling and Simulation laboratory

### Laboratory Scheme:

Lecture: 4 h/week

Objectives:

1. To learn Process Modeling and Simulation of Chemical operations and processes.
2. To understand Dynamic Behavior of processes.
3. To understand Close loop control of processes.
4. To learn Dynamic simulation of chemical processes.
5. To get acquainted with Controllability Analysis of chemical processes.

**Outcomes:** At the end of the course, the student will be able to:

1. Carry out thermodynamic property estimations using property estimation and property analysis in Aspen.
2. Simulate Mixer, splitter, heat exchangers, reactors, distillation columns.
3. Apply sensitivity, design specification and case study tools in Aspen.
4. Solve linear and non-linear programming problems.

### List of experiments: Simulation laboratory practical

1. Thermodynamic property estimations using property estimation and property analysis in Aspen.
2. Simulate Mixer, splitter, heat exchangers, and reactive distillation column.
3. Apply sensitivity, design specification and case study tools in Aspen
4. Solve linear and non-linear programming problems.
5. Controller tuning by Ziegler- Nichol's & Cohen- Coon methods
6. Stability analysis using Bode diagrams for control systems.
7. Simulation of Ideal Binary Distillation Column
8. Simulation of Heat/Mass Transfer coefficient in 3 phase fluidized bed column
9. Simulation studies of various unit operations using CHEMCAD.
10. Modeling and Simulation of cyclone separator

**Note:** Simulation can be done using C/C++ / MATLAB/ ASPEN PLUS/ CHEMCAD

### Lab Practice: II Advanced separation processes

### Laboratory Scheme:

Lecture: 4 h/week

Objectives:

1. To familiarize students with various advanced aspects of separation processes and the selection of separation processes.
2. To enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design an absorber or a membrane unit to achieve a specified separation.

3. To introduce them to new trends used in the separation technologies.

**Outcomes:** At the end of the course, the student will be able to:

1. Knowledge of mass transfer operations and mechanical operations
2. Students should be able to know the synthesis of materials and applications in separation processes.
3. Students will be able to provide applicable solutions to separation processes.

Prerequisites:

**List of experiments: advanced separation processes**

- 1) **Separation of fluoride and arsenic using cellulose acetate asymmetric membrane separation process**
- 2) **Adsorption of dyes from waste water using nano adsorbents.**
- 3) **Supercritical extraction of the fragrance.**
- 4) **Study the effect of pressure on permeate flux and solution rejection in RO system.**
- 5) **Mass transfer studies and study the effect of parameters in separation system using liquid emulsion membrane.**
- 6) **Laboratory experiments on ion exchange membranes: effect of process parameters on flux etc.**
- 7) **Study the reaction with mass transfer: e.g. Synthesis of calcium carbonate.**
- 8) **Study the reactive distillation system considering batch and continuous mode**

## Research Methodology and IPR

### Teaching Scheme

Lectures: 1 hrs/week

### Course Outcomes:

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

### Syllabus Contents:

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis  
Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper  
Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

### References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
- Mayall, "Industrial Design", McGraw Hill, 1992.
- Niebel, "Product Design", McGraw Hill, 1974.
- Asimov, "Introduction to Design", Prentice Hall, 1962.



- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.

T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

## Semester II

### Core III). Advances in Transport Phenomena

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives:

1. To familiarize the student with basic concepts of transport phenomena and brief review of mathematics.
2. To enable students to understand the equations of change for isothermal flow and for non-isothermal flow.
3. To introduce them details of equations of change for multi component systems.
4. To give them insight into properties of two-dimensional flows and aspects of dimensional analysis

**Outcomes:** At the end of the course, the student will be able to:

1. Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.
2. Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scale.
3. Solve the governing equations to obtain velocity, temperature and concentration profiles.
4. Model the momentum, heat and mass transport under turbulent conditions.
5. Develop analogies among momentum, energy and mass transport.

**Unit-1:**Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion,Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the Equations of Change.

Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids. Velocity Distributions in Turbulent Flow -Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids, Time Smoothed Velocity Profile near a wall, Empirical Expressions for the Turbulent Momentum Flux, Turbulent Flow in Ducts, Turbulent Flow in Jets.

**Unit-2:** Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the Viscous loss, Use of the Macroscopic Balances for Steady-State Problems, Derivation of the Macroscopic Mechanical Energy Balance.

Equations of Change for Non-Isothermal Systems: The Energy Equation, Special forms of the Energy Equation, The Boussine sq Equation of Motion for Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems, Dimensional Analysis of the Equations of Change for Non-Isothermal Systems.

**Unit-3:**Temperature Distributions in Solids and in Laminar Flow: Heat Conduction with an Electrical Heat Source, Heat Conduction with a Viscous Heat Source. Temperature Distributions

with more than One Independent Variable - Unsteady Heat Conduction in Solids, Steady Heat Conduction in Laminar, Incompressible Flow. Temperature Distributions in Turbulent Flow - Time-Smoothed Equations of Change for Incompressible Non-Isothermal Flow, Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the Turbulent Heat Flux Temperature Distribution for Turbulent Flow in Tubes.

**Unit-4:** Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Use Of The Macroscopic Balances To Solve Steady State Problems With Flat Velocity Profiles, Concentration Distributions in Solids and in Laminar Flow: Shell Mass Balances Boundary Conditions, Diffusion through a Stagnant Gas Film, Diffusion with a Heterogeneous Chemical Reaction. Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Steady-State Transport in Binary Boundary Layers, Concentration Distributions in Turbulent Flow - Concentration Fluctuations and the Time-Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux, Enhancement of Mass Transfer by a First-Order Reaction in Turbulent Flow.

**Unit-5:** Interphase Transport in Multi-Component Systems: Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions. Macroscopic Balances For Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems.

### References

Thomson W. J., Transport Phenomena, Pearson education, Asia, 2001.

Geankopolis C. J., Transport Processes and Unit Operations, 4th Ed., Prentice Hall (India) Pvt. Ltd., New Delhi. 2004.

Bird R. B., Stewart W. E. and Light Foot E. N., Transport Phenomena, Revised 2nd Edition, John Wiley & Sons, 2007.

## Core IV ). Advanced Reaction Engineering

### Teaching Scheme:

Lecture: 3 hrs/week

**Objectives :** This Subject is essential for Design of Reactor especially heterogeneous reactors. Students will learn the energy balance, temperature and concentration profiles in different reactors, advance design aspects of multiple reactors, students will get insight of importance of population balance of particles. Role of Reaction Engineering in mitigation of Global warming will also addressed.

Outcomes: At the end of the course, the student will be able to:

1. Evaluate heterogeneous reactor performance considering mass transfer limitations
2. Perform the energy balance and obtain concentration profiles in multiphase reactors.
3. Estimate the performance of multiphase reactors under non-isothermal conditions.
4. Understand modern reactor technologies for mitigation of global warming

**Unit-1:** Non-elementary Kinetics Importance: Approximations for formulations of Rate laws, Formulations of Kinetic model.

Effect of flow on conversions in Reactors: Semibatch Reactors : Importance and examples of applications , Material Balance on Semibatch Reactor, Multiple reaction in Semibatch Reactors, Conversion Vs Rate in Reactors, Use of POLYMATHS to solve the equations and understanding the profiles

Non-Isothermal reaction modeling in CSTR & Semi-Batch reactor: Energy Balance equations for CSTR, PFR and Batch reactors, Adiabatic operations Temperature conversion profiles in PFR, CSTR, Steady state tubular reactor with heat exchange.

**Unit-2:** Need for Multi-staging CSTR with multiple stages: Exothermic and Endothermic Reaction with examples, CSTR with heat effects, Multiple reactions in CSTR and PFR with heat effects, Semi batch Reactors with heat exchange.

Design of PFR and Packed Bed Tubular Reactors: Radial and Axial mixing in Tubular reactors, unsteady state in non-isothermal energy balance, CSTR, Energy balance in Batch Reactors, Volume of reactors calculations for non-isothermal reactors.

Optimal Design of Reactors for Reversible exothermic reactions: Unsteady state non-isothermal reactor design, adiabatic operation in batch, Heat effects in semi batch unsteady state operation. Auto thermal Plug flow reactors and packed tubular reactors. PFR with inter stage cooling. Shift of Energy and material balance lines for reversible reactions in CSTR, Examples of optimal design of PFR and Semibatch and CSTR Exothermic Reactions.

**Unit-3:** Catalytic reactions: theory and modeling: Global rate of reaction, Types of Heterogeneous reactions Catalysis, Different steps in catalytic reactions, Theories of heterogeneous catalysis . Steady State approximation, formulations of rate law Rate laws derived from the PSSH, Rate controlling steps, Eley-Rideal model, Reforming catalyst example : Finding mechanism consistent with experimental observations Evaluation of rate law parameters, packed beds : Transport and Reactions, Gradients in the reactors : temperature.

Porous media reactors: Mass transfer coefficients, Flow effects on spheres tube and cylinders, External Mass Transfer pore diffusion, structure and concentration gradients Internal Effectiveness Factor Catalytic wall reactor: limiting steps reactions and mass transfer limiting Porous catalyst on tube wall reactors Design of packed bed porous catalytic reactors: Mass transfer limited reactions in Packed bed.

**Unit-4:** Fluidized bed reactor modeling: Geldart Classification of powders, Fixed bed vs fluidized bed Why fluidized bed, important parameters pressure drop in fixed bed, Class I model Arbitrary Two Region Flow Models, Class II Chemical Reactor: Plug Flow or Mixed Flow Model. Class III Modeling the Bubbling Fluidized Bed Reactor, BFB, The Kunii-Levenspiel bubbling bed model, Gas Flow Around and Within a Rising Gas Bubble in a Fine particle BFB, Reactor performance of BFB.

**Unit-5:** Application of Population Balance Equations for reactor modeling: Particle size distribution, Distribution Functions in Particle Measuring Techniques, Particle distribution model in colloidal particle synthesis in batch reactor, Moments of Distribution, Nucleation rate based on volumetric holdup versus crystal growth rate.

Reaction engineering and mitigation of Global warming: CO<sub>2</sub> absorption in high pressure water, different techniques of mitigation of CO<sub>2</sub>, methods of separations. Recent advancements, automotive monolith catalytic converter example, removal and utilization of CO<sub>2</sub> for thermal power plants.

## References

K.G. Denbigh : Chemical Reactor Theory, Cambridge University Press, Second Edition, 1971.

J.M. Smith : Chemical Engineering Kinetics, Mcgraw Hill, Third Edition, 1981.  
Levenspiel O., Chemical Reaction Engineering, Wiley, 1998.  
Fogger,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008.  
Fromment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley, 2010.

**[Elective – III] (a): Modern concepts in Catalysis and Surface Phenomenon**

**Teaching Scheme:**

Lecture: 3 hrs/week

**Objectives**

1. To give the students insight into advances in catalytic reaction engineering
2. To understand the mechanisms involved in catalytic reactions
3. To study the catalyst characterization techniques
4. To study the advanced industrial applications in catalysis
5. To understand the principles behind catalyst deactivation and study their models

**Course Outcomes:** At the end of the course, the student will be able to:

1. To understand the concepts of homogenous and heterogeneous catalysis, with specific examples.
2. To study reaction mechanisms and kinetics of homogenous and heterogeneous catalytic reactions.
3. To familiarize with the characterization of catalysts
4. To understand the application and mechanisms of several types of catalysts in chemical industry.

**Introduction to Catalysis**

Definition of Catalytic activity, Magnitude of Turnover Frequencies and Active Site Concentrations, Evolution of Important Concepts and Techniques in Heterogeneous Catalysis, Classification of Catalysts – Homogeneous, Heterogeneous, Biocatalysts, Dual Functional Catalysts, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active Ingredients, Supportive materials, Catalysts Activation, Catalyst Deactivation.

**Adsorption in Catalysis**

Adsorption and its importance in Catalysis, Adsorption and potential energy curves, Surface Reconstruction, Adsorption Isotherms and Isobars, Dynamical Considerations, Types of Adsorption Isotherms and their Derivation from Kinetic Principles, Mobility at Surfaces, Kinetics of surface Reactions, Photochemistry on oxide and metallic surfaces, Characterization of the adsorbed molecules

**Catalyst Characterization**

Catalyst Characterization Methods – Their Working Principle and Applications – XRF, XRD, IR Spectroscopy, XPS, UPS, ESR, NMR; Infrared, Raman, NMR, Mossbauer and X-Ray Absorption spectroscopy, Surface Acidity and Toxicity, Activity, Life time, Bulk density, Thermal stability Crystal Defects, Perovskites, Spinel, Clays, Pillared Clays, Zeolites

## Significance of Pore Structure and Surface Area

Importance of Surface Area and Pore Structure, Experimental Methods for Estimating Surface Area – Volumetric, Gravimetric, Dynamic Methods, Experimental Methods for Estimating Pore Volume and Diameter – Gas Adsorption and Mercury Porosimeter Method, Models of the Pore Structure – Hysteresis Loops, Geometric Models, Wheeler's Model, Dusty Gas Model, Random Pore Model, Diffusion in Porous Catalysts – Effective Diffusivity, Knudsen Diffusion, Effect of Intraparticle Diffusion, Non-isothermal Reactions in Pores, Diffusion Control.

## Industrial applications– Case Studies

Industrial processes involving heterogeneous solid catalyst: Synthesis of Methanol, Fischer-Tropsch Catalysis, Synthesis of Ammonia, Automobile Exhaust Catalysts and Catalyst Monolith, Photocatalytic Breakdown of Water and the Harnessing of Solar Energy.

Contribution of homogeneous catalytic process in chemical industry: Oxidations of Alkenes such as production of acetaldehyde, propylene oxide etc., Polymerization such as production of polyethylene, polypropylene or polyester production

## References

1. Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", New York, 1954
2. Smith, J.M. - "Chemical Engineering Kinetics ", McGraw Hill, 1971
3. Thomas and Thomas - "Introduction to Heterogeneous Catalysts ", Academic Press, London 1967
4. Piet W.N.M. van Leeuwen, Homogeneous catalysis: Understanding the Art, Springer, 2004
5. Piet W.N.M. van Leeuwen, and John C. Chadwick, Homogeneous catalysis: Activity-stability –deactivation, Wiley, VCH, 2011.

## [Elective – III] (b): Advanced Downstream Processes

### Teaching Scheme:

Lecture: 3 hrs/week

### Objectives

1. To understand the unit processes involved in downstream processing.
2. To study advanced treatment methods.
3. To study the energy conservation in different separation processes
4. To understand the underlying design principles

**Course Outcomes:** At the end of the course, the student will be able to:

1. To learn effective strategies of downstream processing in chemical industry.
2. Understand the role of downstream processing.
3. Analyze reactors, upstream and downstream processes in production

### Introduction

Introduction to Downstream processes theory, applications in chemical separation for Gas-Liquid system, Gas-Solid system. Super critical fluids extraction in food, pharmaceutical, environmental and petroleum applications, water treatment, desalination, Bio separation, dialysis, industrial dialysis.

### **Downstream Processes in Petrochemical Industry**

Cryogenic distillation for refinery, petrochemical off gases, natural gases, gas recovery-Olefin, Helium, Nitrogen, Desulfurization - coal, flue gases

### **Advanced Distillation Processes**

Azeotropic & extractive distillation - residue curve maps, homogeneous azeotropic distillation, pressure swing distillation, Column sequences, heterogeneous azeotropic distillation.

### **Energy conservation in separation processes**

Energy balance, molecular sieves - zeolites, adsorption, catalytic properties, manufacturing processes, hydrogel process, application, New trends.

### **Non-Ideal Mixtures and Ion Exchange**

Separations process synthesis for nonazeotropic mixtures, non ideal liquid mixtures, separation synthesis algorithm, Ion exchange - manufacture of resins, physical & chemical properties, capacity, selectivity, application, regeneration, equipment, catalysis use.

### **References**

1. Perry's "Chemical Engg. Handbook": McGraw Hill Pub.
2. Douglas J.M., "Conceptual Design of Chemical Processes", McGraw Hill
3. Liu Y.A., "Recent Developments in Chemical Process & Plant Design", John Wiley & Sons Inc.
4. Timmerhaus K.D., "Cryogenic Process Engg.", Plenum Press
5. Othmer Kirk "Encyclopedia of Separation Technology, Vol I & II", Wiley Interscience

### **[Elective – III] (c): Computational Fluid Dynamics**

#### **Teaching Scheme:**

Lecture: 3 hrs/week

#### **Objectives**

1. To make students understand the governing equations of fluid dynamics and their derivation from laws of conservation
2. To develop a good understanding in computational skills, including discretisation, accuracy and stability.
3. To acquaint the students with a process of developing a mathematical and geometrical model of flow, applying appropriate boundary conditions and solving system of equations.

Outcomes: At the end of the course, the students will be able to:

1. Understand the basic principles of mathematics and numerical concepts of fluid dynamics.
2. Develop governing equations for a given fluid flow system.
3. Adapt finite difference techniques for fluid flow models.

4. Apply finite difference method for heat transfer problems.
5. Solve computational fluid flow problems using finite volume techniques.
6. Get familiarized to modern CFD software used for the analysis of complex fluid-flow systems.

### **Introduction to Fluid Dynamics**

Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies. Philosophy of CFD, Governing equations of fluid dynamics and their physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition. Numerical Methods in CFD: Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes, Higher order methods, Implicit and explicit methods, Steady and transient solutions

### **Grid Generation**

Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination

### **Turbulence and its Modelling**

Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model, The k- $\epsilon$  model, Reynolds stress equation models, Algebraic stress equation models

### **Chemical Fluid Mixing Simulation**

Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples

### **Post-Processing of CFD results**

Contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and analysis of data.

### **References**

1. Anderson John D., "Computational Fluid Dynamics: The Basics with Applications", Mc Graw Hill, 1995

2. Ranade V.V., "Computational Flow Modeling for Chemical Reactor Engineering", Process Engineering Science, Volume 5, 2001
3. Knupp Patrick and Steinberg Stanly, "Fundamentals of Grid Generation", CRC Press, 1994
4. Wilcox D.C., "Turbulence Modelling for CFD", 1993
5. Wesseling Pieter, "An Introduction to Multigrid Methods", John Wiley & Sons, 1992
6. Thompson J.F., Warsi Z.U.A. and Mastin C.W., "Numerical Grid Generation: Foundations and Applications", North Holland, 1985
7. Patankar S.V., "Numerical Heat Transfer and Fluid Flow", McGraw-Hill, 1981
8. Gatski Thomas B., Hussaini M. Yousuff and Lumley John L., "Simulation and Modelling of Turbulent Flows", Oxford University Press, 1996
9. Laney, C. B., "Computational Gas Dynamics", Cambridge Uni. Press, 1998.

### [Elective – III] (d): Bioprocess Engineering

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives

1. To learn the principles of bioprocessing for traditional chemical engineering in the design and development of processes involving biocatalyst.
2. To study engineering principles in the development of products based on living cells or subcomponents of such cells.
3. To learn and develop quantitative models and approaches related to bioprocesses
4. To learn mechanistic models for enzyme catalyzed reactions for large scale production of bioproducts

Outcomes: At the end of the course, the students will be able to:

1. Understand the different cells and their use in biochemical processes.
2. Understand the role of enzymes in kinetic analysis of biochemical reaction.
3. Analyze bioreactors, upstream and downstream processes in production of bio-products
4. Demonstrate the fermentation process and its products for the latest industrial revolution

#### Introduction:

Biotechnology and bioprocessing. An overview of biological basics. Basics of enzyme and microbial kinetics. Operating considerations for bioreactors: cultivation method, modifying batch and continuous reactors, immobilized cell systems, solid state fermentations.

#### Advance Enzyme Kinetics

Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

#### Bioreactors

Selection, scale-up, operation and control of bioreactors: Scale-up and its difficulties, bioreactor instrumentation and control, sterilization of process fluids. Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, solid state fermenters.



### **Homogeneous and heterogeneous reactions in bioprocesses**

Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

### **Recovery and purification of products:**

Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products.

### **References**

1. Bailey J.E. and Ollis D.F., "Biochemical Engineering Fundamentals", McGraw-Hill
2. Doran P.M., "Bioprocess Engineering Principles", Academic Press
3. Shuler M.L., Kargi F., "Bioprocess Engineering", Prentice -Hall

### **[Elective – IV] (a): Process Intensification**

#### **Teaching Scheme:**

Lecture: 3 hrs/week

#### **Objectives:**

1. Understand the concept of Process Intensification.
2. Know the limitations of intensification of the chemical processes.
3. Apply the techniques of intensification to a range of chemical processes.
4. Develop various process equipment used for intensifying the processes.
5. Infer alternative solutions keeping in view point, the environmental protection, economic viability and social acceptance.

Outcomes: At the end of this course, students are able to:

1. Assess the values and limitations of process intensification, cleaner technologies and waste minimization options.
2. Measure and monitor the usage of raw materials and wastes generating from production and frame the strategies for reduction, reuse and recycle.
3. Obtain alternative solutions ensuring a more sustainable future based on environmental protection, economic viability and social acceptance.
4. Analyze data, observe trends and relate this to other variables.
5. Plan for research in new energy systems, materials and process intensification.

**Unit-I:** Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application.

**Unit-II:** Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential

Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

**Unit-III:** Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Hige reactors.

**Unit-IV:** Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NO<sub>x</sub> Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

**Unit-V:** Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Supercritical fluids

#### References:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013.
4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.) Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
5. Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.

#### [Elective – IV] (c): Phase transitions in Process Equipment

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives:

1. Basic laws in thermodynamics.
2. Basic statistical concepts and methods: heat, work, energy, temperature and the kinetic theory of matter; entropy, ensemble, partition function, etc
3. Learning phase transition catalysis
4. Have a good grasp of the basic thermodynamic interactions and process: adiabatic, isothermal, etc

Outcomes: At the end of this course, students are able to:

1. The student is expected to obtain considerable insight into various types of phase transitions, and how these can be described theoretically in different ways
2. Predict relationships between physical quantities using the laws and methods of thermodynamics.
3. Find probabilities and thermal quantities (free energy, entropy, etc) given the energy eigenvalues of a system.

**Unit-I:** Thermodynamic aspects of phase transitions: Concept of phase, First-order phase transition, conditions for phase coexistence lines, free energy barrier of nucleation, and crystal-melt interfacial free energy, Ehrenfest classification of phase transitions, Van der Waals equation of state, Critical point

**Unit-II:** Single phase and multiphase catalytic reactions, Acid--base catalysis, Transition metal catalysis, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Heteropoly acid catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts.

**Unit-III:** Applications to Multi-phase Systems Stability conditions for a homogeneous system, equilibrium between phases, phase transformations, general relations for a system with several components, general conditions for chemical equilibrium, chemical equilibrium between ideal gases, and the equilibrium constants in terms of partition functions.

**Unit-IV:** Phase diagrams and transformations Phase rule- single and binary phase diagrams, lever rule, micro structural changes during cooling,  $\text{Al}_2\text{O}_3$ ,  $\text{Cr}_2\text{O}_3$ , Pb-Sn, Ag-Pt and Fe- $\text{Fe}_3\text{C}$  Systems phase diagrams, phase transformations, corrosion- theories of corrosion, control and prevention of corrosion

**UNIT-V:** Energy balance - heat capacity and calculation of enthalpy changes, Enthalpy changes for phase transitions, evaporation, clausius - clapeyron equation,

#### References:

1. Hegedus, L.S., Transition Metals in the Synthesis of Complex Organic Molecules, University Science Book (2010) 3rd ed.
2. Raghavan V., Material Science and Engineering Prentice Hall of India, 1996
3. David.M.Himmelblau, "Basic principles and calculations in chemical engineering", Prentice Hall of India Ltd., 6th Edition, 1998.
4. A.Hougen, K.M. Watson and K.A.Ragatz, "Chemical Process Principles", Vol 1, John Wiley, 1960.

#### [Elective – IV] (c): Micro and Nano fluidics

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives:

1. To introduce to the students, the various opportunities in the emerging field of micro and nano fluids.
2. To the make students familiar with the important concepts applicable to small micro and nano fluidic devices, their fabrication, characterization and application.

3. To get familiarize with the new concepts of real-time nano manipulation & assembly

Outcomes: At the end of this course, students are able to:

1. Introduce students to the physical principles to analyze fluid flow in micro and nano-size devices. It unifies the thermal sciences with electrostatics, electrokinetics, colloid science; electrochemistry; and molecular biology.

**Unit-1:** Introduction: Fundamentals of kinetic theory-molecular models, micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions-Wall slip effects and accommodation coefficients, flow and heat transfer analysis of microscale Couette flows, Pressure driven gas micro-flows with wall slip effects, heat transfer in micro-Poiseuille flows, effects of compressibility. Pressure Driven Liquid Microflow: apparent slip effects, physics of near-wall microscale liquid flows, capillary flows, electro-kinetically driven liquid micro - flows and electric double layer (EDL) effects, concepts of electroosmosis, electrophoresis and dielectrophoresis.

**Unit-2:** Laminar flow: Hagen-Poiseuille eqn, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves & micropumps, Approaches toward combining living cells, microfluidics and 'the body' on a chip, Chemotaxis, cell motility. Case Studies in Microfluidic Devices. Ionic transport: Polymer transport – microtubule transport in nanotube channels driven by Electric Fields and by Kinesin Biomolecular Motors - Electrophoresis of individual nanotubules in microfluidic channels.

**Unit-3:** Fabrication techniques for Nanofluidic channels – Biomolecules separation using Nanochannels - Biomolecules Concentration using Nanochannels – Confinement of Biomolecules using Nanochannels. Hydrodynamics: Particle moving in flow fields – Potential Functions in Low Reynolds Number Flow – Arrays of Obstacles and how particles Move in them: Puzzles and Paradoxes in Low Re Flow.

**Unit-4:** Microfluidics and Lab-on-a-chip: Microfluidic Devices - Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreservoirs, Micro-reaction chambers. Concepts and Advantages of Microfluidic Devices - Fluidic Transport - Stacking and Scaling – Materials for The Manufacture (Silicon, Glass, Polymers) - Fluidic Structures - Fabrication Methods - Surface Modifications - Spotting - Detection Mechanisms. Microcontact printing of Proteins Strategies-printing types- methods and characterization- Cell nanostructure interactions-networks for neuronal cells. Applications in Automatic DNA sequencing, DNA and Protein microarrays.

**Unit-5:** BioMEMS (Micro-Electro-Mechanical Systems): Introduction and Overview, Biosignal Transduction Mechanisms: Electromagnetic Transducers Mechanical Transducers, Chemical Transducers, Optical Transducers – Sensing and Actuating mechanisms (for all types). Case Studies in Biomagnetic Sensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMS and BioNEMS - An alternative approach to traditional surgery, Specific targeting of tumors and other organs for drug delivery, Micro-visualization and manipulation, Implantation of microsensors, microactuators and other components of a larger implanted device or external system (synthetic organs).

### Text Books

1. Joshua Edel “Nanofluidics” RCS publishing, 2009.
2. Patric Tabeling “Introduction to Microfluids” Oxford U. Press, New York 2005.
3. K. Sarit “Nano Fluids; Science and Technology”, RCS Publishing, 2007.

## References

1. M. Madou, Fundamentals of Microfabrication, CRC Press, 1997
2. G. Kovacs, Micromachined Transducers, McGraw-Hill, 1998
3. Steven S Saliterman, Fundamentals of BioMEMS and Medical Microdevices, 2006

## [Elective – IV] (c): Process Integration

### Teaching Scheme:

Lecture: 3 hrs/week

### Objectives:

1. To introduce to the students, the various opportunities in the process integration in chemical industries.
2. To the make students familiar with the important concepts process integration for heat recovery/minimization.
3. To get familiarize with the case studies.

Outcomes: At the end of this course, students are able to:

1. Maximum heat recovery for a given process (both new processes, and retrofit of existing processes) identify opportunities for integration of high-efficiency energy.
2. Energy-intensive thermal separation operations (distillation, evaporation) at an industrial process site.
3. Evaluate the process integration measures with respect to energy efficiency, greenhouse gas emissions and economic performance.

**Unit-I:** Introduction to process Intensification and Process Integration (PI). Areas of application and techniques available for PI, onion diagram.

**Unit-II:** Pinch Technology-an overview: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology, Key steps of Pinch Technology: Concept of  $\Delta T_{\min}$ , Data Extraction, Targeting, Designing, Optimization Super targeting, Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.

**Unit-III:** Heat exchanger networks analysis, Maximum Energy Recovery (MER) networks for multiple utilities and multiple, Chemical Engineering Pre-requisites: Knowledge of basic process design of process equipment. Pinches, design of heat exchanger network.

**Unit-IV:** Heat integrated distillation columns, evaporators, dryers, and reactors.

**Unit-V:** Waste and waste water minimization, flue gas emission targeting, and heat and power integration. Case studies.

### References:

1. Shenoy U.V.; "Heat Exchanger Network Synthesis", Gulf Publishing company.
2. Smith R.; "Chemical Process Design", McGraw-Hill.

3. Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B.E.A., Guy A. R., and Marsland R. H.; "A User Guide on Process Integration for the Efficient Uses of Energy", Inst. of Chemical Engineers.

### **[Elective – IV] (d): Transport in porous Media**

#### **Teaching Scheme:**

Lecture: 3 hrs/week

#### **Objectives:**

1. Introduce the physics and governing mechanisms controlling flow and transport processes in porous media.
2. Learning Liquid and solute transport in porous media.

**Outcomes:** At the end of this course, students are able to:

1. Students will understand the mechanisms involved in transport processes in porous media and will be able to work with the equations that govern the fate and transport of gas, water and solutes in porous media.

**Unit-I:** Fundamentals: Mass, momentum and energy transport, Darcy and Non-Darcy equations, equilibrium and non-equilibrium conditions, species transport, radioactive decay.

**Unit-II:** Effective medium approximation: equivalent thermal conductivity, viscosity, dispersion.

**Unit-III:** Exact solutions: Flow over a flat plate, flow past a cylinder, boundary-layers, reservoir problems.

**Unit-IV:** Special topics: Field scale and stochastic modeling, Turbulent flow, compressible flow, multiphase flow, numerical techniques, hierarchical porous media, nanoscale porous media, multiscale modeling.

**Unit-V:** Engineering applications: Groundwater, waste disposal, oil and gas recovery, regenerators, energy storage systems. Experimental techniques: Flow visualization, quantitative methods, inverse parameter estimation.

#### **References:**

1. Principles of Heat Transfer in Porous Media, by M. Kaviany, Springer New York (1995).
2. Transport Phenomena in Porous Media, Volumes I-III, edited by D. R. Ingham and I. Pop, Elsevier, New York (1998-2005).
3. Dynamics of Fluids in Porous Media, J. Bear, Dover (1988).
4. Introduction to Modeling of Transport Phenomena in Porous Media, J. Bear and Y. Bachmat, Kluwer Academic Publishers, London (1990).
5. Enhanced Oil Recovery, L.W. Lake, Gulf Publishing Co. Texas (1989).
6. The Mathematics of Reservoir Simulation, R.E. Ewing, SIAM Philadelphia (1983).
7. Stochastic Methods for Flow in Porous Media: Coping with Uncertainties, Zhang, D., Academic Press, California (2002).
8. The Method of Volume Averaging, S. Whitaker, Springer, New York (1999).

### [Elective – IV] (d): Micro Flow Chemistry and Process Technology

#### Teaching Scheme:

Lecture: 3 hrs/week

#### Objectives:

1. Introduce the students to micro flow chemistry and process technology.
2. Learning Micromixers, Mixing Principles.
3. Learning micro reactor based chemicals production

**Outcomes:** At the end of this course, students are able to:

1. Students will understand the role of micro flow chemistry and process technology in chemical engineering.
2. The student is expected to obtain considerable insight into various types of micro reactors.

**Unit-I:** State of the Art of Microreaction Technology, Structural Hierarchy of Microreactors, Functional Classification of Microreactors, Fundamental Advantages of Microreactors, Advantages of Microreactors Due to Decrease of Physical Size, Advantages of Microreactors Due to Increase of Number of Units, Potential Benefits of Microreactors

**Unit-II:** Modern Microfabrication Techniques for Microreactors, Evaluation of Suitability of a Technique, Anisotropic Wet Etching of Silicon, Dry Etching of Silicon, LIGA Process, Injection Molding, Wet Chemical Etching of Glass, Advanced Mechanical Techniques

**Unit-III:** Micromixers, Mixing Principles and Classes of Macroscopic Mixing Equipment, Mixing Principles and Classes of Miniaturized Mixers, Mixing Tee-Type Configuration

**Unit-IV:** Microsystems for Gas Phase Reactions, Catalyst Supply for Microreactors, Types of Gas Phase Microreactors, Microchannel Catalyst Structures,  $H_2/O_2$  Reaction, Selective Partial Hydrogenation of Benzene, Selective Oxidation of 1-Butene to Maleic Anhydride, Selective Oxidation of Ethylene to Ethylene Oxide, Oxidative Dehydrogenation of Alcohols, Synthesis of Methyl Isocyanate and Various Other Hazardous Gases, Synthesis of Ethylene Oxide, Oxidation of Ammonia

**Unit-V:** Microsystems for Energy Generation, Microdevices for Vaporization of Liquid Fuels, Microdevices for Conversion of Gaseous Fuels to Syngas by Means of Partial Oxidations, Hydrogen Generation by Partial Oxidations, Microdevices for Conversion of Gaseous Fuels to Syngas by Means of Steam Reforming

#### References:

1. Wolfgang Ehrfeld, Volker Hessel, Holger Löwe Microreactors New Technology for Modern Chemistry © WILEY-VCH Verlag GmbH, D-69469 Weinheim (Federal Republic of Germany), 2000.
2. S.V. Luis and E. Garcia-Verdugo, Chemical Reactions and Processes under Flow Conditions, University Jaume I/CSIC, Castello'n, Spain, The Royal Society of Chemistry 2010
3. Madhvanand N. Kashid, Albert Renken, and Liubov Kiwi-Minsker, Microstructured Devices for Chemical Processing, Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr ©2015 12, 69469 Weinheim, Germany

4. Hessel, V., Renken, A., Schouten, J.C., Yoshida, Micro Process Engineering" A Comprehensive Handbook 2009, ISBN 978-3-527-31550-5.

**[Elective – IV] (d): Process Plant Design & Flow sheeting**

**Teaching Scheme:**

Lecture: 3 hrs/week

**Objectives:**

1. Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.
2. Application of established engineering methods to complex engineering problem solving.
3. Application of systematic engineering synthesis and design processes.

**Outcomes:** At the end of this course, students are able to:

1. Analyze, synthesize and design processes for manufacturing products commercially
2. Integrate and apply techniques and knowledge acquired in other courses such as thermodynamics, heat and mass transfer, fluid mechanics, instrumentation and control to design heat exchangers, plate and packed columns and engineering flow diagrams
3. Use commercial flow sheeting software to simulate processes and design process equipment
4. Recognize economic, construction, safety, operability and other design constraints
5. Estimate fixed and working capitals and operating costs for process plants

**Unit-I:** Introduction: Basic concepts: General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Network analysis, PERT/CPM, Direct and Indirect costs, Optimum scheduling and crashing of activities.

**Unit-II:** Hierarchy of chemical process design; Nature of process synthesis and analysis; Developing a conceptual design and flow sheet synthesis. Synthesis of reaction-separation systems; Distillation sequencing; Energy targets. Heat integration of reactors, distillation columns, evaporators and driers; Process change for improved heat integration. Heat and mass exchange networks and network design.

**Unit-III:** Flow-sheeting: Synthesis of flow sheet: Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.

**Unit-IV:** Analysis of Cost estimation: Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Taxes and Fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements.

**Unit-V:** Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.



## References:

1. Peters, M.A. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, McGraw Hill (2003).
2. Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGraw Hill (1982).
3. Ulrich, G.D., A Guide to Chemical Engineering Process Design and Economics, John Wiley & Sons (1984).
4. Perry, R.H. and Green, D., Chemical Engineer's Handbook, McGraw-Hill (1997).

## Laboratory III: Advanced Chemical Reaction Engineering laboratory

### Teaching Scheme:

Lab 4 hrs/week

Objectives: At the end of the course, the student will be able to:

1. To provide through understanding of Reaction Engineering.
2. To design reactor and identify type of reactor by suiting chemical kinetics and using information from thermodynamics, heat and mass transfer economics.
3. Characteristics of a fluidized bed reactor
4. Understanding of corrosion reaction and monolithic catalytic reactors.

Outcomes:

1. Students will be able to know the solid-liquid, liquid-liquid reactions.
2. Students will be able to know the micro reactor based process intensification.
3. Students will be able to know the monolithic catalytic reactors applications.

List of Laboratory Experiments:

1. Analyze the characteristics of a fluidized bed reactor
2. Kinetics of a (solid-liquid) Esterification reaction in a batch reactor
3. Evaluate the performance of a process intensified Batch Reactive Distillation in catalytic reactions
4. Evaluate the performance of a process intensified micro reactor in catalytic reactions
5. Interfacial (Liquid-Liquid) Nitration
6. Gas-solid catalytic reactor analysis: Understanding of gas-solid catalytic reactor theory and dynamics analysis.
7. Gas-liquid-solid three-phase catalytic reactor analysis: Understanding gas-liquid-solid three-phase catalytic reactor theory and dynamics analysis.
8. Reactor analysis: Understanding the principle and diffusion analysis of batch and flow reactors.
9. Corrosion reaction characteristics of a metal in a given electrolyte.
10. Reactions on Monolithic Catalytic Reactors

## Lab IV: ADVANCED CHEMICAL ENGINEERING LAB

### Teaching Scheme:

Lab 4 hrs/week

Objectives:

- 1) Analyze characteristics of a fluidized bed dryer
- 2) Estimate efficiency of compact heat exchangers
- 3) Evaluate the performance of a process intensification in catalytic reactions, ultrasound assisted reactions, reactive distillation column, micro reactor and advanced flow reactor
- 4) Design controller for a given process
- 5) Evaluate the performance of membrane separation process for water purification
- 6) Characterize electrochemical phenomena such as corrosion

Detailed syllabus

1. Characteristics of a Fluidized bed dryer
2. Helical Coil heat exchanger
3. Determination of Effective thermal conductivity (ETC) in granular material
4. Plate Type Heat Exchanger
5. Kinetics for solid catalyzed esterification reaction in a batch reactor
6. Reactive distillation in Packed Column
7. Ultrasonic cavitation based reactions
8. Micro-reactor
9. Advanced Flow Reactor
10. Membrane Separation for water purification
11. Corrosion characteristics of a metal in a given electrolyte
12. Control of liquid level in non-interacting systems.
13. Identification and control of a three tank system.
14. pH control in a process.

### **Dissertation Phase – I and Phase – II**

Teaching Scheme Lab work: 20 and 32 hrs/week for phase I and II respectively

**Objectives:**

At the end of this course, students will be able to

- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- Presenting the work in International/ National conference or reputed journals.

**Syllabus Contents:**

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following

- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance
- Research and development in various domain

The student should complete the following:

- Literature survey Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:

- Experimental verification / Proof of concept.
- Design, fabrication, testing of Communication System.
- The viva-voce examination will be based on the above report and work.

#### Guidelines for Dissertation Phase – I and II

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include Springer/Science Direct. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work

### **[Elective – V] : Design of Experiments and Parameter Estimation**

#### **Teaching Scheme:**

Lecture: 3 hrs/week

#### **Objectives:**

This subject provides students with the knowledge to

1. Use statistics in experimentation;
2. Understand the important role of experimentation in new product design, manufacturing process development, and process improvement;

3. Analyze the results from such investigations to obtain conclusions; become familiar methodologies that can be used in conjunction with experimental designs for robustness and optimization.

**Outcomes:** At the end of this course, students are able to:

1. Plan experiments for a critical comparison of outputs
2. Include statistical approach to propose hypothesis from experimental data
3. Implement factorial and randomized sampling from experiments
4. Estimate parameters by multi-dimensional optimization

**Unit-1:** Design of experiments. Basic concepts, Bias and confounding, controlling bias, causation, Examples. Random Variables: Introduction to discrete and continuous random variables, quantify spread and central tendencies of discrete and continuous random variables.

**Unit-2:** Exploratory Data Analysis Variable types, Displaying the distribution, mean variance and typical spread, quartiles and unusual spread, multivariate data: finding relations. Probability Definition of a random variable, expectation, percentiles, common distributions such as the binomial, Poisson and normal distributions.

**Unit-III:** Point Estimation Estimators as random variables, sample mean and the central limit theorem, normal approximations, assessing normality. Interval Estimation Confidence intervals for the mean when the variance is known, confidence interval for the mean when the variance is unknown, confidence intervals for a single proportion, sample size, Student distribution. Hypothesis Testing Hypothesis testing for a mean or proportion, testing the equality of two means assuming equal variances, testing the equality of two means with unequal variances, comparison of two proportions.

**Unit-IV:** Linear Regression analysis: The linear regression model, Parameter estimation, accuracy of the coefficient estimates, checking the model, multiple linear regression, confidence and prediction intervals, potential issues, high leverage points, outliers. Matrix approach to linear regression, Variance-Covariance matrix, ANOVA in regression analysis, quantifying regression fits of experimental data, Extra sum of squares approach, confidence intervals on regression coefficients, lack of fit analysis.

**Unit-V: Response Surface Methodology:** Method of steepest ascent, first and second order models, identification of optimal process conditions

#### **References:**

1. Hanneman, Robert A., Kposowa, Augustine J., Riddle, Mark D. (2012). Research Methods for the Social Sciences: Basic Statistics for Social Research. John Wiley & Sons.
2. Saunders, Mark, Brown, Reva Berman (2007). Dealing with Statistics: What You Need to Know. McGraw-Hill Education.
3. Cowles, Michael (2000). Statistics in Psychology: An Historical Perspective (2nd Edition). Lawrence Erlb

#### **[Elective – V] : Computer Aided Design**

#### **Teaching Scheme:**

Lecture: 3 hrs/week

**Objectives:**

1. To understand importance and applications of CAD in the field of chemical engineering
2. To understand the basic structure and components of CAD software
3. To understand the underlying thermodynamic and physical principles To give insight into the approaches used in the simulation of flow sheets
4. To understand flow charts, computer languages and numerical methods used for writing algorithms

**Course Outcomes:** At the end of the course, the student will be able to:

1. Students get the knowledge about computer Aided Flow Sheet Synthesis
2. Computer aided equipment design of Evaporators; Distillation columns; Reactors, adsorption columns.

**Introduction**

Introduction to CAD, Scope and applications in chemical Engineering, Mathematical methods used in flow sheeting and simulation, Introduction to solution methods for linear and non-linear algebraic equations, solving one equation one unknown, solution methods for linear and nonlinear equations, general approach for solving sets of differential equations, solving sets of sparse non-linear equations.

**Properties Estimation**

Physical properties of compounds, Thermodynamic properties of gases and binary mixtures, Viscosity, Vapour pressure, Latent heat, Bubble point and dew point calculation, phase equilibria, Vapour-liquid equilibria, Liquid phase activity coefficients, K-values, Liquid phase activity coefficients, K-values, Liquid-Liquid equilibria, Gas solutions.

**Equipment Design**

Computer aided Design of Equipment: Design of Shell and Tube Heat exchangers; Design of Evaporators; Design of Distillation columns; Design of Reactors, Design of adsorption columns. Distillation columns (specific attention to multi components systems. Heat exchangers)

**Computer Aided Flow Sheet Synthesis**

Computerized physical property systems – physical property calculations, degrees of freedom in process design, degrees of freedom for a unit, degrees of freedom in a flow sheet, steady state flow sheeting and process design, approach to flow sheeting systems, introduction to sequential modular approach, simultaneous modular approach and equation solving approach, sequential modular approach to flow sheeting, examples. Tear streams, convergence of tear streams, partitioning and tearing of a flow sheet, partitioning and precedence ordering, tearing a group of units. Flow sheeting by equation solving methods based on tearing.

**Dynamic Simulation**

Numerical recipes in CLinear and nonlinear equations, Ordinary and partial differential equations, Dynamic simulation of stirred tanks system with heating Multi component system, Reactors, Absorption and distillation columns, Application of orthogonal collocation and weighted residuals techniques in heat and mass transfer systems, Introduction to special software for steady and dynamic simulation of Chemical engineering systems. Introduction to various commercial design software and optimizers used in field of chemical engineering.

## References

1. Douglas James M., "Conceptual design of Chemical Processes", McGraw -Hill Book Company, New York, 1988
2. Remirez, W.F. - " Computational methods for Process Simulations ", Butterworths, New York, 1989
3. Sinnott R.K. "Chemical Engineering", Volume 6, Pergamon Press, New York, 1989
4. Westerberg A.W., et al, "Process Flow Sheeting", Cambridge University Press
5. Biegler Lorenz T, et al, "Systematic method of Chemical Process Design", Prentice Hall
6. Crowe C.M., et al, "Chemical Plant Simulation-An Introduction to Computer Aided Steady State Analysis", Prentice Hall
7. Anil Kumar, "Chemical Process Synthesis and Engineering Design",TMH,1981

## [Elective – V: Cleaner Production

### Teaching Scheme:

Lecture: 3 hrs/week

### Objectives

1. To give student an understanding about the concept of cleaner production.
2. To understand in detail, the methodologies involved
3. Financial evaluation of cleaner production technologies
4. To study the practical applications of cleaner production technologies

**Course Outcomes:** At the end of the course, the student will be able to:

1. Explain the concept and principles of cleaner production.
2. Suggest different unit operations in industrial production process to minimize pollutions.
3. Plan good housekeeping practices for Industry/other places with concern of safety, hygiene and waste reduction.
4. Suggest basic methods and techniques of pollution prevention during production.
5. Suggest cleaner production methods for a given situation which will also lead to cost reduction in long run

### Introduction

Cleaner production definition: Evaluation of cleaner production, Cleaner production network, Area covered by cleaner production (what is not cleaner production?).Difference between cleaner production and other methods, End of the pipe treatment to curb pollution, prerequisites of cleaner production.

### Cleaner production technique

Waste reduction at source, (a) Good housekeeping, (b) Process changes: change in raw material, batter process, control, equipment modification and technology changes, Recycling: on site recovery and reuse creation of useful byproducts, Product modification.

### **Cleaner production methodology**

Methods of environmental protection -- preventive strategy, Methods of environmental protection -- preventive strategy, making team for cleaner production, Analyzing process steps, Generating C.P opportunities

Selection of C.P solution, Implementing C.P solution

### **Concept of cleaner production**

Overview of CP Assessment Steps and skills, Preparing for the site visit, Information Gathering, and process flow diagram, material balance, CP Option Generation Technical and Environmental feasibility analysis-Economic valuation of alternatives fuels, Total cost analysis-CP Financing-Establishing a program-Organizing a program preparing a program plan-Measuring progress-pollution prevention and cleaner production Awareness plan -Waste audit-Environmental Statement. Energy audit related to cleaner production, Energy audit's need and scope, Types of energy audit. Preliminary or walk through energy audit. Detailed energy audit, Methodology of energy audit, Energy balance and identifying the energy conservation opportunities.

### **Financial analysis of cleaner production**

Gathering base line information, Determining the capital or investment cost, Establishing lifetime of equipment and annual depreciation, Determine revenue implication of the project. Estimating change in operating cost, Calculating incremental cash flow, Assessing project's viability.

### **Case studies and Cleaner Production applications**

Application (Industrial application of CP, LCA, EMS and Environmental Audits. C.P in chemical process industry, Practical ways & means to save material loss in loading/unloading and unit operations equipment like distillation column, drying and other equipments like heat exchanger, vacuum unit, conveying, etc. Practical ways & means for energy saving in industries. Case Studies of cleaner production.

### **References**

1. "Cleaner Production Worldwide", 1993, United Nations Environment Programme, Industry and Environment, Paris, France, 1993
2. "Cleaner Production: Training Resource Package", UNEP IE, Paris, 1996
3. "Clean Technology for manufacture of Specialty Chemicals", Editor-W. Hoyle and M. Lancaster, Royal Society of Chemistry, U.K
4. Randall Paul M, "Engineers Guide to Cleaner Production Technologies".
5. Ahluvalia V. K., "Green Chemistry: Environmentally Benign Reactions".
6. Sanders R.E., "Chemical Process Safety: Learning from case Histories", Oxford Butter Worth Publication
7. "Training Manual Package" by NCPC

### **OPEN ELECTIVES**

#### **Business Analytics**

### **Teaching scheme**

**Lecture: - 3 h/week**

|  |                           |
|--|---------------------------|
| <b>Course Code</b>                     |                           |
| <b>Course Name</b>                     | <b>Business Analytics</b> |
| <b>Credits</b><br><b>Prerequisites</b> |                           |

Total Number of Lectures: 48

|  |
|--|
| <b>Course objective</b>  |
| <ol style="list-style-type: none"> <li>1. Understand the role of business analytics within an organization.</li> <li>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.</li> <li>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.</li> <li>4. To become familiar with processes needed to develop, report, and analyze business data.</li> <li>5. Use decision-making tools/Operations research techniques.</li> <li>6. Mange business process using analytical and management tools.</li> <li>7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.</li> </ol> |

| <b>LECTURE WITH BREAKUP</b>   | <b>NO. OF LECTURES</b> |
|---|------------------------|
| <p><b>Unit1:</b></p> <p>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.</p> <p>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p> | 9                      |
| <p><b>Unit 2:</b></p> <p>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.</p> <p>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.</p>  | 8                      |
| <b>Unit 3:</b>  |                        |



|  |    |
|--|----|
| <p>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.</p> <p>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.</p>   | 9  |
| <p><b>Unit 4:</b></p> <p>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.</p> <p>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.</p> | 10 |
| <p><b>Unit 5:</b></p> <p>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.</p>  | 8  |
| <p><b>Unit 6:</b></p> <p>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.</p>   | 4  |

| COURSE OUTCOMES |   |
|-----------------|---|
| 1.              | Students will demonstrate knowledge of data analytics.  |
| 2.              | Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.                             |
| 3.              | Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |
| 4.              | Students will demonstrate the ability to translate data into clear, actionable insights.  |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.

2. Business Analytics by James Evans, persons Education.

## **OPEN ELECTIVES**

### **Industrial Safety**

#### **Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

#### **Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgraw Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

## **OPEN ELECTIVES**

### **Operations Research**

#### **Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, the student should be able to

1. Students should be able to apply the dynamic programming to solve problems of discrete and continuous variables.
2. Students should be able to apply the concept of non-linear programming
3. Students should be able to carry out sensitivity analysis
4. Student should be able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

**Open Elective**

**Cost Management of Engineering Projects**

**Teaching scheme**

**Lecture: - 3 h/week**

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## Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution : conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team : Role of each member. Importance Project site : Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

### References:

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

**Open Elective**  
**Composite Materials**

**Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III: Manufacturing of Metal Matrix Composites:** Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT-IV: Manufacturing of Polymer Matrix Composites:** Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V: Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.**

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

**Open Elective**  
**Waste to Energy**

**Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

### AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

| <b>Course objectives:</b><br>Students will be able to:   |  |       |
|--|--|-------|
| <ol style="list-style-type: none"> <li>1. Understand that how to improve your writing skills and level of readability</li> <li>2. Learn about what to write in each section</li> <li>3. Understand the skills needed when writing a Title</li> </ol> |  |       |
| Ensure the good quality of paper at very first-time submission   |  |       |
| <b>Syllabus</b>  |  |       |
| Units  | CONTENTS   | Hours |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4     |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4     |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4     |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4     |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4     |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4     |

#### Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

### AUDIT 1 and 2: DISASTER MANAGEMENT

| <b>Course Objectives:-</b> Students will be able to:  |                     |       |
|---|---------------------|-------|
| 1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.  |                     |       |
| 2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.  |                     |       |
| 3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.   |                     |       |
| 4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in |                     |       |
| <b>Syllabus</b>   |                     |       |
| Units   | CONTENTS            | Hours |
| 1   | <b>Introduction</b> | 4     |

|   |   |   |
|---|---|---|
|   | Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.   |   |
| 2 | <b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4 |
| 3 | <b>Disaster Prone Areas In India</b><br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics  | 4 |
| 4 | <b>Disaster Preparedness And Management</b><br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.   | 4 |
| 5 | <b>Risk Assessment</b><br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.   | 4 |
| 6 | <b>Disaster Mitigation</b><br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.   | 4 |

### SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.), "Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , "Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

### Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

### Syllabus

| Unit | Content  | Hours |
|------|--|-------|
| 1    | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul> | 8     |



|   |   |   |
|---|---|---|
| 2 | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8 |
| 3 | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8 |

### ***Suggested reading***

1. “Abhyastakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

### ***Course Output***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## **AUDIT 1 and 2: VALUE EDUCATION**

### ***Course Objectives***

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

### ***Syllabus***

| <b>Unit</b> | <b>Content</b>  | <b>Hours</b> |
|-------------|---|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul>   | 4            |
| 2           | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty ,Humanity. Power of faith, National Unity.</li> <li>• Patriotism. Love for nature ,Discipline</li> </ul>  | 6            |
| 3           | <ul style="list-style-type: none"> <li>• Personality and Behaviour Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> <li>• Doing best for saving nature</li> </ul> | 6            |

|   |  |   |
|---|--|---|
| 4 | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality ,Non violence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind ,Self-control.</li> <li>• Honesty, Studying effectively</li> </ul> | 6 |
|---|--|---|

**Suggested reading**

1 Chakroborty , S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press ,New Delhi

**Course outcomes**

Students will be able to

- 1.Knowledge of self-development
- 2.Learn the importance of Human values
- 3.Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

|   |  |              |
|---|--|--------------|
| <b>Course Objectives:</b>   |  |              |
| Students will be able to:   |  |              |
| <ol style="list-style-type: none"> <li>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>2. To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</li> <li>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ol> |  |              |
| <b>Syllabus</b>   |  |              |
| <b>Units</b>  | <b>Content</b>   | <b>Hours</b> |
| 1   | <ul style="list-style-type: none"> <li>•<b>History of Making of the Indian Constitution:</b></li> <li>History</li> <li>Drafting Committee, ( Composition &amp; Working)</li> </ul>   | 4            |
| 2   | <ul style="list-style-type: none"> <li>•<b>Philosophy of the Indian Constitution:</b></li> <li>Preamble</li> <li>Salient Features</li> </ul>   | 4            |
| 3   | <ul style="list-style-type: none"> <li>•<b>Contours of Constitutional Rights &amp; Duties:</b></li> <li>• Fundamental Rights</li> <li>• Right to Equality</li> <li>• Right to Freedom</li> <li>• Right against Exploitation</li> <li>• Right to Freedom of Religion</li> <li>• Cultural and Educational Rights</li> <li>• Right to Constitutional Remedies</li> <li>• Directive Principles of State Policy</li> <li>• Fundamental Duties.</li> </ul> | 4            |
| 4   | <ul style="list-style-type: none"> <li>•<b>Organs of Governance:</b></li> <li>• Parliament</li> <li>• Composition</li> </ul>   | 4            |

|   |  |   |
|---|--|---|
|   | <ul style="list-style-type: none"> <li>• Qualifications and Disqualifications</li> <li>• Powers and Functions <ul style="list-style-type: none"> <li>• Executive</li> </ul> </li> <li>• President</li> <li>• Governor</li> <li>• Council of Ministers</li> <li>• Judiciary, Appointment and Transfer of Judges, Qualifications</li> <li>• Powers and Functions</li> </ul>  |   |
| 5 | <ul style="list-style-type: none"> <li>• <b>Local Administration:</b></li> <li>• District's Administration head: Role and Importance,</li> <li>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.</li> <li>• Pachayati raj: Introduction, PRI: Zila Pachayat.</li> <li>• Elected officials and their roles, CEO Zila Pachayat: Position and role.</li> <li>• Block level: Organizational Hierarchy (Different departments),</li> <li>• Village level: Role of Elected and Appointed officials,</li> <li>• Importance of grass root democracy</li> </ul> | 4 |
| 6 | <ul style="list-style-type: none"> <li>• <b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul>   | 4 |

### Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

### Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

### AUDIT 1 and 2: PEDAGOGY STUDIES

|  |  |              |
|--|--|--------------|
| <b>Course Objectives:</b>  |  |              |
| Students will be able to:  |  |              |
| 4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers. |  |              |
| 5. Identify critical evidence gaps to guide the development.   |  |              |
| <b>Syllabus</b>  |  |              |
| <b>Units</b>   | <b>Content</b>                         | <b>Hours</b> |
| <b>1</b>   | • <b>Introduction and Methodology:</b> | 4            |

|   |   |   |
|---|---|---|
|   | <ul style="list-style-type: none"> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> <li>• Overview of methodology and Searching.</li> </ul>  |   |
| 2 | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>  | 2 |
| 3 | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers' attitudes and beliefs and Pedagogic strategies.</li> </ul> | 4 |
| 4 | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul>  | 4 |
| 5 | <p><b>Research gaps and future directions</b></p> <ul style="list-style-type: none"> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> <li>• Dissemination and research impact.</li> </ul>   | 2 |

### Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal Educational Development*, 33 (3): 272–282.
5. Alexander RJ (2001) *Culture and pedagogy: International comparisons in primary education*. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf)

### Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

### AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

#### Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

#### Syllabus

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> </ul> Do`s and Don`t`s in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> </ul> i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam    | 8     |

#### Suggested reading

1. ‘Yogic Asanas for Group Training-Part-I’ : Janardan Swami Yogabhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

#### Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

### AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

#### Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

#### Syllabus

| Unit | Content | Hours |
|------|---------|-------|
|------|---------|-------|

|   |   |   |
|---|---|---|
| 1 | <p>Neetisatakam-Holistic development of personality</p> <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont's)</li> <li>• Verses- 71,73,75,78 (do's)</li> </ul>   | 8 |
| 2 | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>   | 8 |
| 3 | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad Bhagwad Geeta : Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad Bhagwad Geeta : Chapter2-Verses 17,Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8 |

***Suggested reading***

1. “Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Samskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

# MODEL CURRICULUM

of

Engineering & Technology PG Courses

# **ELECTRONICS & TELECOMMUNICATION**



**ALL INDIA COUNCIL FOR TECHNICAL EDUCATION**

Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070

[www.aicte-india.org](http://www.aicte-india.org)

## M. Tech. (Electronics & Telecommunication) Specialization: Signal Processing

### Semester I

| Sr. No. | Course Type/Code           | Course Name   |
|---------|----------------------------|---|
| 1       | Core 1                     | Advanced Digital Signal Processing  |
| 2       | Core 2                     | Digital Image and Video Processing  |
| 3       | Prog. Specific<br>Elective | <b>Elective I</b><br>(1) DSP Architecture<br>(2) Computer Vision<br>(3) Remote Sensing                          |
| 4       | Prog. Specific<br>Elective | <b>Elective – II</b><br>(1) JTFA and MRA<br>(2) Voice and Data Networks<br>(3) Audio Video Coding & Compression |
| 5       | Lab1                       | Advanced Digital Signal Processing Lab  |
| 6       | Lab2                       | Digital Image and Video Processing Lab  |
| 7       |                            | Research Methodology and IPR  |
| 8       | Aud 1                      | Audit course 1  |

### Semester II

| Sr. No. | Course Code                     | Course Name   |
|---------|---------------------------------|---|
| 1       | Core 3                          | Pattern Recognition and Machine Learning  |
| 2       | Core 4                          | Detection and Estimation Theory   |
| 3       | Program<br>Specific<br>Elective | <b>Elective – III</b><br>(1) Advanced Compute Architecture<br>(2) IOT and Applications<br>(3) Digital Design and Verification |
| 4       | Program<br>Specific<br>Elective | <b>Elective – IV</b><br>(1) Multispectral Signal Analysis<br>(2) Audio Processing<br>(3) Biomedical Signal Processing         |
| 5       | Lab 1                           | Pattern Recognition and Machine Learning Lab  |
| 6       | Lab 2                           | Detection and Estimation Theory Lab   |
| 7       |                                 | Mini Project  |



|   |       |                |
|---|-------|----------------|
| 8 | Aud 2 | Audit course 2 |
|---|-------|----------------|

### Semester III

| Sr. No. | Course Code               | Course Name   |
|---------|---------------------------|---|
| 1.      | Program Specific Elective | <b>Elective – V</b><br>(1) Artificial Intelligence<br>(2) Optimization Techniques<br>(3) Modelling and Simulation Techniques  |
| 2.      | Open Elective             | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3.      | Dissertation              | Dissertation Phase – I  |

### Semester IV

| Sr. No. | Course Code  | Course Name             |
|---------|--------------|-------------------------|
| 1.      | Dissertation | Dissertation Phase – II |

#### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

### M. Tech. (Electronics & Telecommunication) Specialization: Communications

#### Semester I

| Sr. No. | Course Type/Code        | Course Name  |
|---------|-------------------------|--|
| 1       | Core 1                  | Advanced Communication Networks  |
| 2       | Core 2                  | Wireless and Mobile Communication  |
| 3       | Prog. Specific Elective | Elective I<br>(4) Wireless Sensor Networks<br>(5) Optical Networks<br>(6) Statistical Information Processing |

|   |                         |   |
|---|-------------------------|---|
| 4 | Prog. Specific Elective | Elective – II<br>(4) Cognitive Radio<br>(5) RF and Microwave Circuit Design<br>(6) DSP Architecture |
| 5 | Lab1                    | Advanced Communication Networks Lab   |
| 6 | Lab2                    | Wireless and Mobile Communication Lab   |
| 7 |                         | Research Methodology and IPR  |
| 8 | Aud 1                   | Audit course 1  |

### Semester II

| Sr. No. | Course Code               | Course Name  |
|---------|---------------------------|--|
| 1       | Core 3                    | Antennas and Radiating Systems   |
| 2       | Core 4                    | Advanced Digital Signal Processing   |
| 3       | Program Specific Elective | <b>Elective – III</b><br>(1) Satellite Communication<br>(2) Internet of Things<br>(3) Voice and data networks          |
| 4       | Program Specific Elective | <b>Elective – IV</b><br>(1) Markov Chain and Queuing System<br>(2) MIMO System<br>(3) Programmable Networks – SDN, NFV |
| 5       | Lab 3                     | Antennas and Radiating Systems lab   |
| 6       | Lab 4                     | Advanced Digital Signal Processing Lab   |
| 7       |                           | Mini Project   |
| 8       | Aud2                      | Audit course 2   |

### Semester III

| Sr. No. | Course Code               | Course Name   |
|---------|---------------------------|---|
| 1.      | Program Specific Elective | <b>Elective – V</b><br>(1) High Performance Networks<br>(2) Pattern Recognition and Machine learning<br>(3) Remote Sensing  |
| 2.      | Open Elective             | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3.      | Dissertation              | Dissertation Phase – I  |

### Semester IV

| Sr. No. | Course Code | Course Name |
|---------|-------------|-------------|
|---------|-------------|-------------|

|    |              |                         |
|----|--------------|-------------------------|
|    |              |                         |
| 1. | Dissertation | Dissertation Phase – II |

#### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

### M. Tech. (Electronics & Telecommunication) Specialization: VLSI & Embedded Systems

#### Semester I

| Sr. No. | Course Type/Code            | Course Name  |
|---------|-----------------------------|--|
| 1       | Core 1                      | RTL Simulation and Synthesis with PLDs   |
| 2       | Core 2                      | Microcontrollers and Programmable Digital Signal Processors  |
| 3       | Prog. Specific Elective PE1 | Elective I<br>(1) Digital Signal and Image Processing<br>(2) Programming Languages for Embedded Software<br>(3) VLSI signal processing |
| 4       | Prog. Specific Elective PE2 | Elective II<br>(1) Parallel Processing<br>(2) System Design with Embedded Linux<br>(3) CAD of Digital System                           |
| 5       | Lab 1                       | RTL Simulation and Synthesis with PLDs Lab   |
| 6       | Lab2                        | Microcontrollers and Programmable Digital Signal Processors Lab  |
| 7       |                             | Research Methodology and IPR   |
| 8       | Aud 1                       | Audit course 1   |

#### Semester II

| Sr. No. | Course Code | Course Name  |
|---------|-------------|--|
| 1       | Core 3      | Analog and Digital CMOS VLSI Design  |
| 2       | Core 4      | VLSI Design Verification and Testing   |
| 3       | PE-3        | Elective III<br>(1) Memory Technologies<br>(2) SoC Design<br>(3) Low power VLSI Design |
| 4       | PE-4        | Elective IV  |

|   |       |   |
|---|-------|---|
|   |       | (1) Communication Buses and Interfaces<br>(2) Network Security and Cryptography<br>(3) Physical design automation |
| 5 | Lab1  | Analog and Digital CMOS VLSI Design Lab   |
| 6 | Lab2  | VLSI Design Verification and Testing Lab  |
| 7 |       | Mini Project  |
| 8 | Aud 2 | Audit course 2  |

### Semester III

| Sr. No. | Course Code  | Course Name   |
|---------|--------------|---|
| 1.      | PE-5         | <b>Elective – V</b><br>(1) Communication Network<br>(2) Selected Topics in Mathematics<br>(3) Nano materials and Nanotechnology                                       |
| 2.      | OE           | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |
| 3       | Dissertation | Dissertation Phase – I  |

### Semester IV

| Sr. No. | Course Code  | Course Name             |
|---------|--------------|-------------------------|
| 1.      | Dissertation | Dissertation Phase - II |

### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

# M. Tech.(Electronics and Telecommunication)

## Curriculum Structure

### Specialization: Signal processing

#### Program Outcomes (POs)

- a. Ability to apply the knowledge of science, mathematics, and engineering principles for developing problems solving attitude.
- b. Ability to identify, formulate and solve engineering problems in the signal processing areas such as Developing robust and problem specific algorithms for acquisition, processing, analysis, synthesis of signals, to be applied in Signal Processing, Machine Vision and Communication Networks.
- c. Ability to understand and use different software tools in the domain of signal processing. Analysis and Verification of algorithms, Functional and timing Simulation on platforms like MATLAB, code composer studio and assembly language.
- d. Ability to design and conduct experiments, analyze and interpret data, imbibe programming skills for development of simulation experiments.
- e. Ability to function as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.

#### Semester I

| Sr. No. | Course Type/Code        | Course Name  | Teaching Scheme |          |          | Credits   |
|---------|-------------------------|--|-----------------|----------|----------|-----------|
|         |                         |  | L               | T        | P        |           |
| 1       | Core 1                  | Advanced Digital Signal Processing   | 3               | 0        | 0        | 3         |
| 2       | Core 2                  | Digital Image and Video Processing   | 3               | 0        | 0        | 3         |
| 3       | Prog. Specific Elective | Elective I<br>(1) DSP Architecture<br>(2) Computer Vision<br>(3) Remote Sensing                          | 3               | 0        | 0        | 3         |
| 4       | Prog. Specific Elective | Elective – II<br>(1) JTFA and MRA<br>(2) Voice and Data Networks<br>(3) Audio Video Coding & Compression | 3               | 0        | 0        | 3         |
| 5       | Lab1                    | Advanced Digital Signal Processing Lab   | 0               | 0        | 4        | 2         |
| 6       | Lab2                    | Digital Image and Video Processing Lab   | 0               | 0        | 4        | 2         |
| 7       |                         | Research Methodology and IPR   | 2               | 0        | 0        | 2         |
| 8       | Aud 1                   | Audit course 1   | 2               | 0        | 0        | 0         |
|         |                         | <b>Total</b>   | <b>16</b>       | <b>0</b> | <b>8</b> | <b>18</b> |

#### Semester II

| Sr. No. | Course Code               | Course Name   | Teaching Scheme |          |           | Credits   |
|---------|---------------------------|---|-----------------|----------|-----------|-----------|
|         |                           |   | L               | T        | P         |           |
| 1       | Core 3                    | Pattern Recognition and Machine Learning  | 3               | 0        | 0         | 3         |
| 2       | Core 4                    | Detection and Estimation Theory   | 3               | 0        | 0         | 3         |
| 3       | Program Specific Elective | <b>Elective – III</b><br>(1) Advanced Compute Architecture<br>(2) IOT and Applications<br>(3) Digital Design and Verification | 3               | 0        | 0         | 3         |
| 4       | Program Specific Elective | <b>Elective – IV</b><br>(1) Multispectral Signal Analysis<br>(2) AudioProcessing<br>(3)Biomedical Signal Processing           | 3               | 0        | 0         | 3         |
| 5       | Lab 1                     | Pattern Recognition and Machine Learning Lab  | 0               | 0        | 4         | 2         |
| 6       | Lab 2                     | Detection and Estimation Theory Lab   | 0               | 0        | 4         | 2         |
| 7       |                           | Mini Project  | 0               | 0        | 4         | 2         |
| 8       | Aud 2                     | Audit course 2  | 2               | 0        | 0         | 0         |
|         |                           | <b>Total</b>  | <b>14</b>       | <b>0</b> | <b>12</b> | <b>18</b> |

### Semester-III

| Sr. No. | Course Code               | Course Name   | Teaching Scheme |          |           | Credits   |
|---------|---------------------------|---|-----------------|----------|-----------|-----------|
|         |                           |   | L               | T        | P         |           |
| 1.      | Program Specific Elective | <b>Elective – V</b><br>(1) Artificial Intelligence<br>(2) Optimization Techniques<br>(3) Modelling and Simulation Techniques  | 3               | 0        | 0         | 3         |
| 2.      | Open Elective             | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3               | 0        | 0         | 3         |
| 3.      | Dissertation              | Dissertation Phase – I  | 0               | 0        | 20        | 10        |
|         |                           | <b>Total</b>  | <b>06</b>       | <b>0</b> | <b>20</b> | <b>16</b> |

**Semester-IV**

| Sr. No.      | Course Code  | Course Name             | Teaching Scheme |    |    | Credits   |
|--------------|--------------|-------------------------|-----------------|----|----|-----------|
|              |              |                         | L               | T  | P  |           |
| 1.           | Dissertation | Dissertation Phase – II | --              | -- | 32 | 16        |
| <b>Total</b> |              |                         | --              | -- | -- | <b>16</b> |

Total

68 credits

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**Advanced Digital Signal Processing****Teaching Scheme**

Lectures: 3 hrs./week

**Course Outcomes:**

At the end of this course, students will be able to

- To understand theory of different filters and algorithms
- To understand theory of multirate DSP, solve numerical problems and write algorithms
- To understand theory of prediction and solution of normal equations
- To know applications of DSP at block level.

**Syllabus Contents:****Unit 1**

Overview of DSP, Characterization in time and frequency, FFT Algorithms, Digital filter design and structures: Basic FIR/IIR filter design & structures, design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures, and Parallel all pass realization of IIR.

**Unit 2**

Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Applications in subband coding.

**Unit 3**

Linear prediction & optimum linear filters, stationary random process, forward-backward linear prediction filters, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction.

**Unit 4**

Adaptive Filters, Applications, Gradient Adaptive Lattice, Minimum mean square criterion, LMS algorithm, Recursive Least Square algorithm

**Unit 5**

Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigenanalysis Algorithms for Spectrum Estimation.

**Unit 6**

Application of DSP & Multi rate DSP, Application to Radar, introduction to wavelets, application to image processing, design of phase shifters, DSP in speech processing & other applications

**References:**

- J.G.Proakis and D.G.Manolakis “Digital signal processing: Principles, Algorithm and Applications”, 4th Edition, Prentice Hall, 2007.
- N. J. Fliege, “Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets”, 1<sup>st</sup> Edition, John Wiley and Sons Ltd, 1999.
- Bruce W. Suter, “Multirate and Wavelet Signal Processing”, 1<sup>st</sup> Edition, Academic Press, 1997.
- M. H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley & Sons Inc., 2002.
- S.Haykin, “Adaptive Filter Theory”, 4<sup>th</sup> Edition, Prentice Hall, 2001.
- D.G.Manolakis, V.K. Ingle and S.M.Kogon, “Statistical and Adaptive Signal Processing”, McGraw Hill, 2000.

**Digital Image and Video Processing**

**Teaching Scheme**

Lectures: 3 hrs./week

**Course Outcomes:**

At the end of this course, students will be able to

- Learn different techniques for image enhancement, video and image recovery
- Understand techniques for image and video segmentation
- Study techniques for image and video compression and object recognition

**Syllabus Contents:**

**Unit 1**

**Digital Image and Video Fundamentals**

Digital image and video fundamentals and formats, 2-D and 3-D sampling and aliasing, 2-D/3-D filtering, image decimation/interpolation, video sampling and interpolation, Basic image processing operations, Image Transforms

Need for image transforms, DFT, DCT, Walsh, Hadamard transform, Haar transform, Wavelet transform

**Unit 2**



### **Image and Video Enhancement and Restoration**

Histogram, Point processing, filtering, image restoration, algorithms for 2-D motion estimation, change detection, motion-compensated filtering, frame rate conversion, deinterlacing, video resolution enhancement, Image and Video restoration (recovery).

#### **Unit 3**

### **Image and Video Segmentation**

Discontinuity based segmentation- Line detection, edge detection, thresholding, Region based segmentation, Scene Change Detection, Spatiotemporal Change Detection, Motion Segmentation, Simultaneous Motion Estimation and Segmentation Semantic Video Object Segmentation, Morphological image processing.

#### **Unit 4**

### **Colour image Processing**

Colour fundamentals, Colour models, Conversion of colour models, Pseudo colour image processing, Full colour processing

#### **Unit 5**

### **Image and Video Compression**

Lossless image compression including entropy coding, lossy image compression, video compression techniques, and international standards for image and video compression (JPEG, JPEG 2000, MPEG-2/4, H.264, SVC), Video Quality Assessment

#### **Unit 6**

### **Object recognition**

Image Feature representation and description-boundary representation, boundary descriptors, regional descriptors, feature selection techniques, introduction to classification, supervised and unsupervised learning, Template matching, Bayes classifier

#### **References:**

- Ed. Al Bovik ,”Handbook of Image and Video Processing”, 2<sup>nd</sup> Edition, Academic Press, 2000.
- J. W. Woods, “Multidimensional Signal, Image and Video Processing and Coding”, 2<sup>nd</sup> Edition, Academic Press, 2011.
- Rafael C. Gonzalez and Richard E. Woods,” Digital Image Processing”, 3rd Edition, Prentice Hall, 2008.
- A. M. Tekalp, “Digital Video Processing”, 2<sup>nd</sup> Edition, Prentice Hall, 2015.
- S. Shridhar, “Digital Image Processing”, 2<sup>nd</sup> Edition, Oxford University Press, 2016.

### **DSP Architecture**

#### **Teaching Scheme**

Lectures: 3 hrs./week

#### **Course Outcomes:**

At the end of this course, students will be able to

- Identify and formalize architectural level characterization of P-DSP hardware

- Ability to design, programming (assembly and C), and testing code using Code Composer Studio environment
- Deployment of DSP hardware for Control, Audio and Video Signal processing applications
- Understanding of major areas and challenges in DSP based embedded systems

**Syllabus Contents:**

**Unit 1**

Programmable DSP Hardware: Processing Architectures (von Neumann, Harvard), DSP core algorithms (FIR, IIR, Convolution, Correlation, FFT), IEEE standard for Fixed and Floating Point Computations, Special Architectures Modules used in Digital Signal Processors (like MAC unit, Barrel shifters), On-Chip peripherals, DSP benchmarking.

**Unit 2**

Structural and Architectural Considerations: Parallelism in DSP processing, Texas Instruments TMS320 Digital Signal Processor Families, Fixed Point TI DSP Processors: TMS320C1X and TMS320C2X Family, TMS320C25 –Internal Architecture, Arithmetic and Logic Unit, Auxiliary Registers, Addressing Modes (Immediate, Direct and Indirect, Bit-reverse Addressing), Basics of TMS320C54x and C55x Families in respect of Architecture improvements and new applications fields, TMS320C5416 DSP Architecture, Memory Map, Interrupt System, Peripheral Devices, Illustrative Examples for assembly coding.

**Unit 3**

VLIW Architecture: Current DSP Architectures, GPUs as an alternative to DSP Processors, TMS320C6X Family, Addressing Modes, Replacement of MAC unit by ILP, Detailed study of ISA, Assembly Language Programming, Code Composer Studio, Mixed C and Assembly Language programming, On-chip peripherals, Simple applications developments as an embedded environment.

**Unit 4**

Multi-core DSPs: Introduction to Multi-core computing and applicability for DSP hardware, Concept of threads, introduction to P-thread, mutex and similar concepts, heterogeneous and homogenous multi-core systems, Shared Memory parallel programming –OpenMP approach of parallel programming, PRAGMA directives, OpenMP Constructs for work sharing like for loop, sections, TI TMS320C6678 (Eight Core subsystem).

**Unit 5**

FPGA based DSP Systems: Limitations of P-DSPs, Requirements of Signal processing for Cognitive Radio (SDR), FPGA based signal processing design-case study of a complete design of DSP processor.

**Unit 6**

High Performance Computing using P-DSP: Preliminaries of HPC, MPI, OpenMP, multicore DSP as HPC infrastructure.

**References:**

- M. Sasikumar, D. Shikhare, Ravi Prakash, “Introduction to Parallel Processing”, 1<sup>st</sup> Edition, PHI, 2006.
- Fayez Gebali, “Algorithms and Parallel Computing”, 1<sup>st</sup> Edition, John Wiley & Sons, 2011

- Rohit Chandra, Ramesh Menon, Leo Dagum, David Kohr, DrorMaydan, Jeff McDonald, "Parallel Programming in OpenMP", 1st Edition, Morgan Kaufman, 2000.
- Ann Melnichuk, Long Talk, "Multicore Embedded systems", 1st Edition, CRC Press, 2010.
- Wayne Wolf, "High Performance Embedded Computing: Architectures, Applications and Methodologies", 1st Edition, Morgan Kaufman, 2006.
- E.S.Gopi, "Algorithmic Collections for Digital Signal Processing Applications Using MATLAB", 1st Edition, Springer Netherlands, 2007.

### **Computer Vision**

#### **Teaching Scheme**

Lectures: 3 hrs./week

#### **Course Outcomes:**

At the end of this course, students will be able to

- Study the image formation models and feature extraction for computer vision
- Identify the segmentation and motion detection and estimation techniques
- Develop small applications and detect the objects in various applications

#### **Syllabus Contents:**

##### **Unit 1**

##### **Image Formation Models**

• Monocular imaging system • Orthographic & Perspective Projection • Camera model and Camera calibration • Binocular imaging systems, Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration. Apparel, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration. Apparel, Stereo vision

##### **Unit 2**

##### **Feature Extraction**

• Image representations (continuous and discrete) • Edge detection, Edge linking, corner detection, texture, binary shape analysis, boundary pattern analysis, circle and ellipse detection, Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation; Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, color, motion and edges.

##### **Unit 3**

**Shape Representation and Segmentation** • Deformable curves and surfaces • Snakes and active contours • Level set representations • Fourier and wavelet descriptors • Medial representations • Multi-resolution analysis, Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation

##### **Unit 4**

**Motion Detection and Estimation** • Regularization theory • Optical computation • Stereo Vision • Motion estimation, Background Subtraction and Modelling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation • Structure from motion, Motion Tracking in Video

##### **Unit 5**

**Object recognition** • Hough transforms and other simple object recognition methods • Shape

correspondence and shape matching • Principal component analysis • Shape priors for recognition

**Unit 6**

**Applications of Computer Vision**

Automated Visual Inspection, Inspection of Cereal Grains, Surveillance, In-Vehicle Vision Systems, CBIR, CBVR, Activity Recognition, computational photography, Biometrics, stitching and document processing

**References:**

- D. Forsyth and J. Ponce, “Computer Vision - A modern approach”, 2<sup>nd</sup> Edition, Pearson Prentice Hall, 2012
- Szeliski, Richard, “Computer Vision: Algorithms and Applications”, 1<sup>st</sup> Edition, Springer-Verlag London Limited, 2011.
- Richard Hartley and Andrew Zisserman, “Multiple View Geometry in Computer Vision”, 2<sup>nd</sup> Edition, Cambridge University Press, 2004.
- K. Fukunaga, “Introduction to Statistical Pattern Recognition”, 2<sup>nd</sup> Edition, Morgan Kaufmann, 1990.
- Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, 3rd Edition, Prentice Hall, 2008.
- B. K. P. Horn, “Robot Vision”, 1<sup>st</sup> Edition, McGraw-Hill, 1986.
- E. R. Davies “Computer and Machine Vision: Theory, Algorithms, Practicalities”, 4th Edition, Elsevier Inc, 2012.

**Remote Sensing**

**Teaching Scheme**

Lectures: 3hrs/week

**Course Outcomes:**

At the end of this course, students shall be able to

- Understand basic concepts, principles and applications of remote sensing, particularly the geometric and radiometric principles;
- Provide examples of applications of principles to a variety of topics in remote sensing, particularly related to data collection, radiation, resolution, and sampling.

**Syllabus Contents:**

**Unit 1**

Physics Of Remote Sensing: Electro Magnetic Spectrum, Physics of Remote Sensing-Effects of Atmosphere-Scattering–Different types–Absorption-Atmospheric window-Energy interaction with surface features –Spectral reflectance of vegetation, soil and water atmospheric influence on spectral response patterns-multi concept in Remote sensing.

**Unit 2**

Data Acquisition: Types of Platforms–different types of aircrafts-Manned and Unmanned space crafts–sun synchronous and geo synchronous satellites –Types and characteristics of different platforms –LANDSAT, SPOT, IRS, INSAT, IKONOS, QUICKBIRD etc.

**Unit 3**

Photographic products, B/W,color, color IR film and their characteristics –resolving power of lens and film - Optomechanical electro optical sensors –across track and along track scanners-multispectral scanners and thermal scanners–geometric characteristics of scanner imagery - calibration of thermal scanners.

**Unit 4**

Scattering System: Microwave scatterometry,types of RADAR –SLAR –resolution –rangeand azimuth –real aperture and synthetic aperture RADAR. Characteristics of Microwave imagestopographic effect-different types of Remote Sensing platforms –airborne and space borne sensors -ERS, JERS, RADARSAT, RISAT -Scatterometer, Altimeter-LiDAR remote sensing, principles, applications.

**Unit 5**

Thermal And Hyper Spectral Remote Sensing:Sensors characteristics-principle of spectroscopy-imaging spectroscopy–fieldconditions, compound spectral curve, Spectral library, radiative models, processing procedures, derivative spectrometry, thermal remote sensing –thermal sensors, principles, thermal data processing, applications.

**Unit 6**

Data Analysis:Resolution–Spatial, Spectral, Radiometric and temporal resolution-signal to noise ratio-data products and their characteristics-visual and digital interpretation–Basicprinciples of data processing –Radiometric correction–Image enhancement–Imageclassification–Principles of LiDAR, Aerial Laser Terrain Mapping.

**References:**

- Lillesand.T.M. and Kiefer.R.W,“Remote Sensing and Image interpretation”, 6<sup>th</sup>Edition, John Wiley & Sons, 2000.
- John R. Jensen, “Introductory Digital Image Processing: A Remote Sensing Perspective”, 2nd Edition, Prentice Hall,1995.
- Richards, John A., Jia, Xiuping, “Remote Sensing Digital Image Analysis”,5th Edition, Springer-Verlag Berlin Heidelberg, 2013.
- Paul Curran P.J. Principles of Remote Sensing, 1<sup>st</sup> Edition, Longman Publishing Group, 1984.
- Charles Elachi, Jakob J. van Zyl, “Introduction to The Physicsand Techniques of Remote Sensing”, 2<sup>nd</sup> Edition, Wiley Serie, 2006.
- Sabins, F.F.Jr, “Remote Sensing Principles and Image Interpretation”, 3<sup>rd</sup> Edition, W.H.Freeman& Co, 1978

**Joint Time Frequency Analysis & Multi Resolution Analysis**

**Teaching Scheme**

Lectures: 3 hrs./week

**Course Outcomes:**

At the end of this course, students will be able to

- Introduction to Transforms in signal processing
- To understand Time -Frequency Analysis & Multiresolution Analysis
- Study of Wavelets and its Applications

**Syllabus Contents:**

**Unit 1**

Introduction Review of Fourier Transform, Parseval Theorem and need for joint time-frequency Analysis. Concept of non-stationary signals, Short-time Fourier transforms (STFT), Uncertainty Principle, and Localization/Isolation in time and frequency, Hilbert Spaces, Banach Spaces, and Fundamentals of Hilbert Transform.

**Unit 2**

Bases for Time-Frequency Analysis: Wavelet Bases and filter Banks, Tilings of Wavelet Packet and Local Cosine Bases, Wavelet Transform, Real Wavelets, Analytic Wavelets, Discrete Wavelets, Instantaneous Frequency, Quadratic time-frequency energy, Wavelet Frames, Dyadic wavelet Transform, Construction of Haar and Roof scaling function using dilation equation and graphical method.

**Unit 3**

Multiresolution Analysis: Haar Multiresolution Analysis, MRA Axioms, Spanning Linear Subspaces, nested subspaces, Orthogonal Wavelets Bases, Scaling Functions, Conjugate Mirror Filters, Haar 2-band filter Banks, Study of up samplers and down samplers, Conditions for alias cancellation and perfect reconstruction, Discrete wavelet transform and relationship with filter Banks, Frequency analysis of Haar 2-band filter banks, scaling and wavelet dilation equations in time and frequency domains, case study of decomposition and reconstruction of given signal using orthogonal framework of Haar 2band filter bank.

**Unit 4**

Wavelets: Daubechies Wavelet Bases, Daubechies compactly supported family of wavelets; Daubechies filter coefficient calculations, Case study of Daub-4 filter design, Connection between Haar and Daub-4, Concept of Regularity, Vanishing moments. Other classes of wavelets like Shannon, Meyer, and Battle-Lamarie.

**Unit 5**

Bi-orthogonal wavelets and Applications: Construction and design. Case studies of biorthogonal 5/3 tap design and its use in JPEG 2000. Wavelet Packet Trees, Time-frequency localization, compactly supported wavelet packets, case study of Walsh wavelet packet bases generated using Haar conjugate mirror filters till depth level 3. Lifting schemes for generating orthogonal bases of second generation wavelets.

**Unit 6**

JTFA Applications: Riesz Bases, Scalograms, Time-Frequency distributions: fundamental ideas, Applications: Speech, audio, image and video compression; signal denoising, feature extraction, inverse problem.

**References:**

- S. Mallat, "A Wavelet Tour of Signal Processing," 2<sup>nd</sup> Edition, Academic Press, 1999.
- L. Cohen, "Time-frequency analysis", 1<sup>st</sup> Edition, Prentice Hall, 1995.
- G. Strang and T. Q. Nguyen, "Wavelets and Filter Banks", 2<sup>nd</sup> Edition, Wellesley Cambridge Press, 1998.
- I. Daubechies, "Ten Lectures on Wavelets", SIAM, 1992.
- P. P. Vaidyanathan, "Multirate Systems and Filter Banks", Prentice Hall, 1993.
- M. Vetterli and J. Kovacevic, "Wavelets and Subband Coding", Prentice Hall, 1995

| <b>Voice and Data Networks</b>   |  |
|--|--|
| <b>Teaching Scheme</b>   |  |
| Lectures: 3 hrs./week  |  |
| <b>Course Outcomes:</b>  |  |
| At the end of this course, students will be able to  |  |
| <ul style="list-style-type: none"> <li>• Protocol, algorithms, trade-offs rationale.</li> <li>• Routing, transport, DNS resolutions</li> <li>• Network extensions and next generation architectures.</li> </ul>  |  |
| <b>Syllabus Contents:</b>  |  |
| <b>Unit 1</b>  |  |
| Network Design Issues, Network Performance Issues, Network Terminology, centralized and distributed approaches for networks design, Issues in design of voice and data networks.   |  |
| <b>Unit 2</b>  |  |
| Layered and Layer less Communication, Cross layer design of Networks, Voice Networks (wired and wireless) and Switching, Circuit Switching and Packet Switching, Statistical Multiplexing.   |  |
| <b>Unit 3</b>  |  |
| Data Networks and their Design, Link layer design- Link adaptation, Link Layer Protocols, Retransmission. Mechanisms (ARQ), Hybrid ARQ (HARQ), Go Back N, Selective Repeat protocols and their analysis.   |  |
| <b>Unit 4</b>  |  |
| Queuing Models of Networks , Traffic Models , Little's Theorem, Markov chains, M/M/1 and other Markov systems, Multiple Access Protocols , Aloha System , Carrier Sensing , Examples of Local area networks,   |  |
| <b>Unit 5</b>  |  |
| Inter-networking , Bridging, Global Internet , IP protocol and addressing , Sub netting , Classless Inter domain Routing (CIDR) , IP address lookup , Routing in Internet. End to End Protocols, TCP and UDP. Congestion Control , Additive Increase/Multiplicative Decrease , Slow Start, Fast Retransmit/ Fast Recovery,   |  |
| <b>Unit 6</b>  |  |
| Congestion avoidance, RED TCP Throughput Analysis, Quality of Service in Packet Networks. Network Calculus, Packet Scheduling Algorithms.  |  |
| <b>References:</b>   |  |
| <ul style="list-style-type: none"> <li>• D. Bertsekas and R. Gallager, “Data Networks”, 2<sup>nd</sup> Edition, Prentice Hall, 1992.</li> <li>• L. Peterson and B. S. Davie, “Computer Networks: A Systems Approach”, 5<sup>th</sup> Edition, Morgan Kaufman, 2011.</li> <li>• Kumar, D. Manjunath and J. Kuri, “Communication Networking: An analytical approach”, 1<sup>st</sup> Edition, Morgan Kaufman, 2004.</li> <li>• Walrand, “Communications Network: A First Course”, 2<sup>nd</sup> Edition, McGraw Hill, 2002.</li> <li>• Leonard Kleinrock, “Queueing Systems, Volume I: Theory”, 1<sup>st</sup> Edition, John Wiley and Sons, 1975.</li> </ul> |  |

- Aaron Kershenbaum, “Telecommunication Network Design Algorithms”, McGraw Hill, 1993.
- Vijay Ahuja, “Design and Analysis of Computer Communication Networks”, McGraw Hill, 1987

### Audio Video Coding & Compression

#### Teaching Scheme

Lectures: 3 hrs./week

#### Course Outcomes:

At the end of this course, students will be able to

- Familiarity to lossy and lossless compression systems.
- Study of Video coding techniques and standards.
- Understand audio coding and multimedia synchronization techniques.

#### Syllabus Contents:

##### Unit 1

Introduction to Multimedia Systems and Processing, Lossless Image Compression Systems Image Compression Systems, Huffman Coding, Arithmetic and Lempel-Ziv Coding, Other Coding Techniques

##### Unit 2

Lossy Image Compression Systems, Theory of Quantization, Delta Modulation and DPCM, Transform Coding & K-L Transforms, Discrete Cosine Transforms, Multi-Resolution Analysis, Theory of Wavelets, Discrete Wavelet Transforms, Still Image Compression Standards: JBIG and JPEG

##### Unit 3

Video Coding and Motion Estimation: Basic Building Blocks & Temporal Redundancy, Block based motion estimation algorithms, Other fast search motion estimation algorithms

##### Unit 4

Video Coding Standards MPEG-1 standards, MPEG-2 Standard, MPEG-4 Standard, H.261, H.263 Standards, H.264 standard

##### Unit 5

Audio Coding, Basic of Audio Coding, Audio Coding, Transform and Filter banks, Polyphase filter implementation , Audio Coding, Format and encoding, Psychoacoustic Models

##### Unit 6

Multimedia Synchronization, Basic definitions and requirements, References Model and Specification, Time stamping and pack architecture, Packet architectures and audio-video interleaving, Multimedia Synchronization, Playback continuity, Video Indexing And Retrieval: Basics of content based image retrieval, Video Content Representation, Video Sequence Query Processing

#### References:



- Iain E.G. Richardson, “H.264 and MPEG-4 Video Compression”, Wiley, 2003.
- Khalid Sayood, “Introduction to Data Compression”, 4th Edition, Morgan Kaufmann, 2012
- Mohammed Ghanbari, “Standard Codecs: Image Compression to Advanced Video Coding”, 3rd Edition, The Institution of Engineering and Technology, 2011.
- Julius O. Smith III, “Spectral Audio Signal Processing”, W3K Publishing, 2011.
- Nicolas Moreau, “Tools for Signal Compression: Applications to Speech and Audio Coding”, Wiley, 2011.

**Lab 1 : Advanced Digital Signal Processing lab**

**Teaching Scheme**

Lectures: 4 hrs./week

**Course Outcomes:**

At the end of this course, students will be able to

- Design different digital filters in software
- Apply various transforms in time and frequency
- Perform decimation and interpolation

**List of Assignments:**

1. Basic Signal Representation
2. Correlation Auto And Cross
3. Stability Using Hurwitz Routh Criteria
4. Sampling FFT Of Input Sequence
5. Butterworth Low pass And High pass Filter Design
6. Chebychev Type I,II Filter
7. State Space Matrix from Differential Equation
8. Normal Equation Using Levinson Durbin
9. Decimation And Interpolation Using Rationale Factors
10. Maximally Decimated Analysis DFT Filter
11. Cascade Digital IIR Filter Realization
12. Convolution And M Fold Decimation & PSD Estimator
13. Estimation Of PSD
14. Inverse Z Transform
15. Group Delay Calculation
16. Separation Of T/F
17. Parallel Realization of IIR filter

**Digital Image and Video Processing lab**

**Teaching Scheme**

Lectures: 4 hrs./week

**Course Outcomes:**

At the end of this course, students will be able to

- Perform image and video enhancement

- Perform image and video segmentation
- Detect an object in an image/video

**List of Assignments:**

1. Perform basic operations on images like addition, subtraction etc.
2. Plot the histogram of an image and perform histogram equalization
3. Implement segmentation algorithms
4. Perform video enhancement
5. Perform video segmentation
6. Perform image compression using lossy technique
7. Perform image compression using lossless technique
8. Perform image restoration
9. Convert a colour model into another
10. Calculate boundary features of an image
11. Calculate regional features of an image
12. Detect an object in an image/video using template matching/Bayes classifier

**Research Methodology and IPR**

**Teaching Scheme**

Lectures: 2 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**Syllabus Contents:**

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism , Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trademarks and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development.

International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**

- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2nd Edition , “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.
- Asimov , “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

**Semester II**

**Pattern Recognition and Machine Learning**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Study the parametric and linear models for classification
- Design neural network and SVM for classification
- Develop machine independent and unsupervised learning techniques.

**Syllabus Contents:**

**Unit 1**

**Introduction to Pattern Recognition:** Problems, applications, design cycle, learning and adaptation, examples, Probability Distributions, Parametric Learning - Maximum likelihood and Bayesian Decision Theory- Bayes rule, discriminant functions, loss functions and Bayesian error analysis

**Unit 2**

**Linear models:** Linear Models for Regression, linear regression, logistic regression Linear Models for Classification

**Unit 3**

**Neural Network:** perceptron, multi-layer perceptron, backpropagation algorithm, error surfaces, practical techniques for improving backpropagation, additional networks and training methods, Adaboost, Deep Learning

|   |  |
|---|--|
| <p><b>Unit 4</b></p> <p><b>Linear discriminant functions</b> - decision surfaces, two-category, multi-category, minimum-squared error procedures, the Ho-Kashyap procedures, linear programming algorithms, Support vector machine</p> <p><b>Unit 5</b></p> <p><b>Algorithm independent machine learning</b> – lack of inherent superiority of any classifier, bias and variance, re-sampling for classifier design, combining classifiers</p> <p><b>Unit 6</b></p> <p><b>Unsupervised learning and clustering</b> – k-means clustering, fuzzy k-means clustering, hierarchical clustering</p>  |  |
| <p><b>References:</b></p> <ul style="list-style-type: none"> <li>• Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, 2nd Edition John Wiley &amp; Sons, 2001.</li> <li>• Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, “The Elements of Statistical Learning”, 2nd Edition, Springer, 2009.</li> <li>• C. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.</li> </ul>  |  |
| <p><b>Detection and Estimation Theory</b></p>   |  |
| <p><b>Teaching Scheme</b><br/>Lectures: 3 hrs/week</p>  | <p><b>Examination Scheme</b><br/>Marks : 100</p> |
| <p><b>Course Outcomes:</b></p> <p>At the end of this course, students will be able to</p> <ul style="list-style-type: none"> <li>• Understand the mathematical background of signal detection and estimation</li> <li>• Use classical and Bayesian approaches to formulate and solve problems for signal detection and parameter estimation from noisy signals.</li> <li>• Derive and apply filtering methods for parameter estimation.</li> </ul>  |  |
| <p><b>Syllabus Contents:</b></p> <p><b>Unit 1</b></p> <p>Review of Vector Spaces: Vectors and matrices: notation and properties, orthogonality and linear independence, bases, distance properties, matrix operations, Eigen values and eigenvectors.</p> <p><b>Unit 2</b></p> <p>Properties of Symmetric Matrices: Diagonalization of symmetric matrices, symmetric positive definite and semi definite matrices, principal component analysis (PCA), singular value decomposition.</p> <p><b>Unit 3</b></p> <p>Stochastic Processes: Time average and moments, ergodicity, power spectral density, covariance matrices, response of LTI system to random process, cyclostationary process, and spectral factorization.</p> <p><b>Unit 4</b></p> |  |

Detection Theory: Detection in white Gaussian noise, correlator and matched filter interpretation, Bayes' criterion of signal detection, MAP, LMS, entropy detectors, detection in colored Gaussian noise, Karhunen-Loeve expansions and whitening filters.

### Unit 5

Estimation Theory: Minimum variance estimators, Cramer-Rao lower bound, examples of linear models, system identification, Markov classification, clustering algorithms.

### Unit 6

Topics in Kalman and Weiner Filtering: Discrete time Wiener-Hopf equation, error variance computation, causal discrete time Wiener filter, discrete Kalman filter, extended Kalman filter, examples. Specialized Topics in Estimation: Spectral estimation methods like MUSIC, ESPRIT, DOA Estimation.

### References:

- Steven M. Kay, "Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory", Prentice Hall, 1993
- Steven M. Kay, "Fundamentals of Statistical Signal Processing, Volume II: Detection Theory", 1st Edition, Prentice Hall, 1998
- Thomas Kailath, Babak Hassibi, Ali H. Sayed, "Linear Estimation", Prentice Hall, 2000.
- H. Vincent Poor, "An Introduction to Signal Detection and Estimation", 2nd Edition, Springer, 1998.

## Advanced Computer Architecture

### Teaching Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of this course, students will be able to

- Understand parallelism and pipelining concepts, the design aspects and challenges.
- Evaluate the issues in vector and array processors.
- Study and analyze the high performance scalable multithreaded and multiprocessor systems.

### Syllabus Contents:

#### Unit 1

**Parallel Processing and Pipelining Processing-** Architectural Classification, Applications of parallel processing, Instruction level Parallelism and Thread Level Parallelism, Explicitly Parallel Instruction Computing (EPIC) Architecture

#### Unit 2

**Pipeline Architecture-** Principles and implementation of Pipelining, Classification of pipelining processors, Design aspect of Arithmetic and Instruction pipelining, Pipelining hazards and resolving techniques, Data buffering techniques, Advanced pipelining techniques, Software pipelining, VLIW (Very Long Instruction Word) processor.

#### Unit 3

**Vector and Array Processor-** Issues in Vector Processing, Vector performance modeling, SIMD Computer Organization, Static Vs Dynamic network, Parallel Algorithms for Array Processors: Matrix Multiplication.

**Unit 4**

**Multiprocessor Architecture** - Loosely and Tightly coupled multiprocessors, Inter Processor communication network, Time shared bus, Multiport Memory Model, Memory contention and arbitration techniques, Cache coherency and bus snooping, Massively Parallel Processors (MPP).

**Unit 5**

**Multithreaded Architecture-** Multithreaded processors, Latency hiding techniques, Principles of multithreading, Issues and solutions, Parallel Programming Techniques: Message passing program development.

**Unit 6**

**Parallel algorithms for multiprocessors-** Classification and performance of parallel algorithms, operating systems for multiprocessors systems, Message passing libraries for parallel programming interface, PVM (in distributed memory system), Message Passing Interfaces (MPI).

**References:**

- Kai Hwang, Faye A. Briggs, “Computer Architecture and ParallelProcessing” McGraw Hill Education, 2012.
- Kai Hwang, “Advanced Computer Architecture”, McGraw Hill Education, 1993.
- William Stallings, “Computer Organization and Architecture, Designing for Performance” Prentice Hall, 6th edition, 2006.
- Kai Hwang, “ScalableParallelComputing”, McGraw Hill Education, 1998.
- Harold S. Stone “High-Performance Computer Architecture”, Addison-Wesley, 1993.

**IOT and Applications**

**Teaching Scheme**

Lectures: 3 hrs/week

**Examination Scheme**

Marks : 100

**Course Outcomes:**

At the end of this course, students will be able to

- Understand the concept of IOT and M2M
- Study IOT architecture and applications in various fields
- Study the security and privacy issues in IOT.

**Syllabus Contents:**

**Unit 1**

IoT& Web Technology The Internet of Things Today, Time for Convergence, Towards the IoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Applications, Future Internet Technologies, Infrastructure, Networks and Communication, Processes, Data Management, Security, Privacy & Trust, Device Level Energy Issues, IoT Related Standardization, Recommendations on Research Topics.

**Unit 2**

M2M to IoT – A Basic Perspective– Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value

chain and global information monopolies. M2M to IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.

### Unit 3

IoT Architecture -State of the Art – Introduction, State of the art, Architecture Reference Model-Introduction, Reference Model and architecture, IoT reference Model, IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

### Unit 4

IoT Applications for Value Creations Introduction, IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Four Aspects in your Business to Master IoT, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT For Oil and Gas Industry, Opinions on IoT Application and Value for Industry, Home Management, eHealth.

### Unit 5

Internet of Things Privacy, Security and Governance Introduction, Overview of Governance, Privacy and Security Issues,

### Unit 6

Contribution from FP7 Projects, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities, Security

### References:

- Vijay Madiseti and ArshdeepBahga, “Internet of Things (A Hands-on-Approach)”, 1<sup>st</sup> Edition, VPT, 2014.
- Francis daCosta, “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1<sup>st</sup> Edition, Apress Publications, 2013.
- CunoPfister, “Getting Started with the Internet of Things”, OReilly Media, 2011.

## Digital Design and Verification

### Teaching Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of this course, students will be able to

- Familiarity of Front end design and verification techniques and create reusable test environments.
- Verify increasingly complex designs more efficiently and effectively.
- Use EDA tools like Cadence, Mentor Graphics.

### Syllabus Contents:

#### Unit 1

Revision of basic Digital systems: Combinational Circuits, Sequential Circuits, Logic families.

Synchronous FSM and asynchronous design, Metastability, Clock distribution and issues, basic building blocks like PWM module, pre-fetch unit, programmable counter, FIFO, Booth's multiplier, ALU, Barrel shifter etc.

**Unit 2**

Verilog/VHDL Comparisons and Guidelines, Verilog: HDL fundamentals, simulation, and test-bench design, Examples of Verilog codes for combinational and sequential logic, Verilog AMS

**Unit 3**

System Verilog and Verification: Verification guidelines, Data types, procedural statements and routines, connecting the test bench and design, Assertions, Basic OOP concepts, Randomization, Introduction to basic scripting language: Perl, Tcl/Tk

**Unit 4**

Current challenges in physical design: Roots of challenges, Delays: Wire load models Generic PD flow, Challenges in PD flow at different steps, SI Challenge - Noise & Crosstalk, IR Drop, Process effects: Process Antenna Effect & Electromigration

**Unit 5**

Programmable Logic Devices: Introduction, Evolution: PROM, PLA, PAL, Architecture of PAL's, Applications, Programming PLD's, FPGA with technology: Antifuse, SRAM, EPROM, MUX, FPGA structures, and ASIC Design Flows, Programmable Interconnections, Coarse grained reconfigurable devices

**Unit 6**

IP and Prototyping: IP in various forms: RTL Source code, Encrypted Source code, Soft IP, Netlist, Physical IP, and Use of external hard IP during prototyping, Case studies, and Speed issues. Testing of logic circuits: Fault models, BIST, JTAG interface

**References:**

- Douglas Smith, "HDL Chip Design: A Practical Guide for Designing, Synthesizing & Simulating ASICs & FPGAs Using VHDL or Verilog", Doone publications, 1998.
- Samir Palnitkar, "Verilog HDL: A guide to Digital Design and Synthesis", Prentice Hall, 2nd Edition, 2003.
- Doug Amos, Austin Lesea, Rene Richter, "FPGA based Prototyping Methodology Manual", Synopsys Press, 2011.
- Christophe Bobda, "Introduction to Reconfigurable Computing, Architectures, Algorithms and Applications", Springer, 2007.
- Janick Bergeron, "Writing Testbenches: Functional Verification of HDL Models", Second Edition, Springer, 2003.

**Audio Processing**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to



- Understand different characteristics of Speech.
- Identify and analyze different speech analysis system.
- Write algorithms for Recognition of speech.

**Syllabus Contents:**

**Unit 1**

Principle Characteristics of Speech: Linguistic information, Speech and Hearing, Speech production mechanism, Acoustic characteristic of speech Statistical Characteristics of speech. Speech production models, Linear Separable equivalent circuit model, Vocal Tract and Vocal Cord Model.

**Unit 2**

Speech Analysis and Synthesis Systems: Digitization, Sampling, Quantization and coding, Spectral Analysis, Spectral structure of speech, Autocorrelation and Short Time Fourier transform, Window function, Sound Spectrogram, Mel frequency Cepstral Coefficients, Filter bank and Zero Crossing Analysis, Analysis –by-Synthesis, Pitch Extraction.

**Unit 3**

Linear Predictive Coding Analysis: Principle of LPC analysis, Maximum likelihood spectral estimation, Source parameter estimation from residual signals, LPC Encoder and Decoder, PARCOR analysis and Synthesis, Line Spectral Pairs, LSP analysis and Synthesis.

**Unit 4**

Speech Coding: Reversible coding, Irreversible coding and Information rate distortion theory, coding in time domain: PCM, ADPCM, Adaptive Predictive coding, coding in Frequency domain: Sub band coding, Adaptive transform coding, Vector Quantization, Code Excited Linear Predictive Coding (CELP).

**Unit 5**

Speech Recognition: Principles of speech recognition, Speech period detection, Spectral distance measure, Structure of word recognition system, Dynamic Time Warping (DTW), Theory and implementation of Hidden Markov Model (HMM).

**Unit 6**

Speaker recognition: Human and Computer speaker recognition Principles Text dependent and Text Independent speaker recognition systems. Applications of speech Processing.

**References:**

- SadaokiFurui, “Digital Speech Processing, Synthesis and Recognition” 2nd Edition, Taylor & Francis, 2000.
- Rabiner and Schafer, “Digital Processing of Speech Signals”, Pearson Education, 1979.

**Multispectral Signal Analysis**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Select appropriate hyperspectral data for a particular application.
- Understand basic concepts of data acquisition and image processing tasks required for multi and hyperspectral data analysis.

- Learn techniques for classification and analysis of multi and hyperspectral data

### Syllabus Contents:

#### Unit 1

Hyperspectral Sensors and Applications: Introduction, Multi-spectral Scanning Systems (MSS), Hyperspectral Systems, Airborne sensors, Spaceborne sensors, Ground Spectroscopy, Software for Hyperspectral Processing, Applications, Atmosphere and Hydrosphere, Vegetation, Soils and Geology, Environmental Hazards and Anthropogenic Activity

#### Unit 2

Overview of Image Processing: Introduction, Image File Formats, Image Distortion and Rectification, Radiometric Distortion, Geometric Distortion and Rectification, Image Registration, Image Enhancement, Point Operations, Geometric Operation, Image Classification, Supervised Classification, Unsupervised Classification, Crisp Classification Algorithms, Fuzzy Classification Algorithms, Classification Accuracy Assessment, Image Change Detection, Image Fusion, Automatic Target Recognition

#### Unit 3

Mutual Information: A Similarity Measure for Intensity Based Image Registration: Introduction, Mutual Information Similarity Measure, Joint Histogram Estimation Methods, Two-Step Joint Histogram Estimation, One-Step Joint Histogram Estimation, Interpolation Induced Artifacts, Generalized Partial Volume Estimation of Joint Histograms, Optimization Issues in the Maximization of MI

#### Unit 4

Independent Component Analysis: Introduction, Concept of ICA, ICA Algorithms, Preprocessing using PCA, Information Minimization Solution for ICA, ICA Solution through Non-Gaussianity Maximization, Application of ICA to Hyperspectral Imagery, Feature Extraction Based Model, Linear Mixture Model Based Model, An ICA algorithm for Hyperspectral Image Processing, Applications using ICA.

#### Unit 5

Support Vector Machines : Introduction, Statistical Learning Theory, Empirical Risk Minimization, Structural Risk Minimization, Design of Support Vector Machines, Linearly Separable Case, Linearly Non-Separable Case, Non-Linear Support Vector Machines, SVMs for Multiclass Classification, One Against the Rest Classification, Pair wise Classification, Classification based on Decision Directed Acyclic Graph and Decision Tree Structure, Multiclass Objective Function, optimization Methods , Applications using SVM.

#### Unit 6

Markov Random Field Models: Introduction, MRF and Gibbs Distribution, Random Field and Neighborhood ,Cliques, Potential and Gibbs Distributions, MRF Modeling in Remote Sensing Applications, Optimization Algorithms, Simulated Annealing, Metropolis Algorithm, Iterated Conditional Modes Algorithm

### References:

- Pramod K. Varshney, Manoj K. Arora, “Advanced Image Processing Techniques for Remotely Sensed Hyperspectral Data”, Springer, 2013.
- S. Svanberg, “Multi-spectral Imaging– from Astronomy to Microscopy – from Radio waves to Gamma rays”, Springer Verlag, 2009

| <b>Biomedical Signal Processing</b>  |  |
|--|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week   |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Understand different types of biomedical signal.</li> <li>• Identify and analyze different biomedical signals.</li> <li>• Find applications related to biomedical signal processing</li> </ul>   |  |
| <b>Syllabus Contents:</b>  |  |
| <b>Unit 1</b><br>Acquisition, Generation of Bio-signals, Origin of bio-signals, Types of bio-signals, Study of diagnostically significant bio-signal parameters  |  |
| <b>Unit 2</b><br>Electrodes for bio-physiological sensing and conditioning, Electrode-electrolyte interface, polarization, electrode skin interface and motion artefact, biomaterial used for electrode, Types of electrodes (body surface, internal, array of electrodes, microelectrodes), Practical aspects of using electrodes, Acquisition of bio-signals (signal conditioning) and Signal conversion (ADC's DAC's) Processing, Digital filtering   |  |
| <b>Unit 3</b><br>Biomedical signal processing by Fourier analysis, Biomedical signal processing by wavelet (time-frequency) analysis, Analysis (Computation of signal parameters that are diagnostically significant)  |  |
| <b>Unit 4</b><br>Classification of signals and noise, Spectral analysis of deterministic, stationary random signals and non-stationary signals, Coherent treatment of various biomedical signal processing methods and applications.   |  |
| <b>Unit 5</b><br>Principal component analysis, Correlation and regression, Analysis of chaotic signals Application areas of Bio-Signals analysis Multiresolution analysis(MRA) and wavelets, Principal component analysis(PCA), Independent component analysis(ICA)  |  |
| <b>Unit 6</b><br>Pattern classification–supervised and unsupervised classification, Neural networks, Support vector Machines, Hidden Markov models. Examples of biomedical signal classification examples.   |  |
| <b>References:</b> <ul style="list-style-type: none"> <li>• W. J. Tompkins, “Biomedical Digital Signal Processing”, Prentice Hall, 1993.</li> <li>• Eugene N Bruce, “Biomedical Signal Processing and Signal Modeling”, John Wiley &amp; Son’s □publication, 2001.</li> <li>• Myer Kutz, “Biomedical Engineering and Design Handbook, Volume I”, McGraw Hill, 2009. □</li> <li>• D C Reddy, “Biomedical Signal Processing”, McGraw Hill, 2005.</li> <li>• Katarzyn J. Blinowska, Jaroslaw Zygierewicz, “Practical Biomedical Signal Analysis Using MATLAB”, 1st Edition, CRC Press, 2011.</li> </ul> |  |

| <b>Pattern Recognition &amp; Machine Learning Laboratory</b>  |  |
|---|--|
| <b>Teaching Scheme</b><br>Lab work : 4hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Perform image and video enhancement</li> <li>• Perform image and video segmentation</li> <li>• Detect an object in an image/video</li> </ul>  |  |
| <b>List of Assignments:</b> <ol style="list-style-type: none"> <li>1. Implement maximum likelihood algorithm</li> <li>2. Implement Bayes classifier</li> <li>3. Implement linear regression</li> <li>4. Design a classifier using perceptron rule</li> <li>5. Design a classifier using feedforward back-propagation and delta rule algorithms</li> <li>6. Implement deep learning algorithm</li> <li>7. Implement linear discriminant algorithm</li> <li>8. Design a two class classifier using SVM</li> <li>9. Design a multiclass classifier using SVM</li> <li>10. Perform unsupervised learning</li> </ol> |  |

| <b>Detection and Estimation Theory Laboratory</b>   |  |
|---|--|
| <b>Teaching Scheme</b><br>Lab work : 4hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Simulate signals and noise</li> <li>• Detect signals in the presence of noise</li> <li>• Compare various estimation techniques</li> </ul>   |  |
| <b>List of Assignments:</b> <ol style="list-style-type: none"> <li>1. Simulate signal and noise models models.</li> <li>2. Simulate spatially separated target Signal in the presence of Additive Correlated White Noise</li> <li>3. Simulate spatially separated target Signal in the presence of Additive Uncorrelated White Noise</li> <li>4. Simulate spatially separated target Signal in the presence of Additive Correlated Colored Noise</li> <li>5. Detect Constant amplitude Signal in AWGN</li> <li>6. Detect Time varying Known Signals in AWGN</li> <li>7. Detect Unknown Signals in AWGN</li> <li>8. Compare performance comparison of the Estimation techniques - MLE, MMSE, Bayes Estimator, MAP Estimator, Expectation Maximization (EM) algorithm</li> <li>9. Performance comparison of conventional Energy Detectors and Coherent Matched Filter Techniques</li> </ol> |  |

| <b>Mini Project</b>   |   |
|---|---|
| <b>Teaching Scheme</b><br>Lectures: 4hrs/week   | <b>Examination Scheme</b><br>Marks :100 |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Understand of contemporary / emerging technology for various processes and systems.</li> <li>• Share knowledge effectively in oral and written form and formulate documents.</li> </ul> |   |
| <b>Syllabus Contents:</b><br>The students are required to search / gather the material / information on a specific a topic comprehend it and present / discuss in the class.  |   |

### Semester III

| <b>Artificial Intelligence</b>  |  |
|---|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Understand the concept of Artificial Intelligence, search techniques and knowledge representation issues</li> <li>• Understanding reasoning and fuzzy logic for artificial intelligence</li> <li>• Understanding game playing and natural language processing.</li> </ul>   |  |
| <b>Syllabus Contents:</b><br><b>Unit 1</b><br>What is AI (Artificial Intelligence)? : The AI Problems, The Underlying Assumption, What are AI Techniques, The Level Of The Model, Criteria For Success, Some General References, One Final WordProblems, State Space Search & Heuristic Search Techniques: Defining The Problems As A State Space Search, Production Systems, Production Characteristics, Production System Characteristics, And Issues In The Design Of Search Programs, Additional Problems. Generate-And-Test, Hill Climbing, Best-First Search, Problem Reduction, Constraint Satisfaction, Means-Ends Analysis.<br><br><b>Unit 2</b><br>Knowledge Representation Issues: Representations And Mappings, Approaches To Knowledge Representation. Using Predicate Logic: Representation Simple Facts In Logic, Representing Instance And Isa Relationships, Computable Functions And Predicates, Resolution. Representing Knowledge Using Rules: Procedural Versus Declarative Knowledge, Logic Programming, Forward Versus Backward Reasoning.<br><br><b>Unit 3</b><br>Symbolic Reasoning Under Uncertainty: Introduction To No monotonic Reasoning, Logics For Non-monotonic Reasoning. Statistical Reasoning: Probability And Bays' Theorem, Certainty |  |

Factors And Rule-Base Systems, Bayesian Networks, DempsterShafer Theory

**Unit 4**

Fuzzy Logic. Weak Slot-and-Filler Structures: Semantic Nets, Frames. Strong Slot-and-Filler Structures: Conceptual Dependency, Scripts, CYC

**Unit 5**

Game Playing: Overview, And Example Domain: Overview, MiniMax, Alpha-Beta Cut-off, Refinements, Iterative deepening, The Blocks World, Components Of A Planning System, Goal Stack Planning, Nonlinear Planning Using Constraint Posting, Hierarchical Planning, Reactive Systems, Other Planning Techniques. Understanding: What is understanding? What makes it hard? As constraint satisfaction

**Unit 6**

Natural Language Processing: Introduction, Syntactic Processing, Semantic Analysis, Semantic Analysis, Discourse And Pragmatic Processing, Spell Checking Connectionist Models: Introduction: Hopfield Network, Learning In Neural Network, Application Of Neural Networks, Recurrent Networks, Distributed Representations, Connectionist AI And Symbolic AI.

**References:**

- Elaine Rich and Kevin Knight “Artificial Intelligence”, 2nd Edition, Tata Mcgraw-Hill, 2005.
- Stuart Russel and Peter Norvig, “Artificial Intelligence: A Modern Approach”, 3rd Edition, Prentice Hall, 2009.

**Optimization Techniques**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand importance of optimization
  - Apply basic concepts of mathematics to formulate an optimization problem
- Analyze and appreciate variety of performance measures for various optimization problems

**Syllabus Contents:**

**Unit 1**

Introduction to ClassicalMethods & Linear Programming ProblemsTerminology, Design Variables, Constraints, Objective Function, Problem Formulation. Calculus method, Kuhn Tucker conditions, Method of Multipliers.

**Unit 2**

Linear Programming Problem,Simplex method, Two-phase method, Big-M method, duality, Integer linear Programming, Dynamic Programming, Sensitivity analysis.

**Unit 3**

Single Variable Optimization Problems: Optimality Criterion, Bracketing Methods, Region Elimination Methods, Interval Halving Method, Fibonacci Search Method, Golden Section Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method,

Cubic search method.

**Unit 4**

Multi Variable and Constrained Optimization Technique, Optimality criteria , Direct search Method, Simplex search methods, Hooke-Jeeve’s pattern search method, Powell’s conjugate direction method, Gradient based method, Cauchy’s Steepest descent method, Newton’s method , Conjugate gradient method. Kuhn - Tucker conditions, Penalty Function, Concept of Lagrangian multiplier, Complex search method, Random search method

**Unit 5**

Intelligent Optimization Techniques: Introduction to Intelligent Optimization, Soft Computing, Genetic Algorithm: Types of reproduction operators, crossover & mutation, Simulated Annealing Algorithm, Particle Swarm Optimization (PSO) - Graph Grammer Approach - Example Problems

**Unit 6**

Genetic Programming (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP.

**References:**

- S. S. Rao, “Engineering Optimisation: Theory and Practice”, Wiley, 2008.
- K. Deb, “Optimization for Engineering design algorithms and Examples”, Prentice Hall, 2005.
- C.J. Ray, “Optimum Design of Mechanical Elements”, Wiley, 2007.
- R. Saravanan, “Manufacturing Optimization through Intelligent Techniques, Taylor & Francis Publications, 2006.
- D. E. Goldberg, “Genetic algorithms in Search, Optimization, and Machine learning”, Addison-Wesley Longman Publishing, 1989.

**Modelling and Simulation Techniques**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Identify and model discrete systems (deterministic and random)
- Identify and model discrete signals (deterministic and random)
- Understand modelling and simulation techniques to characterize systems/processes.

**Syllabus Contents:**

**Unit 1**

Introduction Circuits as dynamic systems, Transfer functions, poles and zeroes, State space, Deterministic Systems, Difference and Differential Equations, Solution of Linear Difference and Differential Equations, Numerical Simulation Methods for ODEs, System Identification, Stability and Sensitivity Analysis.

**Unit 2**

Statistical methods, Description of data, Data-fitting methods, Regression analysis, Least Squares Method, Analysis of Variance, Goodness of fit.

**Unit 3**

Probability and Random Processes, Discrete and Continuous Distribution, Central Limit theorem, Measure of Randomness, MonteCarlo Methods.

**Unit 4**

Stochastic Processes and Markov Chains, Time Series Models.

**Unit 5**

Modeling and simulation concepts, Discrete-event simulation, Event scheduling/Time advance algorithms, Verification and validation of simulation models.

**Unit 6**

Continuous simulation: Modeling with differential equations, Example models, Bond Graph Modeling, Population Dynamics Modeling, System dynamics.

**References:**

- R. L. Woods and K. L. Lawrence, “Modeling and Simulation of Dynamic Systems”, Prentice-Hall, 1997.
- Z. Navalih, “VHDL Analysis and Modelling of Digital Systems”, McGraw-Hill, 1993.
- J. Banks, JS. Carson and B. Nelson, “Discrete-Event System Simulation”, 2nd Edition, Prentice-Hall of India, 1996.

**(Dissertation) Dissertation Phase – I and Phase - II**

**Teaching Scheme: Lab**  
20 and 30 Hrs/Week

**Course Outcomes:**

At the end of this course, students will be able to

- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- Presenting the work in International/ National conference or reputed journals.

**Syllabus Contents:**

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following



- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance
- Research and development in various domain

The student should complete the following:

- Literature survey Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:

- Experimental verification / Proof of concept.
- Design, fabrication, testing of Communication System.
- The viva-voce examination will be based on the above report and work.

#### **Guidelines for Dissertation Phase – I and II at M. Tech. (Electronics):**

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, a record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of

unsatisfactory performance, committee may recommend for extension or repeating the work

**OPEN ELECTIVES**  
**Business Analytics**

**Teaching scheme**  
**Lecture: - 3 h/week**

|                      |                           |
|----------------------|---------------------------|
| <b>Course Code</b>   |                           |
| <b>Course Name</b>   | <b>Business Analytics</b> |
| <b>Credits</b>       |                           |
| <b>Prerequisites</b> |                           |

Total Number of Lectures: 48

|  |
|--|
| <b>Course objective</b>  |
| <ol style="list-style-type: none"> <li>1. Understand the role of business analytics within an organization.</li> <li>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.</li> <li>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.</li> <li>4. To become familiar with processes needed to develop, report, and analyze business data.</li> <li>5. Use decision-making tools/Operations research techniques.</li> <li>6. Mange business process using analytical and management tools.</li> <li>7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.</li> </ol> |

| <b>LECTURE WITH BREAKUP</b>  | <b>NO. OF LECTURES</b> |
|--|------------------------|
| <b>Unit1:</b><br>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview. | 9                      |
| <b>Unit 2:</b><br>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.  | 8                      |
| <b>Unit 3:</b><br>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br>Descriptive Analytics, predictive analytics, predicative Modelling,  | 9                      |

|   |    |
|---|----|
| Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.   |    |
| <b>Unit 4:</b><br>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. | 10 |
| <b>Unit 5:</b><br>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.  | 8  |
| <b>Unit 6:</b><br>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.   | 4  |

|  |  |
|--|--|
| <b>COURSE OUTCOMES</b>   |  |
| 1. Students will demonstrate knowledge of data analytics.  |  |
| 2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.                             |  |
| 3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |  |
| 4. Students will demonstrate the ability to translate data into clear, actionable insights.  |  |

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

**OPEN ELECTIVES**

**Industrial Safety**

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

**OPEN ELECTIVES**  
**Operations Research**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

#### **Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

#### **Unit 5**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

#### **References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

### **Open Elective**

#### **Cost Management of Engineering Projects**

#### **Teaching scheme**

**Lecture: - 3 h/week**

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#### Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

## **Open Elective Composite Materials**

### **Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III: Manufacturing of Metal Matrix Composites:** Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT-IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V: Strength:** Lamina Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

### **TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

### **References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

## **Open Elective Waste to Energy**

### **Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for

thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

**AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING**

| <b>Course objectives:</b>  |  |       |
|--|--|-------|
| Students will be able to:  |  |       |
| <ol style="list-style-type: none"> <li>1. Understand that how to improve your writing skills and level of readability</li> <li>2. Learn about what to write in each section</li> <li>3. Understand the skills needed when writing a Title</li> </ol> |  |       |
| Ensure the good quality of paper at very first-time submission   |  |       |
| <b>Syllabus</b>  |  |       |
| Units  | CONTENTS   | Hours |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4     |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4     |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4     |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4     |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4     |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4     |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press



3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

### AUDIT 1 and 2: DISASTER MANAGEMENT

|   |   |              |
|---|---|--------------|
| <b>Course Objectives:</b> -Students will be able to:  |   |              |
| 1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.  |   |              |
| 2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.  |   |              |
| 3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.   |   |              |
| 4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in |   |              |
| <b>Syllabus</b>   |   |              |
| <b>Units</b>  | <b>CONTENTS</b>   | <b>Hours</b> |
| 1   | <b>Introduction</b><br>Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.  | 4            |
| 2   | <b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br>Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | 4            |
| 3   | <b>Disaster Prone Areas In India</b><br>Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics  | 4            |
| 4   | <b>Disaster Preparedness And Management</b><br>Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.   | 4            |
| 5   | <b>Risk Assessment</b><br>Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.   | 4            |
| 6   | <b>Disaster Mitigation</b><br>Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.   | 4            |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies” ,Deep &Deep Publication Pvt. Ltd., New Delhi.

**AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE**

**Course Objectives**

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

**Syllabus**

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul>          | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8     |

**Suggested reading**

1. “Abhyastakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

**Course Output**

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

**AUDIT 1 and 2: VALUE EDUCATION**

**Course Objectives**

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students

3. Let the should know about the importance of character

**Syllabus**

| <b>Unit</b> | <b>Content</b>   | <b>Hours</b> |
|-------------|--|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul>  | 4            |
| 2           | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty, Humanity. Power of faith, National Unity.</li> <li>• Patriotism.Love for nature ,Discipline</li> </ul>  | 6            |
| 3           | <ul style="list-style-type: none"> <li>• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> <li>• Doing best for saving nature</li> </ul> | 6            |
| 4           | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality, Nonviolence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind, Self-control.</li> <li>• Honesty, Studying effectively</li> </ul>  | 6            |

**Suggested reading**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

**Course outcomes**

Students will be able to

- 1.Knowledge of self-development
- 2.Learn the importance of Human values
- 3.Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

| <b>Course Objectives:</b>   |  |              |
|---|--|--------------|
| Students will be able to:   |  |              |
| <ol style="list-style-type: none"> <li>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</li> <li>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ol> |  |              |
| <b>Syllabus</b>   |  |              |
| <b>Units</b>  | <b>Content</b>   | <b>Hours</b> |
| <b>1</b>  | <ul style="list-style-type: none"> <li>• <b>History of Making of the Indian Constitution:</b></li> <li>History</li> <li>Drafting Committee, ( Composition &amp; Working)</li> </ul>  | 4            |
| <b>2</b>  | <ul style="list-style-type: none"> <li>• <b>Philosophy of the Indian Constitution:</b></li> <li>Preamble</li> <li>Salient Features</li> </ul>  | 4            |
| <b>3</b>  | <ul style="list-style-type: none"> <li>• <b>Contours of Constitutional Rights &amp; Duties:</b></li> <li>• Fundamental Rights</li> <li>• Right to Equality</li> <li>• Right to Freedom</li> <li>• Right against Exploitation</li> <li>• Right to Freedom of Religion</li> <li>• Cultural and Educational Rights</li> <li>• Right to Constitutional Remedies</li> <li>• Directive Principles of State Policy</li> <li>• Fundamental Duties.</li> </ul>                                      | 4            |
| <b>4</b>  | <ul style="list-style-type: none"> <li>• <b>Organs of Governance:</b></li> <li>• Parliament</li> <li>• Composition</li> <li>• Qualifications and Disqualifications</li> <li>• Powers and Functions                             <ul style="list-style-type: none"> <li>• Executive</li> </ul> </li> <li>• President</li> <li>• Governor</li> <li>• Council of Ministers</li> <li>• Judiciary, Appointment and Transfer of Judges, Qualifications</li> <li>• Powers and Functions</li> </ul> | 4            |

|          |  |   |
|----------|--|---|
| <b>5</b> | <ul style="list-style-type: none"> <li>• <b>Local Administration:</b></li> <li>• District's Administration head: Role and Importance,</li> <li>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.</li> <li>• Pachayati raj: Introduction, PRI: Zila Pachayat.</li> <li>• Elected officials and their roles, CEO Zila Pachayat: Position and role.</li> <li>• Block level: Organizational Hierarchy (Different departments),</li> <li>• Village level: Role of Elected and Appointed officials,</li> <li>• Importance of grass root democracy</li> </ul> | 4 |
| <b>6</b> | <ul style="list-style-type: none"> <li>• <b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul>   | 4 |

### Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

### Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

## AUDIT 1 and 2: PEDAGOGY STUDIES

| <b>Course Objectives:</b><br>Students will be able to: <ol style="list-style-type: none"> <li>4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.</li> <li>5. Identify critical evidence gaps to guide the development.</li> </ol> |  |       |
|---|--|-------|
| Syllabus  |  |       |
| Units   | Content  | Hours |
| <b>1</b>  | <ul style="list-style-type: none"> <li>• <b>Introduction and Methodology:</b></li> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> <li>• Overview of methodology and Searching.</li> </ul> | 4     |

|   |   |   |
|---|---|---|
| 2 | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>  | 2 |
| 3 | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers' attitudes and beliefs and Pedagogic strategies.</li> </ul> | 4 |
| 4 | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul>  | 4 |
| 5 | <ul style="list-style-type: none"> <li>• <b>Research gaps and future directions</b></li> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> <li>• Dissemination and research impact.</li> </ul>   | 2 |

### Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal Educational Development*, 33 (3): 272-282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf).

### Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?

2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

### AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

#### Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

#### Syllabus

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> </ul> Do`s and Don`t`s in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> </ul> i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam    | 8     |

#### Suggested reading

1. ‘Yogic Asanas for Group Training-Part-I’ : Janardan Swami Yogabhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

#### Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

### AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

#### Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

#### Syllabus

| Unit | Content  | Hours |
|------|--|-------|
| 1    | Neetisatakam-Holistic development of personality <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont`s)</li> <li>• Verses- 71,73,75,78 (do`s)</li> </ul> | 8     |

|   |  |   |
|---|--|---|
| 2 | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>  | 8 |
| 3 | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8 |

***Suggested reading***

1. “Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.



## M. Tech. (Electronics and Telecommunication)

### Curriculum Structure Specialization: Communications

#### Program Outcomes (POs)

Students are expected to demonstrate

a. Ability to apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude

b. Ability to identify, formulate and solve engineering problems in the broad areas like Systems Design using communication and networking platforms and tools. Explore recent developments in areas like optical communication, satellite communication, wireless communication, networking, RF-microwave, antennas, measurements and standards in communication.

c. Ability to understand and use different software tools for Design, Analysis and Verification in the domain of communication and networking. System results are obtained through progressive steps such as Design entry, Synthesis, Functional and Timing Simulation.

d. Ability to design and conduct experiments, analyze and interpret data, imbibe programming skills for development of simulation experiments.

e. Ability to function as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.

#### Semester I

| Sr. No. | Course Type/Code        | Course Name  | Teaching Scheme Hrs/Week |   |   | Credits |
|---------|-------------------------|--|--------------------------|---|---|---------|
|         |                         |  | L                        | T | P |         |
| 1       | Core 1                  | Advanced Communication Networks  | 3                        | 0 | 0 | 3       |
| 2       | Core 2                  | Wireless and Mobile Communication  | 3                        | 0 | 0 | 3       |
| 3       | Prog. Specific Elective | Elective I<br>(1) Wireless Sensor Networks<br>(2) Optical Networks<br>(3) Statistical Information Processing | 3                        | 0 | 0 | 3       |
| 4       | Prog. Specific Elective | Elective – II<br>(1) Cognitive Radio<br>(2) RF and Microwave Circuit Design<br>(3) DSP Architecture          | 3                        | 0 | 0 | 3       |
| 5       | Lab1                    | Advanced Communication Networks Lab  | 0                        | 0 | 4 | 2       |

|   |       |                                       |           |          |          |           |
|---|-------|---------------------------------------|-----------|----------|----------|-----------|
| 6 | Lab2  | Wireless and Mobile Communication Lab | 0         | 0        | 4        | 2         |
| 7 |       | Research Methodology and IPR          | 2         | 0        | 0        | 2         |
| 8 | Aud 1 | Audit course 1                        | 2         | 0        | 0        | 0         |
|   |       | <b>Total</b>                          | <b>16</b> | <b>0</b> | <b>8</b> | <b>18</b> |

### Semester II

| Sr. No. | Course Code               | Course Name  | Teaching Scheme |          |           | Credits   |
|---------|---------------------------|--|-----------------|----------|-----------|-----------|
|         |                           |  | Hrs/Week        |          |           |           |
|         |                           |  | L               | T        | P         |           |
| 1       | Core 3                    | Antennas and Radiating Systems   | 3               | 0        | 0         | 3         |
| 2       | Core 4                    | Advanced Digital Signal Processing   | 3               | 0        | 0         | 3         |
| 3       | Program Specific Elective | <b>Elective – III</b><br>(1) Satellite Communication<br>(2) Internet of Things<br>(3) Voice and data networks          | 3               | 0        | 0         | 3         |
| 4       | Program Specific Elective | <b>Elective – IV</b><br>(1) Markov Chain and Queuing System<br>(2) MIMO System<br>(3) Programmable Networks – SDN, NFV | 3               | 0        | 0         | 3         |
| 5       | Lab 3                     | Antennas and Radiating Systems lab   | 0               | 0        | 4         | 2         |
| 6       | Lab 4                     | Advanced Digital Signal Processing Lab   | 0               | 0        | 4         | 2         |
| 7       |                           | Mini Project   | 0               | 0        | 4         | 2         |
| 8       | Aud2                      | Audit course 2   | 2               | 0        | 0         | 0         |
|         |                           | <b>Total</b>   | <b>14</b>       | <b>0</b> | <b>12</b> | <b>18</b> |

### Semester-III

| Sr. No. | Course Code               | Course Name  | Teaching Scheme |   |   | Credits |
|---------|---------------------------|--|-----------------|---|---|---------|
|         |                           |  | Hrs/Week        |   |   |         |
| 1.      | Program Specific Elective | <b>Elective – V</b><br>(1) High Performance Networks<br>(2) Pattern Recognition and Machine learning<br>(3) Remote Sensing | 3               | 0 | 0 | 3       |
| 2.      | Open Elective             | 1. Business Analytics<br>2. Industrial Safety  | 3               | 0 | 0 | 3       |

|              |              |  |           |          |           |           |
|--------------|--------------|--|-----------|----------|-----------|-----------|
|              |              | 3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy |           |          |           |           |
| 3.           | Dissertation | Dissertation Phase – I   | 0         | 0        | 20        | 10        |
| <b>Total</b> |              |  | <b>06</b> | <b>0</b> | <b>20</b> | <b>16</b> |

#### Semester-IV

| Sr. No.      | Course Code  | Course Name             | Teaching Scheme |           |           | Credits   |
|--------------|--------------|-------------------------|-----------------|-----------|-----------|-----------|
|              |              |                         | L               | T         | P         |           |
| 1.           | Dissertation | Dissertation Phase – II | --              | --        | 32        | 16        |
| <b>Total</b> |              |                         | <b>--</b>       | <b>--</b> | <b>--</b> | <b>16</b> |

Total 68 Credits

#### Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

| <b>Advanced Communication Network</b>   |  |
|---|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Understand advanced concepts in Communication Networking.</li> <li>• Design and develop protocols for Communication Networks.</li> <li>• Understand the mechanisms in Quality of Service in networking.</li> <li>• Optimise the Network Design.</li> </ul>  |  |
| <b>Syllabus Contents:</b><br><b>Unit 1 :</b> Overview of Internet-Concepts, challenges and history. Overview of -ATM. TCP/IP Congestion and Flow Control in Internet-Throughput analysis of TCP congestion control. TCP for high bandwidth delay networks. Fairness issues in TCP.<br><b>Unit 2 :</b> Real Time Communications over Internet. Adaptive applications. Latency and throughput issues. Integrated Services Model (intServ). Resource reservation in Internet. RSVP.; |  |

Characterization of Traffic by Linearly Bounded Arrival Processes (LBAP). Leaky bucket algorithm and its properties.

**Unit 3 :**Packet Scheduling Algorithms-requirements and choices. Scheduling guaranteed service connections. GPS, WFQ and Rate proportional algorithms. High speed scheduler design. Theory of Latency Rate servers and delay bounds in packet switched networks for LBAP traffic.; Active Queue Management - RED, WRED and Virtual clock. Control theoretic analysis of active queue management.

**Unit 4 :**IP address lookup-challenges. Packet classification algorithms and Flow Identification-Grid of Tries, Cross producting and controlled prefix expansion algorithms.

**Unit 5 :**Admission control in Internet. Concept of Effective bandwidth. Measurement based admission control. Differentiated Services in Internet (DiffServ). DiffServ architecture and framework.

**Unit 6 :**IPV4, IPV6, IP tunnelling, IPswitching and MPLS, Overview of IP over ATM and its evolution to IP switching. MPLS architecture and framework. MPLS Protocols. Traffic engineering issues in MPLS.

**References:**

- Jean Wairand and Pravin Varaiya, “High Performance Communications Networks”, 2<sup>nd</sup> edition, 2000.
- Jean Le Boudec and Patrick Thiran, “Network Calculus A Theory of Deterministic Queueing Systems for the Internet”, Springer Veriag, 2001.
- Zhang Wang, “Internet QoS”, Morgan Kaufman, 2001.
- Anurag Kumar, D. Manjunath and Joy Kuri, “Communication Networking: An Analytical Approach” , Morgan Kaufman Publishers, 2004.
- George Kesidis, “ATM Network Performance”, Kluwer Academic, Research Papers, 2005.

**Wireless and Mobile Communication**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Design appropriate mobile communication systems.
- Apply frequency-reuse concept in mobile communications, and to analyze its effects on interference, system capacity, handoff techniques
- Distinguish various multiple-access techniques for mobile communications e.g. FDMA, TDMA, CDMA, and their advantages and disadvantages.
- Analyze path loss and interference for wireless telephony and their influences on a mobile-communication system’s performance.
- Analyze and design CDMA system functioning with knowledge of forward and reverse channel details, advantages and disadvantages of using the technology
- Understanding upcoming technologies like 3G, 4G etc.

**Syllabus Contents:**

**Unit 1:**Cellular Communication Fundamentals:Cellular system design, Frequency reuse, cell splitting, handover concepts, Co channel and adjacent channel interference, interference reduction

techniques and methods to improve cell coverage, Frequency management and channel assignment. GSM architecture and interfaces, GSM architecture details, GSM subsystems, GSM Logical Channels, Data Encryption in GSM, Mobility Management, Call Flows in GSM. 2.5 G Standards: High speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS), 2.75 G Standards: EDGE,

**Unit 2:** Spectral efficiency analysis based on calculations for Multiple access technologies: TDMA, FDMA and CDMA, Comparison of these technologies based on their signal separation techniques, advantages, disadvantages and application areas. Wireless network planning (Link budget and power spectrum calculations)

**Unit 3:** Mobile Radio Propagation: Large Scale Path Loss, Free Space Propagation Model, Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering, Practical Link Budget Design using Path Loss Models, Outdoor Propagation Models, Indoor Propagation Models, Signal Penetration into Buildings. Small Scale Fading and Multipath Propagation, Impulse Response Model, Multipath Measurements, Parameters of Multipath channels, Types of Small Scale Fading: Time Delay Spread; Flat, Frequency selective, Doppler Spread; Fast and Slow fading.

**Unit 4:** Equalization, Diversity: Equalizers in a communications receiver, Algorithms for adaptive equalization, diversity techniques, space, polarization, frequency diversity, Interleaving.

**Unit 5:** Code Division Multiple Access: Introduction to CDMA technology, IS 95 system Architecture, Air Interface, Physical and logical channels of IS 95, Forward Link and Reverse link operation, Physical and Logical channels of IS 95 CDMA, IS 95 CDMA Call Processing, soft Handoff, Evolution of IS 95 (CDMA One) to CDMA 2000, CDMA 2000 layering structure and channels.

**Unit 6:** Higher Generation Cellular Standards: 3G Standards: evolved EDGE, enhancements in 4G standard, Architecture and representative protocols, call flow for LTE, VoLTE, UMTS, introduction to 5G

**References:**

- V.K.Garg, J.E.Wilkes, “Principle and Application of GSM”, Pearson Education, 5<sup>th</sup> edition, 2008.
- V.K.Garg, “IS-95 CDMA & CDMA 2000”, Pearson Education, 4<sup>th</sup> edition, 2009.
- T.S.Rappaport, “Wireless Communications Principles and Practice”, 2<sup>nd</sup> edition, PHI, 2002.
- William C.Y.Lee, “Mobile Cellular Telecommunications Analog and Digital Systems”, 2<sup>nd</sup> edition, TMH, 1995.
- Asha Mehrotra, “A GSM system Engineering” Artech House Publishers Boston, London, 1997.

**Program Elective : 1 Wireless Sensor Networks**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Design wireless sensor network system for different applications under consideration.
- Understand the hardware details of different types of sensors and select right type of sensor for various applications.
- Understand radio standards and communication protocols to be used for wireless sensor

|   |
|---|
| <p>network based systems and application.</p> <ul style="list-style-type: none"> <li>• Use operating systems and programming languages for wireless sensor nodes, performance of wireless sensor networks systems and platforms.</li> <li>• Handle special issues related to sensors like energy conservation and security challenges.</li> </ul> |
|---|

**Syllabus Contents:**

**Unit 1:** Introduction and overview of sensor network architecture and its applications, sensor network comparison with Ad Hoc Networks, Sensor node architecture with hardware and software details.

**Unit 2:** Hardware: Examples like mica2, micaZ, telosB, cricket, Imote2, tmote, btnode, and Sun SPOT, Software (Operating Systems): tinyOS, MANTIS, Contiki, and RetOS.

**Unit 3:** Programming tools: C, nesC. Performance comparison of wireless sensor networks simulation and experimental platforms like open source (ns-2) and commercial (QualNet, Opnet)

**Unit 4:** Overview of sensor network protocols (details of atleast 2 important protocol per layer): Physical, MAC and routing/ Network layer protocols, node discovery protocols, multi-hop and cluster based protocols, Fundamentals of 802.15.4, Bluetooth, BLE (Bluetooth low energy), UWB.

**Unit 5:** Data dissemination and processing; differences compared with other database management systems, data storage; query processing.

**Unit 6:** Specialized features: Energy preservation and efficiency; security challenges; fault-tolerance, Issues related to Localization, connectivity and topology, Sensor deployment mechanisms; coverage issues; sensor Web; sensor Grid, Open issues for future research, and Enabling technologies in wireless sensor network.

**References:**

- H. Karl and A. Willig, “Protocols and Architectures for Wireless Sensor Networks”, John Wiley & Sons, India, 2012.
- C. S. Raghavendra, K. M. Sivalingam, and T. Znati, Editors, “Wireless Sensor Networks”, Springer Verlag, 1<sup>st</sup> Indian reprint, 2010.
- F. Zhao and L. Guibas, “Wireless Sensor Networks: An Information Processing Approach”, Morgan Kaufmann, 1<sup>st</sup> Indian reprint, 2013.
- YingshuLi, MyT. Thai, Weili Wu, “Wireless sensor Network and Applications”, Springer series on signals and communication technology, 2008.

**Program Elective 1: Optical Networks**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Contribute in the areas of optical network and WDM network design.
- Implement simple optical network and understand further technology developments for future enhanced network.

**Syllabus Contents:**

|  |
|--|
| <p><b>Unit 1:</b>SONET/SDH: optical transport network, IP, routing and forwarding, multiprotocol label switching.</p> <p><b>Unit 2:</b>WDM network elements: optical line terminals and amplifiers, optical add/drop multiplexers, OADM architectures, reconfigurable OADM, optical cross connects.</p> <p><b>Unit 3:</b>Control and management: network management functions, optical layer services and interfacing, performance and fault management, configuration management, optical safety.</p> <p><b>Unit 4:</b>Network Survivability: protection in SONET/SDH &amp; client layer, optical layer protection schemes</p> <p><b>Unit 5:</b>WDM network design: LTD and RWA problems, dimensioning wavelength routing networks, statistical dimensioning models.</p> <p><b>Unit 6:</b>Access networks: Optical time division multiplexing, synchronization, header processing, buffering, burst switching, test beds, Introduction to PON, GPON, AON.</p> <p><b>References:</b></p> <ul style="list-style-type: none"> <li>• Rajiv Ramaswami, Sivarajan, Sasaki, “Optical Networks: A Practical Perspective”, MK, Elsevier, 3<sup>rd</sup> edition, 2010.</li> <li>• C. Siva Ram Murthy and Mohan Gurusamy, “WDM Optical Networks: Concepts Design, and Algorithms”, PHI, EEE, 2001.</li> </ul> |
|--|

**Program Elective 1 : Statistical Information Processing**

|  |  |
|--|--|
| <p><b>Teaching Scheme</b><br/>Lectures: 3 hrs/week</p>   |  |
| <p><b>Course Outcomes:</b></p> <p>At the end of this course, students will be able to</p> <ul style="list-style-type: none"> <li>• Characterize and apply probabilistic techniques in modern decision systems, such as information systems, receivers, filtering and statistical operations.</li> <li>• Demonstrate mathematical modelling and problem solving using such models.</li> <li>• Comparatively evolve key results developed in this course for applications to signal processing, communications systems.</li> <li>• Develop frameworks based in probabilistic and stochastic themes for modelling and analysis of various systems involving functionalities in decision making, statistical inference, estimation and detection.</li> </ul>   |  |
| <p><b>Syllabus Contents:</b></p> <p><b>Unit 1:</b> Review of random variables: Probability Concepts, distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of Random variables, Vector quantization, Tchebaychef inequality theorem, Central Limit theorem, Discrete &amp; Continuous Random Variables.</p> <p>Random process: Expectations, Moments, Ergodicity, Discrete-Time Random Processes Stationary process, autocorrelation and auto covariance functions, Spectral representation of random signals, Properties of power spectral density, Gaussian Process and White noise process.</p> <p><b>Unit 2:</b> Random signal modelling: MA(q), AR(p), ARMA(p,q) models, Hidden Markov Model &amp; its applications ,Linear System with random input , Forward and Backward Predictions, Levinson Durbin Algorithm.</p> <p><b>Unit 3:</b> Statistical Decision Theory: Bayes’ Criterion, Binary Hypothesis Testing, M-ary</p> |  |

Hypothesis Testing, Minimax Criterion, Neyman-Pearson Criterion, Composite Hypothesis Testing.

Parameter Estimation Theory: Maximum Likelihood Estimation, Generalized Likelihood Ratio Test, Some Criteria for Good Estimators, Bayes' Estimation Minimum Mean-Square Error Estimate, Minimum, Mean Absolute Value of Error Estimate Maximum A Posteriori Estimate, Multiple Parameter Estimation Best Linear Unbiased Estimator, Least-Square Estimation Recursive Least-Square Estimator.

**Unit 4:** Spectral analysis: Estimated autocorrelation function, Periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Parametric method, AR(p) spectral estimation and detection of Harmonic signals.

**Unit 5:** Information Theory and Source Coding: Introduction, Uncertainty, Information and Entropy, Source coding theorem, Huffman, Shannon Fano, Arithmetic, Adaptive coding, RLE, LZW Data compaction, LZ-77, LZ-78. Discrete Memory less channels, Mutual information, channel capacity, Channel coding theorem, Differential entropy and mutual information for continuous ensembles.

**Unit 6:** Application of Information Theory: Group, Ring & Field, Vector, GF addition, multiplication rules. Introduction to BCH codes, Primitive elements, Minimal polynomials, Generator polynomials in terms of Minimal polynomials, Some examples of BCH codes, & Decoder, Reed-Solomon codes & Decoder, Implementation of Reed Solomon encoders and decoders.

**References:**

- Papoulis and S.U. Pillai, "Probability, Random Variables and Stochastic Processes", 4th Edition, McGraw-Hill, 2002.
- D.G. Manolakis, V.K. Ingle and S.M. Kogon, "Statistical and Adaptive Signal Processing", McGraw Hill, 2000.
- Mourad Barkat, "Signal Detection and Estimation", Artech House, 2nd Edition, 2005.
- R.G. Gallager, "Information theory and reliable communication", Wiley, 1<sup>st</sup> edition, 1968.
- F. J. MacWilliams and N. J. A. Sloane, "The Theory of Error-Correcting Codes", New York, North-Holland, 1977.
- Rosen K.H, "Elementary Number Theory", Addison-Wesley, 6<sup>th</sup> edition, 2010.

**Program Elective 2 : Cognitive Radio**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand the fundamental concepts of cognitive radio networks.
- Develop the cognitive radio, as well as techniques for spectrum holes detection that cognitive radio takes advantages in order to exploit it.
- Understand technologies to allow an efficient use of TVWS for radio communications based on two spectrum sharing business models/policies.
- Understand fundamental issues regarding dynamic spectrum access, the radio-resource management and trading, as well as a number of optimisation techniques for better



spectrum exploitation.

**Syllabus Contents:**

**Unit 1:**Introduction to Cognitive Radios: Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, dynamic spectrum access (DSA), components of cognitive radio, spectrum sensing, spectrum analysis and decision, potential applications of cognitive radio.

**Unit 2:**Spectrum Sensing: Spectrum sensing, detection of spectrum holes (TVWS), collaborative sensing, geo-location database and spectrum sharing business models (spectrum of commons, real time secondary spectrum market).

**Unit 3:**Optimization Techniques of Dynamic Spectrum Allocation: Linear programming, convex programming, non-linear programming, integer programming, dynamic programming, stochastic programming.

**Unit 4:**Dynamic Spectrum Access and Management: Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access, learning algorithms and protocols.

**Unit 5:**Spectrum Trading: Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA (utility, auction theory), classification of auctions (single auctions, double auctions, concurrent, sequential).

**Unit 6:** Research Challenges in Cognitive Radio: Network layer and transport layer issues, cross-layer design for cognitive radio networks.

**References:**

- Ekram Hossain, Dusit Niyato, Zhu Han, “Dynamic Spectrum Access and Management in Cognitive Radio Networks”, Cambridge University Press, 2009.
- Kwang-Cheng Chen, Ramjee Prasad, “Cognitive radio networks”, John Wiley & Sons Ltd., 2009.
- Bruce Fette, “Cognitive radio technology”, Elsevier, 2<sup>nd</sup> edition, 2009.
- Huseyin Arslan, “Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems”, Springer, 2007.
- Francisco Rodrigo Porto Cavalcanti, Soren Andersson, “Optimizing Wireless Communication Systems” Springer, 2009.
- Linda Doyle, “Essentials of Cognitive Radio”, Cambridge University Press, 2009.

**Program Elective 2 : RF and Microwave Circuit Design**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand the behaviour of RF passive components and model active components.
- Perform transmission line analysis.
- Demonstrate use of Smith Chart for high frequency circuit design.
- Justify the choice/selection of components from the design aspects.
- Contribute in the areas of RF circuit design.

**Syllabus Contents:**

**Unit 1:**Transmission Line Theory:Lumped element circuit model for transmission line, field analysis, Smith chart, quarter wave transformer, generator and load mismatch, impedance

matching and tuning.

**Unit 2:** Microwave Network Analysis: Impedance and equivalent voltage and current, Impedance and admittance matrix, The scattering matrix, transmission matrix, Signal flow graph.

**Unit 3:** Microwave Components: Microwave resonators, Microwave filters, power dividers and directional couplers, Ferromagnetic devices and components.

**Unit 4:** Nonlinearity And Time Variance: Inter-symbol interference, random process & noise, definition of sensitivity and dynamic range, conversion gain and distortion.

**Unit 5:** Microwave Semiconductor Devices And Modeling: PIN diode, Tunnel diodes, Varactor diode, Schottky diode, IMPATT and TRAPATT devices, transferred electron devices, Microwave BJTs, GaAs FETs, low noise and power GaAs FETs, MESFET, MOSFET, HEMT.

**Unit 6:** Amplifiers Design: Power gain equations, stability, impedance matching, constant gain and noise figure circles, small signal, low noise, high power and broadband amplifier, oscillators, Mixers design.

**References:**

- Matthew M. Radmanesh, “Advanced RF & Microwave Circuit Design: The Ultimate Guide to Superior Design”, AuthorHouse, 2009.
- D.M.Pozar, “ Microwave engineering” ,Wiley, 4<sup>th</sup> edition, 2011.
- R.Ludwig and P.Bretchko, “R. F. Circuit Design”, Pearson Education Inc, 2009.
- G.D. Vendelin, A.M. Pavo, U. L. Rohde, “Microwave Circuit Design Using Linear And Non Linear Techniques”, John Wiley 1990.
- S.Y. Liao, “Microwave circuit Analysis and Amplifier Design”, Prentice Hall 1987.
- Radmanesh, “RF and Microwave Electronics Illustrated” , Pearson Education, 2004.

**Program Elective 2 : DSP Architecture**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Identify and formalize architectural level characterization of P-DSP hardware
- Ability to design, programming (assembly and C), and testing code using Code Composer Studio environment
- Deployment of DSP hardware for Control, Audio and Video Signal processing applications
- Understanding of major areas and challenges in DSP based embedded systems

**Syllabus Contents:**

**Unit 1 :** Programmable DSP Hardware: Processing Architectures (von Neumann, Harvard), DSP core algorithms (FIR, IIR, Convolution, Correlation, FFT), IEEE standard for Fixed and Floating Point Computations, Special Architectures Modules used in Digital Signal Processors (like MAC unit, Barrel shifters), On-Chip peripherals, DSP benchmarking.

**Unit 2:** Structural and Architectural Considerations: Parallelism in DSP processing, Texas Instruments TMS320 Digital Signal Processor Families, Fixed Point TI DSP Processors: TMS320C1X and TMS320C2X Family, TMS320C25 –Internal Architecture, Arithmetic and

Logic Unit, Auxiliary Registers, Addressing Modes (Immediate, Direct and Indirect, Bit-reverse Addressing), Basics of TMS320C54x and C55x Families in respect of Architecture improvements and new applications fields, TMS320C5416 DSP Architecture, Memory Map, Interrupt System, Peripheral Devices, Illustrative Examples for assembly coding.

**Unit 3:** VLIW Architecture: Current DSP Architectures, GPUs as an alternative to DSP Processors, TMS320C6X Family, Addressing Modes, Replacement of MAC unit by ILP, Detailed study of ISA, Assembly Language Programming, Code Composer Studio, Mixed Cand Assembly Language programming, On-chip peripherals, Simple applications developments as an embedded environment.

**Unit 4:** Multi-core DSPs: Introduction to Multi-core computing and applicability for DSP hardware, Concept of threads, introduction to P-thread, mutex and similar concepts, heterogeneous and homogenous multi-core systems, Shared Memory parallel programming –OpenMP approach of parallel programming, PRAGMA directives, OpenMP Constructs for work sharing like for loop, sections, TI TMS320C6678 (Eight Core subsystem).

**Unit 5:** FPGA based DSP Systems: Limitations of P-DSPs, Requirements of Signal processing for Cognitive Radio (SDR), FPGA based signal processing design-case study of a complete design of DSP processor.

**Unit 6:** High Performance Computing using P-DSP: Preliminaries of HPC, MPI, OpenMP, multicore DSP as HPC infrastructure.

- M. Sasikumar, D. Shikhare, Ravi Prakash, “Introduction to Parallel Processing”, 1<sup>st</sup> Edition, PHI, 2006.
- Fayez Gebali, “Algorithms and Parallel Computing”, 1<sup>st</sup> Edition, John Wiley & Sons, 2011
- Rohit Chandra, Ramesh Menon, Leo Dagum, David Kohr, DrorMaydan, Jeff McDonald, “Parallel Programming in OpenMP”, 1st Edition, Morgan Kaufman, 2000.
- Ann Melnichuk, Long Talk, “Multicore Embedded systems”, 1<sup>st</sup> Edition, CRC Press, 2010.
- Wayne Wolf, “High Performance Embedded Computing: Architectures, Applications and Methodologies”, 1<sup>st</sup> Edition, Morgan Kaufman, 2006.
- E.S.Gopi, “Algorithmic Collections for Digital Signal Processing Applications Using MATLAB”, 1<sup>st</sup> Edition, Springer Netherlands, 2007.

### Advanced Communication Networks Laboratory

**Teaching Scheme**

Lab work : 4 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Identify the different types of network devices and their functions within a network.
- Understand and build the skills of sub-netting and routing mechanisms.
- Understand basic protocols of computer networks, and how they can be used to assist in network design and implementation.

**List of Assignments:**

1. Study of Networking Commands (Ping, Tracert, TELNET, nslookup, netstat, ARP, RARP) and Network Configuration Files.
2. Linux Network Configuration.

- a. Configuring NIC's IP Address.
  - b. Determining IP Address and MAC Address using if-config command.
  - c. Changing IP Address using if-config.
  - d. Static IP Address and Configuration by Editing.
  - e. Determining IP Address using DHCP.
  - f. Configuring Hostname in /etc/hosts file.
3. Design TCP iterative Client and Server application to reverse the given input sentence.
  4. Design a TCP concurrent Server to convert a given text into upper case using multiplexing system call "select".
  5. Design UDP Client Server to transfer a file.
  6. Configure a DHCP Server to serve contiguous IP addresses to a pool of four IP devices with a default gateway and a default DNS address. Integrate the DHCP server with a BOOTP demon to automatically serve Windows and Linux OS Binaries based on client MAC address.
    - a. Configure DNS: Make a caching DNS client, and a DNS Proxy; implement reverse DNS and forward DNS, using TCP dump/Wireshark characterise traffic when the DNS server is up and when it is down.
  7. Configure a mail server for IMAP/POP protocols and write a simple SMTP client in C/C++/Java client to send and receive mails.
  8. Configure FTP Server on a Linux/Windows machine using a FTP client/SFTP client characterise file transfer rate for a cluster of small files 100k each and a video file of 700mb. Use a TFTP client and repeat the experiment.
  9. Signaling and QoS of labeled paths using RSVP in MPLS.
  10. Find shortest paths through provider network for RSVP and BGP.
  11. Understand configuration, forwarding tables, and debugging of MPLS.

### **Lab 2 Wireless and Mobile Communication Laboratory**

#### **Teaching Scheme**

Lab work : 4 hrs/week

#### **Course Outcomes:**

At the end of this course, students will be able to

- Understanding Cellular concepts, GSM and CDMA networks
- To study GSM handset by experimentation and fault insertion techniques
- Understating of 3G communication system by means of various AT commands usage in GSM
- Understanding CDMA concept using DSSS kit
- To learn, understand and develop concepts of Software Radio in real time environment

#### **List of Assignments:**

1. Understanding Cellular Fundamentals like Frequency Reuse, Interference, cell splitting, multi path environment, Coverage and Capacity issues using communication software.
2. Knowing GSM and CDMA architecture, network concepts, call management, call setup, call release, Security and Power Control, Handoff Process and types, Rake Receiver etc.
3. Study of GSM handset for various signalling and fault insertion techniques (Major GSM handset sections: clock, SIM card, charging, LCD module, Keyboard, User interface).
4. To study transmitters and receiver section in mobile handset and measure frequency band signal and GMSK modulating signal.
5. To study various GSM AT Commands their use and developing new application using it. Understating of 3G Communication System with features like; transmission of voice and videocalls, SMS, MMS, TCP/IP, HTTP, GPS and File system by AT Commands in 3G

network.

6. Study of DSSS technique for CDMA, observe effect of variation of types of PN codes, chip rate, spreading factor, processing gain on performance.
7. To learn and develop concepts of Software Radio in real time environment by studying the building blocks like Base band and RF section, convolution encoder, Interleaver and De-Interleaver.
8. To study and analyze different modulation techniques in time and frequency domain using SDR kit.

### Research Methodology and IPR

#### Teaching Scheme

Lectures: 2 hrs/week

#### Course Outcomes:

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

#### Syllabus Contents:

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis

Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

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| <b>References:</b>   |
| <ul style="list-style-type: none"> <li>• Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science &amp; engineering students”</li> <li>• Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”</li> <li>• Ranjit Kumar, 2 nd Edition , “Research Methodology: A Step by Step Guide for beginners”</li> <li>• Halbert, “Resisting Intellectual Property”, Taylor &amp; Francis Ltd ,2007.</li> <li>• Mayall , “Industrial Design”, McGraw Hill, 1992.</li> <li>• Niebel , “Product Design”, McGraw Hill, 1974.</li> <li>• Asimov , “Introduction to Design”, Prentice Hall, 1962.</li> <li>• Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.</li> <li>• T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008</li> </ul> |

### Semester II

#### Core 3 : Antennas and Radiating Systems

|  |  |
|--|--|
| <b>Teaching Scheme</b>   |  |
| Lab work : 3 hrs/week  |  |
| <b>Course Outcomes:</b>  |  |
| <p>At the end of this course, students will be able to</p> <ul style="list-style-type: none"> <li>• Compute the far field distance, radiation pattern and gain of an antenna for given current distribution.</li> <li>• Estimate the input impedance, efficiency and ease of match for antennas.</li> <li>• Compute the array factor for an array of identical antennas.</li> <li>• Design antennas and antenna arrays for various desired radiation pattern characteristics.</li> </ul>   |  |
| <b>Syllabus Contents:</b>  |  |
| <p><b>Unit 1:</b>Types of Antennas: Wire antennas, Aperture antennas, Micro strip antennas, Array antennas Reflector antennas, Lens antennas, Radiation Mechanism, Current distribution on thin wire antenna.</p> <p>Fundamental Parameters of Antennas: Radiation Pattern, Radiation Power Density, Radiation Intensity, Directivity, Gain, Antenna efficiency, Beam efficiency, Bandwidth, Polarization, Input Impedance, radiation efficiency, Antenna Vector effective length, Friis Transmission equation, Antenna Temperature.</p> <p><b>Unit 2:</b>Linear Wire Antennas: Infinitesimal dipole, Small dipole, Region separation, Finite length dipole, half wave dipole, Ground effects.</p> <p>Loop Antennas: Small Circular loop, Circular Loop of constant current, Circular loop with non uniform current.</p> <p><b>Unit 3:</b>Linear Arrays: Two element array, N Element array: Uniform Amplitude and spacing, Broadside and End fire array, Super directivity, Planar array, Design consideration.</p> <p><b>Unit 4:</b>Aperture Antennas: Huygen’s Field Equivalence principle, radiation equations, Rectangular Aperture, Circular Aperture.</p> <p>Horn Antennas: E-Plane, H-plane Sectoral horns, Pyramidal and Conical horns.</p> |  |

**Unit 5:**Micro strip Antennas: Basic Characteristics, Feeding mechanisms, Method of analysis, Rectangular Patch, Circular Patch.

**Unit 6:**Reflector Antennas: Plane reflector, parabolic reflector, Cassegrain reflectors, Introduction to MIMO.

**References:**

- Constantine A. Balanis, “Antenna Theory Analysis and Design”, John Wiley & Sons, 4th edition, 2016.
- John D Kraus, Ronald J Marhefka, Ahmad S Khan, “Antennas for All Applications”, Tata McGraw-Hill, 2002.
- R.C.Johnson and H.Jasik, “Antenna Engineering hand book”, Mc-Graw Hill, 1984.
- I.J.Bhal and P.Bhartia, “Micro-strip antennas”, Artech house, 1980.

**Core-4 Advanced Digital Signal Processing**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- To understand theory of different filters and algorithms
- To understand theory of multirate DSP, solve numerical problems and write algorithms
- To understand theory of prediction and solution of normal equations
- To know applications of DSP at block level.

**Syllabus Contents:**

**Unit 1:** Overview of DSP, Characterization in time and frequency, FFT Algorithms, Digital filter design and structures: Basic FIR/IIR filter design & structures, design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures, parallel realization of IIR.

**Unit 2 :** Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Applications in subband coding.

**Unit 3:** Linear prediction & optimum linear filters, stationary random process, forward-backward linear prediction filters, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction.

**Unit 4:** Adaptive Filters, Applications, Gradient Adaptive Lattice, Minimum mean square criterion, LMS algorithm, Recursive Least Square algorithm

**Unit 5:** Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation.

**Unit6 :**Application of DSP & Multi rate DSP, Application to Radar, introduction to wavelets, application to image processing, design of phase shifters, DSP in speech processing & other applications

**References:**

- J.G.Proakis and D.G.Manolakis“Digital signal processing: Principles, Algorithm and

- Applications”, 4th Edition, Prentice Hall, 2007.
- N. J. Fliege, “Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets”, 1<sup>st</sup> Edition, John Wiley and Sons Ltd, 1999.
- Bruce W. Suter, “Multirate and Wavelet Signal Processing”, 1<sup>st</sup> Edition, Academic Press, 1997.
- M. H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley & Sons Inc., 2002.
- S.Haykin, “Adaptive Filter Theory”, 4<sup>th</sup> Edition, Prentice Hall, 2001.
- D.G.Manolakis, V.K. Ingle and S.M.Kogon, “Statistical and Adaptive Signal Processing”, McGraw Hill, 2000

### PE 3 : Satellite Communication

#### Teaching Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

At the end of this course, students will be able to

- Visualize the architecture of satellite systems as a means of high speed, high range communication system.
- State various aspects related to satellite systems such as orbital equations, sub-systems in a satellite, link budget, modulation and multiple access schemes.
- Solve numerical problems related to orbital motion and design of link budget for the given parameters and conditions.

#### Syllabus Contents:

**Unit 1:**Architecture of Satellite Communication System: Principles and architecture of satellite Communication, Brief history of Satellite systems, advantages, disadvantages, applications, and frequency bands used for satellite communication and their advantages/drawbacks.

**Unit 2:**Orbital Analysis: Orbital equations, Kepler’s laws of planetary motion, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc of a satellite, concepts of Solar day and Sidereal day.

**Unit 3:**Satellite sub-systems: Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Attitude and orbit control system (AOCS), Communication sub-system, power sub-systems, antenna sub-system.

**Unit 4:**Typical Phenomena in Satellite Communication: Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift.

**Unit 5:**Satellite link budget: Flux density and received signal power equations, Calculation of System noise temperature for satellite receiver, noise power calculation, Drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions, Case study of Personal Communication system (satellite telephony) using LEO.

**Unit 6:**Modulation and Multiple Access Schemes used in satellite communication. Typical case studies of VSAT, DBS-TV satellites and few recent communication satellites launched by NASA/ ISRO. GPS.



**References:**

- Timothy Pratt and Others, “Satellite Communications”, Wiley India, 2<sup>nd</sup> edition, 2010.
- S. K. Raman, “Fundamentals of Satellite Communication”, Pearson Education India, 2011.
- Tri T. Ha, “Digital Satellite Communications”, Tata McGraw Hill, 2009.
- Dennis Roddy, “Satellite Communication”, McGraw Hill, 4<sup>th</sup> Edition, 2008.

**PE 3 : Internet of things**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand what IoT technologies are used for today, and what is required in certain scenarios.
- Understand the types of technologies that are available and in use today and can be utilized to implement IoT solutions.
- Apply these technologies to tackle scenarios in teams of using an experimental platform for implementing prototypes and testing them as running applications.

**Syllabus Contents:**

**Unit 1:** Smart cities and IoT revolution, Fractal cities, From IT to IoT, M2M and peer networking concepts, Ipv4 and IPV6.

**Unit 2:** Software Defined Networks SDN, From Cloud to Fog and MIST networking for IoT communications, Principles of Edge/P2P networking, Protocols to support IoT communications, modular design and abstraction, security and privacy in fog.

**Unit 3:** Wireless sensor networks: introduction, IOT networks (PAN, LAN and WAN), Edge resource pooling and caching, client side control and configuration.

**Unit 4:** Smart objects as building blocks for IoT, Open source hardware and Embedded systems platforms for IoT, Edge/gateway, IO drivers, C Programming, multithreading concepts.

**Unit 5:** Operating systems requirement of IoT environment, study of mbed, RIoT, and Contiki operating systems, Introductory concepts of big data for IoT applications.

**Unit 6:** Applications of IoT, Connected cars IoT Transportation, Smart Grid and Healthcare sectors using IoT, Security and legal considerations, IT Act 2000 and scope for IoT legislation.

**References:**

- A Bahaga, V. Madiseti, “Internet of Things- Hands on approach”, VPT publisher, 2014.
- A. McEwen, H. Cassimally, “Designing the Internet of Things”, Wiley, 2013.
- Cuno Pfister, “Getting started with Internet of Things”, Maker Media, 1<sup>st</sup> edition, 2011.
- Samuel Greengard, “Internet of things”, MIT Press, 2015.

**Web resources :**

- <http://www.datamation.com/open-source/35-open-source-tools-for-the-internet-of-things-1.html>
- <https://developer.mbed.org/handbook/AnalogIn>
- [http://www.libelium.com/50\\_sensor\\_applications/](http://www.libelium.com/50_sensor_applications/)

- M2MLabs Mainspring <http://www.m2mlabs.com/framework>
- Node-RED <http://nodered.org/>

### PE 3 : Voice and Data Networks

#### Teaching Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

At the end of this course, students will be able to

- Protocol, algorithms, trade-offs rationale.
- Routing, transport, DNS resolutions
- Network extensions and next generation architectures.

#### Syllabus Contents:

**Unit 1:** Network Design Issues, Network Performance Issues, Network Terminology, centralized and distributed approaches for networks design, Issues in design of voice and data networks.

**Unit 2:** Layered and Layer less Communication, Cross layer design of Networks, Voice Networks (wired and wireless) and Switching, Circuit Switching and Packet Switching, Statistical Multiplexing.

**Unit 3:** Data Networks and their Design, Link layer design- Link adaptation, Link Layer Protocols, Retransmission. Mechanisms (ARQ), Hybrid ARQ (HARQ), Go Back N, Selective Repeat protocols and their analysis.

**Unit 4:** Queuing Models of Networks , Traffic Models , Little's Theorem, Markov chains, M/M/1 and other Markov systems, Multiple Access Protocols , Aloha System , Carrier Sensing , Examples of Local area networks,

**Unit 5:** Inter-networking, Bridging, Global Internet , IP protocol and addressing , Sub netting , Classless Inter domain Routing (CIDR) , IP address lookup , Routing in Internet. End to End Protocols, TCP and UDP. Congestion Control , Additive Increase/Multiplicative Decrease , Slow Start, Fast Retransmit/ Fast Recovery,

**Unit 6:** Congestion avoidance, RED TCP Throughput Analysis, Quality of Service in Packet Networks. Network Calculus, Packet Scheduling Algorithms.

#### References:

- D. Bertsekas and R. Gallager, "Data Networks", 2<sup>nd</sup> Edition, Prentice Hall, 1992.
- L. Peterson and B. S. Davie, "Computer Networks: A Systems Approach", 5<sup>th</sup> Edition, Morgan Kaufman, 2011.
- Kumar, D. Manjunath and J. Kuri, "Communication Networking: An analytical approach", 1<sup>st</sup> Edition, Morgan Kaufman, 2004.
- Walrand, "Communications Network: A First Course", 2<sup>nd</sup> Edition, McGraw Hill, 2002.
- Leonard Kleinrock, "Queueing Systems, Volume I: Theory", 1<sup>st</sup> Edition, John Wiley and Sons, 1975.
- Aaron Kershenbaum, "Telecommunication Network Design Algorithms", McGraw Hill, 1993.
- Vijay Ahuja, "Design and Analysis of Computer Communication Networks", McGraw Hill, 1987

| <b>PE 4 : Markov Chains and Queueing Systems</b>  |  |
|---|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Understand Markov Chains and regenerative processes used in modelling a wide variety of systems and phenomena.</li> <li>• Model a system as queueing system with some aspect of the queue governed by a random process.</li> <li>• Understand telecommunication systems modelling using Markov chains with special emphasis on developing queueing models.</li> </ul>   |  |
| <b>Syllabus Contents:</b><br><b>Unit 1:</b> Introduction: Review of basic probability, properties of nonnegative random variables, laws of large numbers and the Central Limit Theorem.<br><b>Unit 2:</b> Renewal Processes: Basic definitions, recurrence times, rewards and renewal reward theorem, point processes, Poisson process, Walds equation, Blackwell's theorem.<br><b>Unit 3:</b> Discrete time Markov chains: definitions and properties, matrix representation, Perron-Frobenius theory.<br><b>Unit 4:</b> Continuous time Markov chains: basic definitions, Q-matrix, birth-death processes, quasi birth death processes.;Embedded Markov processes, semi Markov processes, reversible Markov chains, Random walks.<br><b>Unit 5:</b> Fundamental queueing results: Little's theorem, invariance of the mean delay, Conservation law.<br>Markovian queues: Jackson and BCMP networks, numerical Algorithms. M/G/1 & G/M/1 queues and G/G/1 queues.<br><b>Unit 6:</b> Advanced queueing models: priority, vacation and retrials in queues. |  |
| <b>References:</b> <ul style="list-style-type: none"> <li>• Cliffs, “Stochastic Modelling and the Theory Queues”, Prentice Hall, 1989.</li> <li>• P.Bremaud, “Markov Chains”, Springer-Verlag, 1999.</li> <li>• E.Seneta, “Non Negative Matrices and Markov Chains”, Springer Series in Statistics, Springer,1981.</li> <li>• R.Gallager, “Discrete Stochastic Processes”, Kluwer Academic Press, 1996.</li> <li>• L.Kleinrock, “Queueing Systems”, vols I and II, John Wiley and Sons 1976.</li> </ul>   |  |

| <b>PE 4 : MIMO Systems</b>   |  |
|--|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week   |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Understand channel modelling and propagation, MIMO Capacity, space-time coding,</li> </ul> |  |

MIMO receivers, MIMO for multi-carrier systems (e.g. MIMO-OFDM), multi-user communications, multi-user MIMO.

- Understand cooperative and coordinated multi-cell MIMO, introduction to MIMO in 4G (LTE, LTE-Advanced, WiMAX).
- Perform Mathematical modelling and analysis of MIMO systems.

**Syllabus Contents:**

**Unit 1:** Introduction to Multi-antenna Systems, Motivation, Types of multi-antenna systems, MIMO vs. multi-antenna systems.

**Unit 2:** Diversity, Exploiting multipath diversity, Transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, Receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing, Spectral efficiency and capacity, Transmitting independent streams in parallel, Mathematical notation

**Unit 3:** The generic MIMO problem, Singular Value Decomposition, Eigenvalues and eigenvectors, Equalising MIMO systems, Disadvantages of equalising MIMO systems, Pre-distortion in MIMO systems, Disadvantages of pre-distortion in MIMO systems, Pre-coding and combining in MIMO systems, Advantages of pre-coding and combining, Disadvantages of pre-coding and combining, Channel state information.

**Unit 4:** Codebooks for MIMO, Beamforming, Beamforming principles, Increased spectrum efficiency, Interference cancellation, Switched beamformer, Adaptive beamformer, Narrowband beamformer, Wideband beamformer

**Unit 5:** Case study: MIMO in LTE, Codewords to layers mapping, Pre-coding for spatial multiplexing, Pre-coding for transmit diversity, Beamforming in LTE, Cyclic delay diversity based pre-coding, Pre-coding codebooks, Propagation Channels, Time & frequency channel dispersion, AWGN and multipath propagation channels, Delay spread values and time variations, Fast and slow fading environments, Complex baseband multipath channels, Narrowband and wideband channels, MIMO channel models

**Unit 6:** Channel Estimation, Channel estimation techniques, Estimation and tracking, Training based channel estimation, Blind channel estimation, Channel estimation architectures, Iterative channel estimation, MMSE channel estimation, Correlative channel sounding, Channel estimation in single carrier systems, Channel estimation for CDMA, Channel estimation for OFDM.

**References:**

- Claude Oestges, Bruno Clerckx, "MIMO Wireless Communications : From Real-world Propagation to Space-time Code Design", Academic Press, 1<sup>st</sup> edition, 2010.
- Mohinder Janakiraman, "Space - Time Codes and MIMO Systems", Artech House Publishers, 2004.

**PE 4 : Programmable Networks - SDN, NFV**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Understand advanced concepts in Programmable Networks.
- Understand Software Defined Networking, an emerging Internet architectural framework.
- Implement the main concepts, architectures, algorithms, protocols and applications in SDN and NFV.

**Syllabus Contents:**

**Unit 1 :**Introduction to Programmable Networks, History and Evolution of Software Defined Networking (SDN), Fundamental Characteristics of SDN, Separation of Control Plane and Data Plane, Active Networking.

**Unit 2 :**Control and Data Plane Separation: Concepts, Advantages and Disadvantages, the basics of OpenFlow protocol.

**Unit 3 :**Network Virtualization: Concepts, Applications, Existing Network Virtualization Framework, Mininet A simulation environment for SDN.

**Unit 4 :**Control Plane: Overview, Existing SDN Controllers including Floodlight and OpenDaylight projects. Customization of Control Plane: Switching and Firewall Implementation using SDN Concepts. Data Plane: Software-based and Hardware-based; Programmable Network Hardware.

**Unit 5 :**Programming SDNs: Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs. Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications.

**Unit 6 :**Data Center Networks: Packet, Optical and Wireless Architectures, Network Topologies. Use Cases of SDNs: Data Centers, Internet Exchange Points, Backbone Networks, Home Networks, Traffic Engineering.

**References:**

- Thomas D. Nadeau, Ken Gray, “SDN: Software Defined Networks, An Authoritative Review of Network Programmability Technologies”, O’Reilly Media, August 2013.
- Paul Goransson, Chuck Black, Timothy Culver. “Software Defined Networks: A Comprehensive Approach”, Morgan Kaufmann Publishers, 2016.
- Fei Hu, “Network Innovation through OpenFlow and SDN: Principles and Design”, CRC Press, 2014.
- Vivek Tiwari, “SDN and OpenFlow for Beginners”, Amazon Digital Services, Inc., ASIN: , 2013.
- Nick Feamster, Jennifer Rexford and Ellen Zegura, “The Road to SDN: An Intellectual History of Programmable Networks” ACM CCR April 2014.
- Open Networking Foundation (ONF) Documents, <https://www.opennetworking.org>, 2015.
- OpenFlow standards, <http://www.openflow.org>, 2015.

**Antennas and Radiating Systems Laboratory**

**Teaching Scheme**

Lab :4 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Determine specifications, design, construct and test antenna.
- Explore and use tools for designing, analyzing and testing antennas. These tools include Antenna design and analysis software, network analyzers, spectrum analyzers, and antenna pattern measurement techniques.

**List of Assignments:**

1. Simulation of half wave dipole antenna.
2. Simulation of change of the radius and length of dipole wire on frequency of resonance of antenna.
3. Simulation of quarter wave, full wave antenna and comparison of their parameters.
4. Simulation of monopole antenna with and without ground plane.
5. Study the effect of the height of the monopole antenna on the radiation characteristics of the antenna.
6. Simulation of a half wave dipole antenna array.
7. Study the effect of change in distance between elements of array on radiation pattern of dipole array.
8. Study the effect of the variation of phase difference 'beta' between the elements of the array on the radiation pattern of the dipole array.
9. Case study.

**Semester III**

**Lab 4 : Advanced Digital Signal Processing lab**

**Teaching Scheme**

Lectures: 4 hrs./week

**Course Outcomes:**

At the end of this course, students will be able to

- Design different digital filters in software
- Apply various transforms in time and frequency
- Perform decimation and interpolation

**List of Assignments:**

12. Basic Signal Representation
13. Correlation Auto And Cross
14. Stability Using Hurwitz Routh Criteria
15. Sampling FFT Of Input Sequence
16. Butterworth Lowpass And Highpass Filter Design
17. Chebychev Type I,II Filter
18. State Space Matrix from Differential Equation
19. Normal Equation Using Levinson Durbin
20. Decimation And Interpolation Using Rationale Factors
21. Maximally Decimated Analysis DFT Filter
22. Cascade Digital IIR Filter Realization
23. Convolution And M Fold Decimation & PSD Estimator
24. Estimation Of PSD
25. Inverse Z Transform

- 26. Group Delay Calculation
- 27. Separation Of T/F
- 28. Parallel Realization of IIR filter

### PEV- High Performance Networks

#### Teaching Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

At the end of this course, students will be able to

- Apply knowledge of mathematics, probability, and statistics to model and analyze some networking protocols.
- Design, implement, and analyze computer networks.
- Identify, formulate, and solve network engineering problems.
- Show knowledge of contemporary issues in high performance computer networks. Use techniques, skills, and modern networking tools necessary for engineering practice.

#### Syllabus Contents:

**Unit 1:** Types of Networks, Network design issues, Data in support of network design. Network design tools, protocols and architecture. Streaming stored Audio and Video, Best effort service, protocols for real time interactive applications, Beyond best effort, scheduling and policing mechanism, integrated services, and RSVP-differentiated services.

**Unit 2:** VoIP system architecture, protocol hierarchy, Structure of a voice endpoint, Protocols for the transport of voice media over IP networks. Providing IP quality of service for voice, signaling protocols for VoIP, PSTN gateways, VoIP applications.

**Unit 3:** VPN-Remote-Access VPN, site-to-site VPN, Tunneling to PPP, Security in VPN. MPLS-operation, Routing, Tunneling and use of FEC, Traffic Engineering, MPLS based VPN, overlay networks-P2P connections.

**Unit 4:** Traffic Modeling: Little's theorem, Need for modeling, Poisson modeling, Non-poisson models, Network performance evaluation.

**Unit 5:** Network Security and Management: Principles of cryptography, Authentication, integrity, key distribution and certification, Access control and fire walls, attacks and counter measures, security in many layers.

**Unit 6:** Infrastructure for network management, The internet standard management framework – SMI, MIB, SNMP, Security and administration, ASN.1.

#### References:

- Kershenbaum A., "Telecommunications Network Design Algorithms", Tata McGraw Hill, 1993.
- Larry Peterson & Bruce David, "Computer Networks: A System Approach", Morgan Kaufmann, 2003.
- Douskalis B., "IP Telephony: The Integration of Robust VoIP Services", Pearson Ed. Asia, 2000.
- Warland J., Varaiya P., "High-Performance Communication Networks", Morgan Kaufmann, 1996.

- Stallings W., “High-Speed Networks: TCP/IP and ATM Design Principles”, Prentice Hall, 1998.
- Leon Garcia, Widjaja, “Communication networks”, TMH 7<sup>th</sup> reprint 2002.
- William Stallings, “Network security, essentials”, Pearson education Asia publication, 4<sup>th</sup> Edition, 2011.

### PE 5 : Pattern Recognition and Machine Learning

#### Teaching Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

At the end of this course, students will be able to

- Study the parametric and linear models for classification
- Design neural network and SVM for classification
- Develop machine independent and unsupervised learning techniques.

#### Syllabus Contents:

##### Unit 1

**Introduction to Pattern Recognition:** Problems, applications, design cycle, learning and adaptation, examples, Probability Distributions, Parametric Learning - Maximum likelihood and Bayesian Decision Theory- Bayes rule, discriminant functions, loss functions and Bayesian error analysis

##### Unit 2

**Linear models:** Linear Models for Regression, linear regression, logistic regression Linear Models for Classification

##### Unit 3

**Neural Network:** perceptron, multi-layer perceptron, backpropagation algorithm, error surfaces, practical techniques for improving backpropagation, additional networks and training methods, Adaboost, Deep Learning

##### Unit 4

**Linear discriminant functions** - decision surfaces, two-category, multi-category, minimum-squared error procedures, the Ho-Kashyap procedures, linear programming algorithms, Support vector machine

##### Unit 5

**Algorithm independent machine learning** – lack of inherent superiority of any classifier, bias and variance, re-sampling for classifier design, combining classifiers

##### Unit 6

**Unsupervised learning and clustering** – k-means clustering, fuzzy k-means clustering, hierarchical clustering

#### References:

- Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, 2nd Edition John Wiley & Sons, 2001.
- Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, “The Elements of Statistical



|   |  |
|---|--|
| <p>Learning”, 2nd Edition, Springer, 2009.</p> <ul style="list-style-type: none"> <li>• C. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.</li> </ul>   |  |
| <p><b>Remote Sensing</b></p>  |  |
| <p><b>Teaching Scheme</b><br/>Lectures: 3hrs/week</p>   |  |
| <p><b>Course Outcomes:</b></p> <p>At the end of this course, students shall be able to</p> <ul style="list-style-type: none"> <li>• Understand basic concepts, principles and applications of remote sensing, particularly the geometric and radiometric principles;</li> <li>• Provide examples of applications of principles to a variety of topics in remote sensing, particularly related to data collection, radiation, resolution, and sampling.</li> </ul>   |  |
| <p><b>Syllabus Contents:</b></p> <p><b>Unit 1:</b> Physics Of Remote Sensing: Electro Magnetic Spectrum, Physics of Remote Sensing- Effects of Atmosphere-Scattering–Different types–Absorption-Atmospheric window-Energy interaction with surface features –Spectral reflectance of vegetation, soil and water atmospheric influence on spectral response patterns-multi concept in Remote sensing.</p> <p><b>Unit 2:</b> Data Acquisition: Types of Platforms–different types of aircrafts-Manned and Unmanned spacecrafts–sun synchronous and geo synchronous satellites –Types and characteristics of different platforms –LANDSAT, SPOT, IRS, INSAT, IKONOS, QUICKBIRD etc</p> <p><b>Unit 3:</b> Photographic products, B/W, color, color IR film and their characteristics –resolving power of lens and film -Opto mechanical electro optical sensors –across track and along track scanners-multispectral scanners and thermal scanners–geometric characteristics of scanner imagery -calibration of thermal scanners.</p> <p><b>Unit 4:</b> Scattering System: Microwave scatterometry, types of RADAR –SLAR –resolution – range and azimuth –real aperture and synthetic aperture RADAR. Characteristics of Microwave images topographic effect-different types of Remote Sensing platforms –airborne and space borne sensors -ERS, JERS, RADARSAT, RISAT -Scatterometer, Altimeter-LiDAR remote sensing, principles, applications.</p> <p><b>Unit 5:</b> Thermal And Hyper Spectral Remote Sensing: Sensors characteristics-principle of spectroscopy-imaging spectroscopy–field conditions, compound spectral curve, Spectral library, radiative models, processing procedures, derivative spectrometry, thermal remote sensing – thermal sensors, principles, thermal data processing, applications.</p> <p><b>Unit 6:</b> Data Analysis: Resolution–Spatial, Spectral, Radiometric and temporal resolution-signal to noise ratio-data products and their characteristics-visual and digital interpretation–Basic principles of data processing –Radiometric correction–Image enhancement–Image classification–Principles of LiDAR, Aerial Laser Terrain Mapping.</p> |  |
| <p><b>References:</b></p> <ul style="list-style-type: none"> <li>• Lillesand T.M., and Kiefer, R.W. Remote Sensing and Image interpretation, John Wiley &amp; Sons-2000, 6<sup>th</sup> Edition</li> <li>• John R. Jensen, Introductory Digital Image Processing: A Remote Sensing Perspective, 2nd Edition, 1995.</li> <li>• John A. Richards, Springer –Verlag, Remote Sensing Digital Image Analysis, 1999.</li> <li>• Paul Curran P.J. Principles of Remote Sensing, ELBS; 1995.</li> </ul>   |  |

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|---|--|
| <ul style="list-style-type: none"> <li>• Charles Elachi and Jakob J. van Zyl , Introduction To The Physics and Techniques of Remote Sensing , Wiley Series in Remote Sensing and Image Processing, 2006.</li> <li>• Sabins, F.F.Jr, Remote Sensing Principles and Image interpretation, W.H.Freeman&amp; Co, 1978</li> </ul>  |  |
| <b>(Dissertation) Dissertation Phase – I and Phase - II</b>   |  |
| <b>Teaching Scheme</b><br>Lab work : 20 and 32 hrs/week for phase I and II respectively   |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.</li> <li>• Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.</li> <li>• Ability to present the findings of their technical solution in a written report.</li> <li>• Presenting the work in International/ National conference or reputed journals.</li> </ul>  |  |
| <b>Syllabus Contents:</b><br>The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following <ul style="list-style-type: none"> <li>• Relevance to social needs of society</li> <li>• Relevance to value addition to existing facilities in the institute</li> <li>• Relevance to industry need</li> <li>• Problems of national importance</li> <li>• Research and development in various domain</li> </ul> The student should complete the following: <ul style="list-style-type: none"> <li>• Literature survey Problem Definition</li> <li>• Motivation for study and Objectives</li> <li>• Preliminary design / feasibility / modular approaches</li> <li>• Implementation and Verification</li> <li>• Report and presentation</li> </ul> The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on: <ul style="list-style-type: none"> <li>• Experimental verification / Proof of concept.</li> <li>• Design, fabrication, testing of Communication System.</li> <li>• The viva-voce examination will be based on the above report and work.</li> </ul> |  |
| <b>Guidelines for Dissertation Phase – I and II</b> <ul style="list-style-type: none"> <li>• As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.</li> <li>• The dissertation may be carried out preferably in-house i.e. department’s laboratories and centers OR in industry allotted through department’s T &amp; P coordinator.</li> <li>• After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred</li> </ul>  |  |

literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.

- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work

**OPEN ELECTIVES**  
**Business Analytics**

**Teaching scheme**  
**Lecture: - 3 h/week**

|                      |                           |
|----------------------|---------------------------|
| <b>Course Code</b>   |                           |
| <b>Course Name</b>   | <b>Business Analytics</b> |
| <b>Credits</b>       |                           |
| <b>Prerequisites</b> |                           |

Total Number of Lectures: 48

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| <b>Course objective</b>   |
| <ol style="list-style-type: none"> <li>1. Understand the role of business analytics within an organization.</li> <li>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.</li> <li>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.</li> <li>4. To become familiar with processes needed to develop, report, and analyze business data.</li> <li>5. Use decision-making tools/Operations research techniques.</li> </ol> |

- |    |  |
|----|--|
| 6. | Mange business process using analytical and management tools.  |
| 7. | Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc. |

| LECTURE WITH BREAKUP   | NO. OF LECTURES |
|--|-----------------|
| <p><b>Unit 1:</b><br/>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br/>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p>   | 9               |
| <p><b>Unit 2:</b><br/>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br/>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.</p>   | 8               |
| <p><b>Unit 3:</b><br/>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br/>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.</p>   | 9               |
| <p><b>Unit 4:</b><br/>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br/>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.</p> | 10              |
| <p><b>Unit 5:</b><br/>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.</p>   | 8               |
| <p><b>Unit 6:</b><br/>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.</p>  | 4               |

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|------------------------|--|
| <b>COURSE OUTCOMES</b> |  |
|                        |  |

1. Students will demonstrate knowledge of data analytics.
2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Students will demonstrate the ability to translate data into clear, actionable insights.

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

**OPEN ELECTIVES**  
**Industrial Safety**

**Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical

motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, McGraw Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

**OPEN ELECTIVES**  
**Operations Research**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:** At the end of the course, the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

**Syllabus Contents:**

**Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit 5**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010

6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

**Open Elective**  
**Cost Management of Engineering Projects**

**Teaching scheme**

**Lecture: - 3 h/week**

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Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

**Open Elective**  
**Composite Materials**

**Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle

reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

**Open Elective  
Waste to Energy**

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.



2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

### AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

| <b>Course objectives:</b>  |  |       |
|--|--|-------|
| Students will be able to:  |  |       |
| <ol style="list-style-type: none"> <li>1. Understand that how to improve your writing skills and level of readability</li> <li>2. Learn about what to write in each section</li> <li>3. Understand the skills needed when writing a Title</li> </ol> |  |       |
| Ensure the good quality of paper at very first-time submission   |  |       |
| <b>Syllabus</b>  |  |       |
| Units  | CONTENTS   | Hours |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4     |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4     |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4     |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4     |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4     |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4     |

#### Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

### AUDIT 1 and 2: DISASTER MANAGEMENT

|  |
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| <b>Course Objectives:</b> -Students will be able to:   |
| 1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.   |
| 2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives. |

| <p>3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.</p> <p>4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in</p> |  |              |
|---|--|--------------|
| <b>Syllabus</b>   |  |              |
| <b>Units</b>  | <b>CONTENTS</b>  | <b>Hours</b> |
| 1   | <p><b>Introduction</b><br/>                     Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.</p>  | 4            |
| 2   | <p><b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br/>                     Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.</p> | 4            |
| 3   | <p><b>Disaster Prone Areas In India</b><br/>                     Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics</p>  | 4            |
| 4   | <p><b>Disaster Preparedness And Management</b><br/>                     Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.</p>   | 4            |
| 5   | <p><b>Risk Assessment</b><br/>                     Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.</p>   | 4            |
| 6   | <p><b>Disaster Mitigation</b><br/>                     Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.</p>   | 4            |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.), "Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , "Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

**AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE**

**Course Objectives**

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world

2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

### **Syllabus**

| <b>Unit</b> | <b>Content</b>  | <b>Hours</b> |
|-------------|---|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul>          | 8            |
| 2           | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8            |
| 3           | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8            |

### **Suggested reading**

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

### **Course Output**

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## **AUDIT 1 and 2: VALUE EDUCATION**

### **Course Objectives**

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

### **Syllabus**

| <b>Unit</b> | <b>Content</b>  | <b>Hours</b> |
|-------------|---|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul> | 4            |

|   |  |   |
|---|--|---|
| 2 | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty, Humanity. Power of faith, National Unity.</li> <li>• Patriotism.Love for nature ,Discipline</li> </ul>  | 6 |
| 3 | <ul style="list-style-type: none"> <li>• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> <li>• Doing best for saving nature</li> </ul> | 6 |
| 4 | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality, Nonviolence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind, Self-control.</li> <li>• Honesty, Studying effectively</li> </ul>  | 6 |

**Suggested reading**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

**Course outcomes**

Students will be able to

- 1.Knowledge of self-development
- 2.Learn the importance of Human values
- 3.Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

|   |                |              |
|---|----------------|--------------|
| <b>Course Objectives:</b>   |                |              |
| Students will be able to:   |                |              |
| <ol style="list-style-type: none"> <li>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>2. To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</li> <li>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ol> |                |              |
| <b>Syllabus</b>   |                |              |
| <b>Units</b>  | <b>Content</b> | <b>Hours</b> |

|          |   |   |
|----------|---|---|
| <b>1</b> | <ul style="list-style-type: none"> <li>●<b>History of Making of the Indian Constitution:</b></li> <li>History</li> <li>Drafting Committee, ( Composition &amp; Working)</li> </ul>  | 4 |
| <b>2</b> | <ul style="list-style-type: none"> <li>●<b>Philosophy of the Indian Constitution:</b></li> <li>Preamble</li> <li>Salient Features</li> </ul>  | 4 |
| <b>3</b> | <ul style="list-style-type: none"> <li>●<b>Contours of Constitutional Rights &amp; Duties:</b></li> <li>● Fundamental Rights</li> <li>• Right to Equality</li> <li>• Right to Freedom</li> <li>• Right against Exploitation</li> <li>• Right to Freedom of Religion</li> <li>• Cultural and Educational Rights</li> <li>• Right to Constitutional Remedies</li> <li>• Directive Principles of State Policy</li> <li>• Fundamental Duties.</li> </ul>  | 4 |
| <b>4</b> | <ul style="list-style-type: none"> <li>●<b>Organs of Governance:</b></li> <li>● Parliament</li> <li>• Composition</li> <li>• Qualifications and Disqualifications</li> <li>• Powers and Functions                             <ul style="list-style-type: none"> <li>• Executive</li> </ul> </li> <li>• President</li> <li>• Governor</li> <li>• Council of Ministers</li> <li>• Judiciary, Appointment and Transfer of Judges, Qualifications</li> <li>• Powers and Functions</li> </ul>   | 4 |
| <b>5</b> | <ul style="list-style-type: none"> <li>●<b>Local Administration:</b></li> <li>• District's Administration head: Role and Importance,</li> <li>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.</li> <li>• Pachayati raj: Introduction, PRI: Zila Pachayat.</li> <li>• Elected officials and their roles, CEO Zila Pachayat: Position and role.</li> <li>• Block level: Organizational Hierarchy (Different departments),</li> <li>• Village level: Role of Elected and Appointed officials,</li> <li>• Importance of grass root democracy</li> </ul> | 4 |
| <b>6</b> | <ul style="list-style-type: none"> <li>●<b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul>   | 4 |

### Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

### Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.

2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

### AUDIT 1 and 2: PEDAGOGY STUDIES

| <b>Course Objectives:</b><br>Students will be able to:   |   |              |
|--|---|--------------|
| <ol style="list-style-type: none"> <li>4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.</li> <li>5. Identify critical evidence gaps to guide the development.</li> </ol> |   |              |
| <b>Syllabus</b>  |   |              |
| <b>Units</b>   | <b>Content</b>  | <b>Hours</b> |
| <b>1</b>   | <ul style="list-style-type: none"> <li>• <b>Introduction and Methodology:</b></li> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> <li>• Overview of methodology and Searching.</li> </ul>  | 4            |
| <b>2</b>   | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>  | 2            |
| <b>3</b>   | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers' attitudes and beliefs and Pedagogic strategies.</li> </ul> | 4            |
| <b>4</b>   | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul>  | 4            |
| <b>5</b>   | <ul style="list-style-type: none"> <li>• <b>Research gaps and future directions</b></li> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> <li>• Dissemination and research impact.</li> </ul>   | 2            |

### Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal Educational Development*, 33 (3): 272-282.
5. Alexander RJ (2001) *Culture and pedagogy: International comparisons in primary education*. Oxford and Boston: Blackwell.
6. Chavan M (2003) *Read India: A mass scale, rapid, 'learning to read' campaign*.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf).

### Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

### AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

#### Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

#### Syllabus

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> </ul> Do's and Don't's in life.<br>i) Ahinsa, satya, asthaya, bramhacharya and aparigraha<br>ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> </ul> i) Various yog poses and their benefits for mind & body<br>ii)Regularization of breathing techniques and its effects-Types of pranayam    | 8     |

#### Suggested reading

1. 'Yogic Asanas for Group Training-Part-I' : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

**AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE  
ENLIGHTENMENT SKILLS**

**Course Objectives**

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

**Syllabus**

| Unit | Content  | Hours |
|------|--|-------|
| 1    | Neetisatakam-Holistic development of personality <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont's)</li> <li>• Verses- 71,73,75,78 (do's)</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>  | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8     |

**Suggested reading**

1. “Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

**Course Outcomes**

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.



## M. Tech. (Electronics and Telecommunication)

### Curriculum Structure

#### Specialization: VLSI and Embedded Systems

#### Program Outcomes (POs)

Students will be able to

1. Apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude.
2. Identify, formulate and solve engineering problems in the broad areas like System Design using VLSI and Embedded Platforms and tools, Semiconductor Technologies, Applications in Signal Processing, Machine Vision and Communication Networks.
3. Use different software tools in the domain of VLSI and Embedded Systems Design, Analysis and Verification such as Design entry, Synthesis, Functional and Timing Simulation, Floor-planning, Place and route, Layout editors, RTL schematic, Platform specific EDA sets, MATLAB.
4. Design and conduct experiments, analyze and interpret data, imbibe programming skills for development of simulation experiments.
5. Function as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility

#### Semester I

| Sr. No. | Course Type/Code            | Course Name  | Teaching Scheme |          |          | Credits   |
|---------|-----------------------------|--|-----------------|----------|----------|-----------|
|         |                             |  | L               | T        | P        |           |
| 1       | Core 1                      | RTL Simulation and Synthesis with PLDs   | 3               | 0        | 0        | 3         |
| 2       | Core 2                      | Microcontrollers and Programmable Digital Signal Processors  | 3               | 0        | 0        | 3         |
| 3       | Prog. Specific Elective PE1 | Elective I<br>(1) Digital Signal and Image Processing<br>(2) Programming Languages for Embedded Software<br>(3) VLSI signal processing | 3               | 0        | 0        | 3         |
| 4       | Prog. Specific Elective PE2 | Elective II<br>(1) Parallel Processing<br>(2) System Design with Embedded Linux<br>(3) CAD of Digital System                           | 3               | 0        | 0        | 3         |
| 5       | Lab 1                       | RTL Simulation and Synthesis with PLDs Lab   | 0               | 0        | 4        | 2         |
| 6       | Lab2                        | Microcontrollers and Programmable Digital Signal Processors Lab  | 0               | 0        | 4        | 2         |
| 7       |                             | Research Methodology and IPR   | 2               | 0        | 0        | 2         |
| 8       | Aud 1                       | Audit course 1   | 2               | 0        | 0        | 0         |
|         |                             | <b>Total</b>   | <b>16</b>       | <b>0</b> | <b>0</b> | <b>18</b> |

**Semester II**

| Sr. No. | Course Code | Course Name  | Teaching Scheme |          |           | Credits   |
|---------|-------------|--|-----------------|----------|-----------|-----------|
|         |             |  | L               | T        | P         |           |
| 1       | Core 3      | Analog and Digital CMOS VLSI Design  | 3               | 0        | 0         | 3         |
| 2       | Core 4      | VLSI Design Verification and Testing   | 3               | 0        | 0         | 3         |
| 3       | PE-3        | Elective III<br>(1) Memory Technologies<br>(2) SoC Design<br>(3) Low power VLSI Design   | 3               | 0        | 0         | 3         |
| 4       | PE-4        | Elective IV<br>(1) Communication Buses and Interfaces<br>(2) Network Security and Cryptography<br>(3) Physical design automation | 3               | 0        | 0         | 3         |
| 5       | Lab1        | Analog and Digital CMOS VLSI Design Lab  | 0               | 0        | 4         | 2         |
| 6       | Lab2        | VLSI Design Verification and Testing Lab   | 0               | 0        | 4         | 2         |
| 7       |             | Mini Project   | 0               | 0        | 4         | 2         |
| 8       | Aud 2       | Audit course 2   | 2               | 0        | 0         | 0         |
|         |             | <b>Total</b>   | <b>14</b>       | <b>0</b> | <b>12</b> | <b>18</b> |

**Semester-III**

| Sr. No. | Course Code  | Course Name   | Teaching Scheme |          |           | Credits   |
|---------|--------------|---|-----------------|----------|-----------|-----------|
|         |              |   | L               | T        | P         |           |
| 1.      | PE-5         | <b>Elective – V</b><br>(1) Communication Network<br>(2) Selected Topics in Mathematics<br>(3) Nano materials and Nanotechnology                                       | 3               | 0        | 0         | 3         |
| 2.      | OE           | 1. Business Analytics<br>2. Industrial Safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3               | 0        | 0         | 3         |
| 3       | Dissertation | Dissertation Phase – I  | 0               | 0        | 20        | 10        |
|         |              | <b>Total</b>  | <b>6</b>        | <b>0</b> | <b>20</b> | <b>16</b> |

**Semester-IV**

| Sr. No.      | Course Code  | Course Name             | Teaching Scheme |    |    | Credits   |
|--------------|--------------|-------------------------|-----------------|----|----|-----------|
|              |              |                         | L               | T  | P  |           |
| 1.           | Dissertation | Dissertation Phase - II | --              | -- | 32 | 16        |
| <b>Total</b> |              |                         | --              | -- | -- | <b>16</b> |

**Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**RTL Simulation and Synthesis with PLDs****Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

- Familiarity of Finite State Machines, RTL design using reconfigurable logic.
- Design and develop IP cores and Prototypes with performance guarantees
- Use EDA tools like Cadence, Mentor Graphics and Xilinx.

**Syllabus Contents:****Unit1:** Top down approach to design, Design of FSMs (Synchronous and asynchronous), Static timing

analysis, Meta-stability, Clock issues, Need and design strategies for multi-clock domain designs.

**Unit 2:** Design entry by Verilog/VHDL/FSM, Verilog AMS.**Unit 3:** Programmable Logic Devices, Introduction to ASIC Design Flow, FPGA, SoC, Floor planning,

Placement, Clock tree synthesis, Routing, Physical verification, Power analysis, ESD protection.

**Unit 4:** Design for performance, Low power VLSI design techniques. Design for testability.**Unit 5:** IP and Prototyping: IP in various forms: RTL Source code, Encrypted Source code, Soft IP, Netlist,

Physical IP, Use of external hard IP during prototyping

**Unit 6:** Case studies and Speed issues.**References:**

- Richard S. Sandige, “Modern Digital Design”, MGH, International Editions.
- Donald D Givone, “Digital principles and Design”, TMH
- Charles Roth, Jr. and Lizy K John, “Digital System Design using VHDL”, Cengage

Learning.

- Samir Palnitkar, “Verilog HDL, a guide to digital design and synthesis”, Prentice Hall.
- Doug Amos, Austin Lesea, Rene Richter, “FPGA based prototyping methodology manual”, Xilinx
- Bob Zeidman, “Designing with FPGAs & CPLDs”, CMP Books.

### **Microcontrollers and Programmable Digital Signal Processors**

#### **Teaching Scheme**

Lectures: 3 hrs/week

#### **Course Outcomes:**

At the end of this course, students will be able to

- Compare and select ARM processor core based SoC with several features/peripherals based on requirements of embedded applications.
- Identify and characterize architecture of Programmable DSP Processors
- Develop small applications by utilizing the ARM processor core and DSP processor based platform.

#### **Syllabus Contents:**

**Unit 1:** ARM Cortex-M3 processor: Applications, Programming model – Registers, Operation modes,

Exceptions and Interrupts, Reset Sequence Instruction Set, Unified Assembler Language, Memory Maps, Memory Access Attributes, Permissions, Bit-Band Operations, Unaligned and Exclusive Transfers. Pipeline, Bus Interfaces

**Unit 2:** Exceptions, Types, Priority, Vector Tables, Interrupt Inputs and Pending behaviour, Fault Exceptions, Supervisor and Pendable Service Call, Nested Vectored Interrupt Controller, Basic Configuration, SYSTICK Timer, Interrupt Sequences, Exits, Tail Chaining, Interrupt Latency.

**Unit 3:** LPC 17xx microcontroller- Internal memory, GPIOs, Timers, ADC, UART and other serial interfaces, PWM, RTC, WDT

**Unit 4:** Programmable DSP (P-DSP) Processors:

Harvard architecture, Multi port memory, architectural structure of P-DSP- MAC unit, Barrel shifters, Introduction to TI DSP processor family

**Unit 5:** VLIW architecture and TMS320C6000 series, architecture study, data paths, cross paths, Introduction to Instruction level architecture of C6000 family, Assembly Instructions memory addressing, for arithmetic, logical operations

**Unit 6:** Code Composer Studio for application development for digital signal processing, On chip peripherals, Processor benchmarking

#### **References:**

1. Joseph Yiu, “The definitive guide to ARM Cortex-M3”, Elsevier, 2<sup>nd</sup> Edition
2. Venkatramani B. and Bhaskar M. “Digital Signal Processors: Architecture, Programming and Applications”, TMH, 2<sup>nd</sup> Edition
3. Sloss Andrew N, Symes Dominic, Wright Chris, “ARM System Developer's Guide: Designing and Optimizing”, Morgan Kaufman Publication
4. Steve Furber, “ARM System-on-Chip Architecture”, Pearson Education
5. Frank Vahid and Tony Givargis, “Embedded System Design”, Wiley
6. Technical references and user manuals on [www.arm.com](http://www.arm.com), NXP Semiconductor [www.nxp.com](http://www.nxp.com) and Texas Instruments [www.ti.com](http://www.ti.com)

| <b>Elective IDigital Signal and Image Processing</b>   |  |
|--|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week   |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Analyze discrete-time signals and systems in various domains</li> <li>• Design and implement filters using fixed point arithmetic targeted for embedded platforms</li> <li>• Compare algorithmic and computational complexities in processing and coding digital images.</li> </ul>  |  |
| <b>Syllabus Contents:</b><br><b>Unit 1:</b> Review of Discrete Time signals and systems, Characterization in time and Z and Fourier – domain, Fast Fourier Transform algorithms – In-place computations, Butterfly computations, bit reversal's.<br><b>Unit 2:</b> Digital Filter design: FIR - Windowing and Frequency Sampling, IIR – Impulse invariance, bilinear Transformation.<br><b>Unit 3:</b> Fixed point implementation of filters – challenges and techniques.<br><b>Unit 4:</b> Digital Image Acquisition, Enhancement, Restoration. Digital Image Coding and Compression – JPEG and JPEG 2000.<br><b>Unit 5:</b> Color Image processing – Handling multiple planes, computational challenges.<br><b>Unit 6:</b> VLSI architectures for implementation of Image Processing algorithms, Pipelining. |  |
| <b>References:</b> <ul style="list-style-type: none"> <li>• J.G. Proakis, Manolakis “Digital Signal Processing”, Pearson, 4<sup>th</sup> Edition</li> <li>• Gonzalez and Woods, “Digital Image Processing”, PHI, 3<sup>rd</sup> Edition</li> <li>• S. K. Mitra. “Digital Signal Processing – A Computer based Approach”, TMH, 3<sup>rd</sup> Edition, 2006</li> <li>• A. K. Jain, “Fundamentals of Digital Image Processing”, Prentice Hall</li> <li>• KeshabParhi, “VLSI Digital Signal Processing Systems – Design and Implementation”, Wiley India</li> </ul>   |  |

| <b>Elective IProgramming Languages for Embedded Software</b>   |  |
|--|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week   |  |
| <b>Course Outcomes:</b><br>At the end of this course, students will be able to <ul style="list-style-type: none"> <li>• Write an embedded C application of moderate complexity.</li> <li>• Develop and analyze algorithms in C++.</li> <li>• Differentiate interpreted languages from compiled languages.</li> </ul> |  |

**Syllabus Contents:**

**Unit 1:** Embedded ‘C’ Programming

- Bitwise operations, Dynamic memory allocation, OS services
- Linked stack and queue, Sparse matrices, Binary tree
- Interrupt handling in C, Code optimization issues
- Writing LCD drives, LED drivers, Drivers for serial port communication
- Embedded Software Development Cycle and Methods (Waterfall, Agile)

**Unit 2:** Object Oriented Programming

- Introduction to procedural, modular, object-oriented and generic programming techniques, Limitations of procedural programming, objects, classes, data members, methods, data encapsulation, data abstraction and information hiding, inheritance, polymorphism

**Unit 3:** CPP Programming: ‘cin’, ‘cout’, formatting and I/O manipulators, new and delete operators,

Defining a class, data members and methods, ‘this’ pointer, constructors, destructors, friend function, dynamic memory allocation

**Unit 4:** Overloading and Inheritance: Need of operator overloading, overloading the assignment, overloading using friends, type conversions, single inheritance, base and derived classes, friend classes, types of inheritance, hybrid inheritance, multiple inheritance, virtual base class, polymorphism, virtual functions,

**Unit 5:** Templates: Function template and class template, member function templates and template arguments, Exception Handling: syntax for exception handling code: try-catch- throw, Multiple Exceptions.

**Unit 6:** Scripting Languages

Overview of Scripting Languages – PERL, CGI, VB Script, Java Script.

PERL: Operators, Statements Pattern Matching etc. Data Structures, Modules, Objects, Tied Variables, Inter process Communication Threads, Compilation & Line Interfacing.

**References:**

- Michael J. Pont , “Embedded C”, Pearson Education, 2<sup>nd</sup> Edition, 2008
- Randal L. Schwartz, “Learning Perl”, O’Reilly Publications, 6<sup>th</sup> Edition 2011
- A. Michael Berman, “Data structures via C++”, Oxford University Press, 2002
- Robert Sedgewick, “Algorithms in C++”, Addison Wesley Publishing Company, 1999
- Abraham Silberschatz, Peter B, Greg Gagne, “Operating System Concepts”, John Willey & Sons, 2005

**Elective I VLSI SIGNAL PROCESSING**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Acquired knowledge about DSP algorithms, its DFG representation, pipelining and parallel processing approaches.
- Ability to acquire knowledge about retiming techniques, folding and register minimization

path problems.

- Ability to have knowledge about algorithmic strength reduction techniques and parallel processing of FIR and IIR digital filters.
- Acquired knowledge about finite word-length effects and round off noise computation in DSP systems.

**Syllabus Contents:**

**Unit 1:** Introduction to DSP systems, Pipelined and parallel processing.

**Unit 2:** Iteration Bound, Retiming, unfolding, algorithmic strength reduction in filters and Transforms.

**Unit 3:** Systolic architecture design, fast convolution, pipelined and parallel recursive and adaptive filters, Scaling and round off noise.

**Unit 4:** Digital lattice filter structures, bit level arithmetic, architecture, redundant arithmetic.

**Unit 5:** Numerical strength reduction, synchronous, wave and asynchronous pipe lines, low power design.

**Unit 6:** Programmable digit signal processors.

**References:**

- Keshab K. Parthi [\[A1\]](#) , VLSI Digital signal processing systems, design and implementation [\[A2\]](#) , Wiley, Inter Science, 1999.
- Mohammad Isamail and Terri Fiez, Analog VLSI signal and information processing, McGraw Hill, 1994
- S.Y. Kung, H.J. White House, T. Kailath, VLSI and Modern Signal Processing, Prentice Hall, 1985.

**Elective II Parallel Processing**

**Teaching Scheme**

Lectures: 3hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Identify limitations of different architectures of computer
- Analysis quantitatively the performance parameters for different architectures
- Investigate issues related to compilers and instruction set based on type of architectures.

**Syllabus Contents:**

**Unit 1:** Overview of Parallel Processing and Pipelining, Performance analysis, Scalability

**Unit 2:** Principles and implementation of Pipelining, Classification of pipelining processors, Advanced pipelining techniques, Software pipelining

**Unit 3:** VLIW processors

Case study: Superscalar Architecture- Pentium, Intel Itanium Processor, Ultra SPARC,

MIPS on  
FPGA, Vector and Array Processor, FFT Multiprocessor Architecture

**Unit 4:** Multithreaded Architecture, Multithreaded processors, Latency hiding techniques, Principles of multithreading, Issues and solutions

**Unit 5:** Parallel Programming Techniques:

Message passing program development, Synchronous and asynchronous message passing, Shared Memory Programming, Data Parallel Programming, Parallel Software Issues

**Unit 6:** Operating systems for multiprocessors systems  
Customizing applications on parallel processing platforms

### References:

- Kai Hwang, Faye A. Briggs, “Computer Architecture and Parallel Processing”, MGH International Edition
- Kai Hwang, “Advanced Computer Architecture”, TMH
- V. Rajaraman, L. Sivaram Murthy, “Parallel Computers”, PHI.
- William Stallings, “Computer Organization and Architecture, Designing for performance” Prentice Hall, Sixth edition
- Kai Hwang, Zhiwei Xu, “Scalable Parallel Computing”, MGH
- David Harris and Sarah Harris, “Digital Design and Computer Architecture”, Morgan Kaufmann.

## Elective II System Design with Embedded Linux

### Teaching Scheme

Lectures: 3 hrs/week

### Course Outcomes:

At the end of this course, students will be able to

1. Familiarity of the embedded Linux development model.
2. Write, debug, and profile applications and drivers in embedded Linux.
3. Understand and create Linux BSP for a hardware platform

### Syllabus Contents:

**Unit 1:** Embedded Linux Vs Desktop Linux, Embedded Linux Distributions

**Unit 2:** Embedded Linux

Architecture, Kernel Architecture – HAL, Memory manager, Scheduler, File System, I/O and Networking subsystem, IPC, User space, Start-up sequence

**Unit 3:** Board Support Package

Embedded Storage: MTD, Architecture, Drivers, Embedded File System

Embedded Drivers: Serial, Ethernet, I<sup>2</sup>C, USB, Timer, Kernel Modules

**Unit 4:** Porting Applications

Real-Time Linux: Linux and Real time, Programming, Hard Real-time Linux

**Unit 5:** Building and Debugging: Kernel, Root file system

Embedded Graphics

**Unit 6:** Case study of uClinux



**References:**

- Karim Yaghmour, “Building Embedded Linux Systems”, O’Reilly & Associates
- P Raghvan, Amol Lad, SriramNeelakandan, “Embedded Linux System Design and Development”, Auerbach Publications
- Christopher Hallinan, “Embedded Linux Primer: A Practical Real World Approach”, Prentice Hall, 2<sup>nd</sup> Edition, 2010.
- Derek Molloy, “Exploring BeagleBone: Tools and Techniques for Building with Embedded Linux”, Wiley, 1<sup>st</sup> Edition, 2014.

**Elective II CAD of Digital System**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Fundamentals of CAD tools for modelling, design, test and verification of VLSI systems.
- Study of various phases of CAD, including simulation, physical design, test and verification.
- Demonstrate knowledge of computational algorithms and tools for CAD.

**Syllabus Contents:**

**Unit 1:** Introduction to VLSI Methodologies – Design and Fabrication of VLSI Devices, Fabrication

Process and its impact on Design.

**Unit 2:** VLSI design automation tools – Data structures and basic algorithms, graph theory and computational complexity, tractable and intractable problems.

**Unit 3:** General purpose methods for combinational optimization – partitioning, floor planning and pin assignment, placement, routing.

**Unit 4:** Simulation – logic synthesis, verification, high level Synthesis.

**Unit 5 and 6:** MCMS-VHDL-Verilog-implementation of simple circuits using VHDL

**References:**

- N.A. Sherwani, “Algorithms for VLSI Physical Design Automation”.
- S.H. Gerez, “Algorithms for VLSI Design Automation.

| <b>RTL Simulation and Synthesis with PLDs Lab</b>   |  |
|---|--|
| <b>Teaching Scheme</b><br>Lectures:4 hrs/week   |  |
| <b>Course Outcomes:</b><br>At the end of the laboratory work, students will be able to: <ul style="list-style-type: none"> <li>• Identify, formulate, solve and implement problems in signal processing, communication systems etc using RTL design tools.</li> <li>• Use EDA tools like Cadence, Mentor Graphics and Xilinx.</li> </ul>  |  |
| <b>List of Experiments:</b> <ol style="list-style-type: none"> <li>1) Verilog implementation of 8:1 Mux/Demux, Full Adder, 8-bit Magnitude comparator, Encoder/decoder, Priority encoder, D-FF, 4-bit Shift registers (SISO, SIPO, PISO, bidirectional), 3-bit Synchronous Counters, Binary to Gray converter, Parity generator.</li> <li>2) Sequence generator/detectors, Synchronous FSM – Mealy and Moore machines.</li> <li>3) Vending machines - Traffic Light controller, ATM, elevator control.</li> <li>4) PCI Bus &amp; arbiter and downloading on FPGA.</li> <li>5) UART/ USART implementation in Verilog.</li> <li>6) Realization of single port SRAM in Verilog.</li> <li>7) Verilog implementation of Arithmetic circuits like serial adder/ subtractor, parallel adder/subtractor, serial/parallel multiplier.</li> <li>8) Discrete Fourier transform/Fast Fourier Transform algorithm in Verilog.</li> </ol> |  |

| <b>Microcontrollers and Programmable Digital Signal Processors Lab</b>  |  |
|---|--|
| <b>Teaching Scheme</b><br>Lectures: 4 hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of the laboratory work, students will be able to: <ol style="list-style-type: none"> <li>1. Install, configure and utilize tool sets for developing applications based on ARM processor core SoC and DSP processor.</li> <li>2. Develop prototype codes using commonly available on and off chip peripherals on the Cortex M3 and DSP development boards.</li> </ol>                        |  |
| <b>List of Assignments:</b><br><b>Part A)</b> Experiments to be carried out on Cortex-M3 development boards and using GNU tool-chain <ol style="list-style-type: none"> <li>1. Blink an LED with software delay, delay generated using the SysTick timer.</li> <li>2. System clock real time alteration using the PLL modules.</li> <li>3. Control intensity of an LED using PWM implemented in software and hardware.</li> </ol> |  |

4. Control an LED using switch by polling method, by interrupt method and flash the LED once every five switch presses.
5. UART Echo Test.
6. Take analog readings on rotation of rotary potentiometer connected to an ADC channel.
7. Temperature indication on an RGB LED.
8. Mimic light intensity sensed by the light sensor by varying the blinking rate of an LED.
9. Evaluate the various sleep modes by putting core in sleep and deep sleep modes.
10. System reset using watchdog timer in case something goes wrong.
11. Sample sound using a microphone and display sound levels on LEDs.

**Part B)** Experiments to be carried out on DSP C6713 evaluation kits and using Code Composer Studio (CCS)

1. To develop an assembly code and C code to compute Euclidian distance between any two points
2. To develop assembly code and study the impact of parallel, serial and mixed execution
3. To develop assembly and C code for implementation of convolution operation
4. To design and implement filters in C to enhance the features of given input sequence/signal

### Research Methodology and IPR

#### Teaching Scheme

Lectures: 1hrs/week

#### Course Outcomes:

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

#### Syllabus Contents:

**Unit 1:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

**Unit 2:** Effective literature studies approaches, analysis  
Plagiarism, Research ethics,

**Unit 3:** Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**Unit 4:** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit 5:** Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit 6:** New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**

- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall, “Industrial Design”, McGraw Hill, 1992.
- Niebel, “Product Design”, McGraw Hill, 1974.
- Asimov, “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

**Semester II**

**Analog and Digital CMOS VLSI Design**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Analyze, design, optimize and simulate analog and digital circuits using CMOS constrained by the design metrics.
- Connect the individual gates to form the building blocks of a system.
- Use EDA tools like Cadence, Mentor Graphics and other open source software tools like Ngspice.

**Syllabus Contents:**

Technology Scaling and Road map, Scaling issues, Standard 4 mask NMOS Fabrication process

**Digital CMOS Design:**

**Unit 1:**Review: Basic MOS structure and its static behavior, Quality metrics of a digital design: Cost, Functionality, Robustness, Power, and Delay, Stick diagram and Layout, Wire delay models.

Inverter: Static CMOS inverter, Switching threshold and noise margin concepts and their evaluation, Dynamic behavior, Power consumption.

**Unit 2:**Physical design flow: Floor planning, Placement, Routing, CTS, Power analysis and IR

|  |
|--|
| <p>drop estimation-static and dynamic, ESD protection-human body model, Machine model.</p> <p>Combinational logic: Static CMOS design, Logic effort, Ratioed logic, Pass transistor logic, Dynamic logic, Speed and power dissipation in dynamic logic, Cascading dynamic gates, CMOS transmission gate logic.</p> <p><b>Unit 3:</b> Sequential logic: Static latches and registers, Bi-stability principle, MUX based latches, Static SR flip-flops, Master-slave edge-triggered register, Dynamic latches and registers, Concept of pipelining, Pulse registers, Non-bistable sequential circuit.<br/>Advanced technologies: Giga-scale dilemma, Short channel effects, High-k, Metal Gate Technology, FinFET, TFET etc.</p> <p><b>Analog CMOS Design:</b></p> <p><b>Unit 4:</b> Single Stage Amplifier: CS stage with resistance load, Divide connected load, Current source load, Triode load, CS stage with source degeneration, Source follower, Common-gate stage, Cascade stage, Choice of device models. Differential Amplifiers: Basic difference pair, Common mode response, Differential pair with MOS loads, Gilbert cell.</p> <p><b>Unit 5:</b> Passive and active current mirrors: Basic current mirrors, Cascade mirrors, Active current mirrors. Frequency response of CS stage: Source follower, Common gate stage, Cascade stage and difference pair, Noise</p> <p><b>Unit 6:</b> Operational amplifiers: One stage OPAMP, Two stage OPAMP, Gain boosting, Common mode feedback, Slew rate, PSRR, Compensation of 2 stage OPAMP, Other compensation techniques.</p> |
|--|

**References:**

- J P Rabaey, A P Chandrakasan, B Nikolic, “Digital Integrated circuits: A design perspective”, Prentice Hall electronics and VLSI series, 2<sup>nd</sup> Edition.
- Baker, Li, Boyce, “CMOS Circuit Design, Layout, and Simulation”, Wiley, 2<sup>nd</sup> Edition.
- Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, TMH, 2007.
- Phillip E. Allen and Douglas R. Holberg, “CMOS Analog Circuit Design”, Oxford, 3<sup>rd</sup> Edition.
- R J Baker, “CMOS circuit Design, Layout and Simulation”, IEEE Inc., 2008.
- Kang, S. and Leblebici, Y., “CMOS Digital Integrated Circuits, Analysis and Design”, TMH, 3<sup>rd</sup> Edition.
- Pucknell, D.A. and Eshraghian, K., “Basic VLSI Design”, PHI, 3<sup>rd</sup> Edition.

**VLSI Design Verification and Testing**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of this course, students will be able to

- Familiarity of Front end design and verification techniques and create reusable test environments.
- Verify increasingly complex designs more efficiently and effectively.
- Use EDA tools like Cadence, Mentor Graphics.

**Syllabus Contents:**

**Unit 1:** Verification guidelines: Verification Process, Basic Testbench functionality, directed

testing, Methodology basics, Constrained-Random stimulus, Functional coverage, Testbench components, Layered testbench, Building layered testbench, Simulation environment phases, Maximum code reuse, Testbench performance.

**Unit 2:**Data types: Built-in data types, Fixed-size arrays, Dynamic arrays, Queues, Associative arrays, Linked lists, Array methods, Choosing a storage type, Creating new types with typedef , Creating user-defined structures, Type conversion, Enumerated types, Constants strings, Expression width.

**Unit 3:**Procedural statements and routines: Procedural statements, tasks, functions and void functions, Routine arguments, Returning from a routine, Local data storage, Time values  
Connecting the testbench and design: Separating the testbench and design, Interface constructs, Stimulus timing, Interface driving and sampling, Connecting it all together, Top-level scope  
Program – Module interactions.

**Unit 4:** SystemVerilog Assertions: Basic OOP: Introduction, think of nouns, Not verbs, your first class, where to define a class, OOP terminology, Creating new objects, Object de-allocation, Using objects, Static variables vs. Global variables, Class methods, Defining methods outside of the class, Scoping rules, Using one class inside another, Understanding dynamic objects, Copying objects, Public vs. Local, Straying off course building a testbench.

**Unit 5:**Randomization: Introduction, What to randomize, Randomization in SystemVerilog, Constraint details solution probabilities, Controlling multiple constraint blocks, Valid constraints, In-line constraints, The pre\_randomize and post\_randomize functions,

**Unit 6:**Random number functions, Constraints tips and techniques, Common randomization problems, Iterative and array constraints, Atomic stimulus generation vs. Scenario generation, Random control, Random number generators, Random device configuration.

#### References:

- Chris Spears, “ System Verilog for Verification”, Springer, 2<sup>nd</sup> Edition
- M. Bushnell and V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers
- IEEE 1800-2009 standard (IEEE Standard for SystemVerilog— Unified Hardware Design, Specification, and Verification Language).
- System Verilog website – [www.systemverilog.org](http://www.systemverilog.org)
- [http://www.sunburstdesign.com/papers/CummingsSNUG2006Boston\\_SystemVerilog\\_Events.pdf](http://www.sunburstdesign.com/papers/CummingsSNUG2006Boston_SystemVerilog_Events.pdf)
- General reuse information and resources [www.design-reuse.com](http://www.design-reuse.com)
- OVM, UVM(on top of SV) [www.verifacationacademy.com](http://www.verifacationacademy.com)
- Verification IP resources

[http://www.cadence.com/products/fv/verification\\_ip/pages/default.aspx](http://www.cadence.com/products/fv/verification_ip/pages/default.aspx)

- <http://www.synopsys.com/Tools/Verification/FunctionalVerification/VerificationIP/Pages/default.aspx>

### Elective III Memory Technologies

#### Teaching Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

At the end of the course, students will be able to:

- Select architecture and design semiconductor memory circuits and subsystems.
- Identify various fault models, modes and mechanisms in semiconductor memories and their testing procedures.
- Knowhow of the state-of-the-art memory chip design

#### Syllabus Contents:

##### Unit 1: Random Access Memory Technologies:

Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, MOS SRAM Cell and Peripheral Circuit, Bipolar SRAM, Advanced SRAM Architectures, Application Specific SRAMs.

##### Unit 2: DRAMs, MOS DRAM Cell, BiCMOS DRAM, Error Failures in DRAM, Advanced DRAM Design and

Architecture, Application Specific DRAMs. SRAM and DRAM Memory controllers.

##### Unit 3: Non-Volatile Memories: Masked ROMs, PROMs, Bipolar & CMOS PROM, EEPROMs, Floating Gate

EPROM Cell, OTP EPROM, EEPROMs, Non-volatile SRAM, Flash Memories.

##### Unit 4: Semiconductor Memory Reliability and Radiation Effects: General Reliability Issues, RAM Failure

Modes and Mechanism, Nonvolatile Memory, Radiation Effects, SEP, Radiation Hardening Techniques. Process and Design Issues, Radiation Hardened Memory Characteristics, Radiation Hardness Assurance and Testing.

##### Unit 5 : Advanced Memory Technologies and High-density Memory Packing Technologies:

Ferroelectric Random Access Memories (FRAMs), Gallium Arsenide (GaAs) FRAMs, Analog Memories, Magneto Resistive Random Access Memories (MRAMs), Experimental Memory Devices.

##### Unit 6: Memory Hybrids (2D & 3D), Memory Stacks, Memory Testing and Reliability Issues, Memory Cards,

High Density Memory Packaging

#### References:

- Ashok K Sharma, “Advanced Semiconductor Memories: Architectures, Designs and Applications”, Wiley Interscience
- Kiyoo Itoh, “VLSI memory chip design”, Springer International Edition
- Ashok K Sharma, ” Semiconductor Memories: Technology, Testing and Reliability , PHI

| <b>Elective III SoC Design</b>  |  |
|---|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week  |  |
| <p><b>Course Outcomes:</b></p> <p>At the end of the course, students will be able to:</p> <ul style="list-style-type: none"> <li>• Identify and formulate a given problem in the framework of SoC based design approaches</li> <li>• Design SoC based system for engineering applications</li> <li>• Realize impact of SoC on electronic design philosophy and Macro-electronics thereby incline towards entrepreneurship &amp; skill development.</li> </ul>   |  |
| <p><b>Syllabus Contents:</b></p> <p><b>Unit 1:ASIC</b></p> <ul style="list-style-type: none"> <li>- Overview of ASIC types, design strategies, CISC, RISC and NISC approaches for SOC architectural issues and its impact on SoC design methodologies, Application Specific Instruction Processor (ASIP) concepts.</li> </ul> <p><b>Unit 2: NISC</b></p> <ul style="list-style-type: none"> <li>- NISC Control Words methodology, NISC Applications and Advantages, Architecture Description Languages (ADL) for design and verification of Application Specific Instruction-set Processors (ASIP), No-Instruction-Set-computer (NISC)- design flow, modeling NISC architectures and systems, use of Generic Netlist Representation - A formal language for specification, compilation and synthesis of embedded processors.</li> </ul> <p><b>Unit 3:Simulation</b></p> <ul style="list-style-type: none"> <li>- Different simulation modes, behavioural, functional, static timing, gate level, switch level, transistor/circuit simulation, design of verification vectors, Low power FPGA, Reconfigurable systems, SoC related modeling of data path design and control logic, Minimization of interconnects impact, clock tree design issues.</li> </ul> <p><b>Unit 4:Low power SoC design / Digital system,</b></p> <ul style="list-style-type: none"> <li>- Design synergy, Low power system perspective- power gating, clock gating, adaptive voltage scaling (AVS), Static voltage scaling, Dynamic clock frequency and voltage scaling (DCFS), building block optimization, building block memory, power down techniques, power consumption verification.</li> </ul> <p><b>Unit 5 :Synthesis</b></p> <ul style="list-style-type: none"> <li>- Role and Concept of graph theory and its relevance to synthesizable constructs, Walks, trails paths, connectivity, components, mapping/visualization, nodal and admittance graph. Technology independent and technology dependent approaches for synthesis, optimization constraints, Synthesis report analysisSingle core and Multi core systems, dark silicon issues, HDL coding techniques for minimization of power consumption, Fault tolerant designs</li> </ul> <p><b>Unit 6:Case study for overview of cellular phone design with emphasis on area optimization, speed improvement and power minimization.</b></p> <p><i>Note:</i> Students will prepare and present a term paper on relevant identified current topics (in batches of three students per topic) as a part of theory course.</p> |  |



**References:**

- Hubert Kaeslin, “Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication”, Cambridge University Press, 2008.
- B. Al Hashimi, “System on chip-Next generation electronics”, The IET, 2006
- RochitRajsuman, “System-on- a-chip: Design and test”, Advantest America R & D Center, 2000
- P Mishra and N Dutt, “Processor Description Languages”, Morgan Kaufmann, 2008
- Michael J. Flynn and Wayne Luk, “Computer System Design: System-on-Chip”. Wiley, 2011

**Elective III Low Power VLSI Design**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course, students will be able to:

- CO1: Identify the sources of power dissipation in digital IC systems & understand the impact of power on system performance and reliability.
- CO2: Characterize and model power consumption & understand the basic analysis methods.
- CO3: Understand leakage sources and reduction techniques.

**Syllabus Contents:**

**Unit 1:** Technology & Circuit Design Levels: Sources of power dissipation in digital ICs, degree of

freedom, recurring themes in low-power, emerging low power approaches, dynamic dissipation in CMOS, effects of V<sub>dd</sub> & V<sub>t</sub> on speed, constraints on V<sub>t</sub> reduction, transistor sizing & optimal gate oxide thickness, impact of technology scaling, technology innovations.

**Unit 2:**Low Power Circuit Techniques: Power consumption in circuits, flip-flops & latches, high capacitance nodes, energy recovery, reversible pipelines, high performance approaches.

**Unit 3:** Low Power Clock Distribution: Power dissipation in clock distribution, single driver versus

distributed buffers, buffers & device sizing under process variations, zero skew Vs. tolerable skew, chip & package co-design of clock network.

**Unit 4:**Logic Synthesis for Low Power estimation techniques: Power minimization techniques, low

power arithmetic components- circuit design styles, adders, multipliers.

**Unit 5:** Low Power Memory Design: Sources & reduction of power dissipation in memory subsystem, sources of power dissipation in DRAM & SRAM, low power DRAM circuits, low power SRAM circuits.

**Unit 6:**Low Power Microprocessor Design System: power management support, architectural trade offs for power, choosing the supply voltage, low-power clocking, implementation problem for low power, comparison of microprocessors for power & performance.

**References:**

- P. Rashinkar, Paterson and L. Singh, “Low Power Design Methodologies”, Kluwer Academic, 2002
- Kaushik Roy, Sharat Prasad, “Low power CMOS VLSI circuit design”, John Wiley sons Inc.,2000.
- J.B.Kulo and J.H Lou, “Low voltage CMOS VLSI Circuits”, Wiley, 1999.
- A.P.Chandrasekaran and R.W.Broadersen, “Low power digital CMOS design”, Kluwer,1995
- Gary Yeap, “Practical low power digital VLSI design”, Kluwer, 1998.

**Elective IV Communication Busses and Interfaces**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course, students will be able to:

- Select a particular serial bus suitable for a particular application.
- Develop APIs for configuration, reading and writing data onto serial bus.
- Design and develop peripherals that can be interfaced to desired serial bus.

**Syllabus Contents:**

**Unit 1:**Serial Busses

– Physical interface, Data and Control signals, features,

**Unit 2:** limitations and applications of RS232, RS485, I<sup>2</sup>C, SPI

**Unit 3:** CAN - Architecture, Data transmission, Layers, Frame formats, applications

**Unit 4:**PCIe - Revisions, Configuration space, Hardware protocols, applications

**Unit 5:**USB - Transfer types, enumeration, Descriptor types and contents, Device driver

**Unit 6:**Data Streaming Serial Communication Protocol

– Serial Front Panel Data Port (SFPDP) using fibre optic and copper cable

**References:**

- Jan Axelson, “Serial Port Complete - COM Ports, USB Virtual Com Ports, and Ports for Embedded Systems ”, Lakeview Research, 2<sup>nd</sup> Edition
- Jan Axelson, “USB Complete”, Penram Publications
- Mike Jackson, Ravi Budruk, “PCI Express Technology”, Mindshare Press
- Wilfried Voss, “A Comprehensible Guide to Controller Area Network”, Copperhill Media Corporation, 2<sup>nd</sup> Edition, 2005.
- Serial Front Panel Draft Standard VITA 17.1 – 200x
- Technical references on [www.can-cia.org](http://www.can-cia.org), [www.pcisig.com](http://www.pcisig.com), [www.usb.org](http://www.usb.org)

| <b>Elective IV Network Security and Cryptography</b>  |  |
|---|--|
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of the course, students will be able to: <ul style="list-style-type: none"> <li>• Identify and utilize different forms of cryptography techniques.</li> <li>• Incorporate authentication and security in the network applications.</li> <li>• Distinguish among different types of threats to the system and handle the same.</li> </ul>  |  |
| <b>Syllabus Contents:</b>   |  |
| <b>Unit 1: Security</b><br>- Need, security services, Attacks, OSI Security Architecture, one time passwords, Model for Network security, Classical Encryption Techniques like substitution ciphers, Transposition ciphers, Cryptanalysis of Classical Encryption Techniques.   |  |
| <b>Unit 2: Number Theory</b><br>- Introduction, Fermat's and Euler's Theorem, The Chinese Remainder Theorem, Euclidean Algorithm, Extended Euclidean Algorithm, and Modular Arithmetic.   |  |
| <b>Unit 3: Private-Key (Symmetric) Cryptography</b><br>- Block Ciphers, Stream Ciphers, RC4 Stream cipher, Data Encryption Standard (DES), Advanced Encryption Standard (AES), Triple DES, RC5, IDEA, Linear and Differential Cryptanalysis.  |  |
| <b>Unit 4: Public-Key (Asymmetric) Cryptography</b><br>- RSA, Key Distribution and Management, Diffie-Hellman Key Exchange, Elliptic Curve Cryptography, Message Authentication Code, hash functions, message digest algorithms: MD4 MD5, Secure Hash algorithm, RIPEMD-160, HMAC.  |  |
| <b>Unit 5: Authentication</b><br>- IP and Web Security Digital Signatures, Digital Signature Standards, Authentication Protocols, Kerberos, IP security Architecture, Encapsulating Security Payload, Key Management, Web Security Considerations, Secure Socket Layer and Transport Layer Security, Secure Electronic Transaction.   |  |
| <b>Unit 6: System Security</b><br>- Intruders, Intrusion Detection, Password Management, Worms, viruses, Trojans, Virus Countermeasures, Firewalls, Firewall Design Principles, Trusted Systems.  |  |
| <b>References:</b> <ul style="list-style-type: none"> <li>• William Stallings, "Cryptography and Network Security, Principles and Practices", Pearson Education, 3<sup>rd</sup> Edition.</li> <li>• Charlie Kaufman, Radia Perlman and Mike Speciner, "Network Security, Private Communication in a Public World", Prentice Hall, 2<sup>nd</sup> Edition</li> <li>• Christopher M. King, Ertem Osmanoglu, Curtis Dalton, "Security Architecture, Design Deployment and Operations", RSA Pres,</li> <li>• Stephen Northcutt, Leny Zeltser, Scott Winters, Karen Kent, and Ronald W. Ritchey, "Inside Network Perimeter Security", Pearson Education, 2<sup>nd</sup> Edition</li> <li>• Richard Bejtlich, "The Practice of Network Security Monitoring: Understanding Incident</li> </ul> |  |

|   |  |
|---|--|
| Detection and Response”, William Pollock Publisher, 2013.   |  |
| <b>Elective IV Physical Design Automation</b>   |  |
| <b>Teaching Scheme</b><br>Lectures: 3 hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of the course, students will be able to: <ul style="list-style-type: none"> <li>• Study automation process for VLSI System design.</li> <li>• Understanding of fundamentals for various physical design CAD tools.</li> <li>• Develop and enhance the existing algorithms and computational techniques for physical design process of VLSI systems.</li> </ul>  |  |
| <b>Syllabus Contents:</b><br><b>Unit 1:</b> Introduction to VLSI Physical Design Automation.<br><b>Unit 2:</b> Standard cell, Performance issues in circuit layout, delay models Layout styles.<br><b>Unit 3:</b> Discrete methods in global placement.<br><b>Unit 4:</b> Timing-driven placement. Global Routing Via Minimization.<br><b>Unit 5:</b> Over the Cell Routing - Single layer and two-layer routing, Clock and Power Routing.<br><b>Unit 6:</b> Compaction, algorithms, Physical Design Automation of FPGAs..  |  |
| <b>References:</b> <ul style="list-style-type: none"> <li>• William Stallings, “Cryptography and Network Security, Principles and Practices”, Pearson Education, 3<sup>rd</sup> Edition.</li> <li>• Charlie Kaufman, Radia Perlman and Mike Speciner, “Network Security, Private Communication in a Public World”, Prentice Hall, 2<sup>nd</sup> Edition</li> <li>• Christopher M. King, ErtemOsmanoglu, Curtis Dalton, “Security Architecture, Design Deployment and Operations”, RSA Pres,</li> <li>• Stephen Northcutt, LenyZeltser, Scott Winters, Karen Kent, and Ronald W. Ritchey, “Inside Network Perimeter Security”, Pearson Education, 2<sup>nd</sup> Edition</li> <li>• Richard Bejtlich, “The Practice of Network Security Monitoring: Understanding Incident Detection and Response”, William Pollock Publisher, 2013.</li> </ul> |  |

|  |  |
|--|--|
| <b>Analog and Digital CMOS VLSI Design Lab</b>   |  |
| <b>Teaching Scheme</b><br>Lab work : 4 hrs/week  |  |
| <b>Course Outcomes:</b><br>At the end of the laboratory work, students will be able to: <ul style="list-style-type: none"> <li>• Design digital and analog Circuit using CMOS.</li> <li>• Use EDA tools like Cadence, Mentor Graphics and other open source software tools like</li> </ul> |  |

## Ngspice

**List of Experiments:**

- 1) Use VDD=1.8V for 0.18um CMOS process, VDD=1.3V for 0.13um CMOS Process and VDD=1V for 0.09um CMOS Process.
  - a) Plot ID vs. VGS at different drain voltages for NMOS, PMOS.
  - b) Plot ID vs. VGS at particular drain voltage (low) for NMOS, PMOS and determine Vt.
  - c) Plot log ID vs. VGS at particular gate voltage (high) for NMOS, PMOS and determine IOFF and sub-threshold slope.
  - d) Plot ID vs. VDS at different gate voltages for NMOS, PMOS and determine Channel length modulation factor.
  - e) Extract Vth of NMOS/PMOS transistors (short channel and long channel). Use VDS = 30mV  
To extract Vth use the following procedure.
    - i. Plot gm vs VGS using NGSPICE and obtain peak gm point.
    - ii. Plot  $y=ID/(gm)^{1/2}$  as a function of VGS using Ngspice.
    - iii. Use Ngspice to plot tangent line passing through peak gm point in y (VGS) plane and determine Vth.
  - f) Plot ID vs. VDS at different drain voltages for NMOS, PMOS, plot DC load line and calculate gm, gds, gm/gds, and unity gain frequency.

Tabulate your result according to technologies and comment on it.
- 2) Use VDD=1.8V for 0.18um CMOS process, VDD=1.2V for 0.13um CMOS Process and VDD=1V for 0.09um CMOS Process.
  - a) Perform the following
    - i. Plot VTC curve for CMOS inverter and thereon plot dVout vs. dVin and determine transition voltage and gain g. Calculate VIL, VIH, NMH, NML for the inverter.
    - ii. Plot VTC for CMOS inverter with varying VDD.
    - iii. Plot VTC for CMOS inverter with varying device ratio.
  - b) Perform transient analysis of CMOS inverter with no load and with load and determine tpHL, tpLH, 20%-to-80% tr and 80%-to-20% tf. (use VPULSE = 2V, Cload = 50fF)
  - c) Perform AC analysis of CMOS inverter with fanout 0 and fanout 1. (Use Cin= 0.012pF, Cload = 4pF, Rload = k)
- 3) Use Ngspice to build a three stage and five stage ring oscillator circuit in 0.18um and 0.13um technology and compare its frequencies and time period.
- 4) Perform the following
  - a) Draw small signal voltage gain of the minimum-size inverter in 0.18um and 0.13um technology as a function of input DC voltage. Determine the small signal voltage gain at the switching point using Ngspice and compare the values for 0.18um and 0.13um process.
  - b) Consider a simple CS amplifier with active load, as explained in the lecture, with NMOS transistor MN as driver and PMOS transistor MP as load, in 0.18um technology. (W/L)MN=5, (W/L)MP=10 and L=0.5um for both transistors.
    - i. Establish a test bench, as explained in the lecture, to achieve VDSQ=VDD/2.
    - ii. Calculate input bias voltage if bias current=50uA.

- iii. Use Ngspice and obtain the bias current. Compare its value with 50uA.
- iv. Determine small signal voltage gain, -3dB BW and GBW of the amplifier using small signal analysis in Ngspice (consider 30fF load capacitance).
- v. Plot step response of the amplifier for input pulse amplitude of 0.1V. Derive time constant of the output and compare it with the time constant resulted from -3dB BW
- vi. Use Ngspice to determine input voltage range of the amplifier

5) Three OPAMP INA. Vdd=1.8V Vss=0V, CAD tool: Mentor Graphics DA. Note: Use proper values of resistors to get a three OPAMP INA with differential-mode voltage gain=10. Consider voltage gain=2 for the first stage and voltage gain=5 for the second stage.

- i. Draw the schematic of op-amp macro model.
- ii. Draw the schematic of INA.
- iii. Obtain parameters of the op-amp macro model such that
  - a. low-frequency voltage gain =  $5 \times 10^4$ ,
  - b. unity gain BW ( $f_u$ ) = 500KHz,
  - c. input capacitance=0.2pF,
  - d. output resistance =  $\infty$ ,
  - e. CMRR=120dB
- iv. Draw schematic diagram of CMRR simulation setup.
- v. Simulate CMRR of INA using AC analysis (it's expected to be around 6dB below CMRR of OPAMP).
- vi. Plot CMRR of the INA versus resistor mismatches (for resistors of second stage only) changing from -5% to +5% (use AC analysis). Generate a separate plot for mismatch in each resistor pair. Explain how CMRR of OPAMP changes with resistor mismatches.
- vii. Repeat (iii) to (vi) by considering CMRR of all OPAMPs to be 90dB.

6) Technology: UMC 0.18um, VDD=1.8V. Use MAGIC or Microwind.

- a) Draw layout of a minimum size inverter in UMC 0.18um technology using MAGIC Station layout editor. Use that inverter as a cell and lay out three cascaded minimum-sized inverters. Use M1 as interconnect line between inverters.
- b) Run DRC, LVS and RC extraction. Make sure there is no DRC error. Extract the netlist.
- c) Use extracted netlist and obtain tPHLtPLH for the middle inverter using Eldo.
- d) Use interconnect length obtained and connect the second and third inverter. Extract the new netlist and obtain tPHL and tPLH of the middle inverter. Compare new values of delay times with corresponding values obtained in part 'c'.

**VLSI Design Verification and Testing Lab**

**Teaching Scheme**

Lectures: 4 hrs/week

**Course Outcomes:**

At the end of the laboratory work, students will be able to:

- Verify increasingly complex designs more efficiently and effectively.

- Use EDA tools like Cadence, Mentor Graphics.

**List of Assignments:**

1. Sparse memory
2. Semaphore
3. Mail box
4. Classes
5. Polymorphism
6. Coverage
7. Assertions

**Semester III**

**Elective V Communication Networks**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

At the end of the course, students will be able to:

- Analyze protocols and algorithms, acknowledge tradeoffs and rationale
- Use routing, transport protocols for the given networking scenario and application
- Evaluate and develop small network applications

**Syllabus Contents:**

**Unit 1:**Introduction:

- Network Architecture, Performance

**Unit 2:**Connecting nodes:

- Connecting links, Encoding, framing, Reliable transmission, Ethernet and Multiple access networks, Wireless networks

**Unit 3:**Queuing models

- For a) one or more servers b) with infinite and finite queue size c) Infinite population

Internetworking:

- Switching and bridging, IPv4, Addressing, Routing Protocols, Scale issues, Routers - Architecture, IPv6

**Unit 4:**End-to-End Protocols:

- Services, Multiplexing, De-multiplexing, UDP, TCP, RPC, RTP

**Unit 5:**Congestion control and Resource Allocation

- Issues, Queuing disciplines, TCP congestion control, Congestion Avoidance, QoS Applications:

- Domain Name Resolution, File Transfer, Electronic Mail, WWW, Multimedia Applications

**Unit 6:**Network monitoring – Packet sniffing tools such as Wireshark

Simulations using NS2/OPNET

**References:**

- Larry L. Peterson, Bruce S, Devie, “Computer Networks” , MK, 5<sup>th</sup> Edition

- Aaron Kershenbaum, “Telecommunication Network Design Algorithms”, MGH, International Edition 1993.
- Vijay Ahuja, “Communications Network Design and Analysis of Computer Communication Networks”, MGH, International Editions.
- Douglas E. Comer, “Internetworking with TCP/IP”, Pearson Education, 6<sup>th</sup> Edition

### Elective IV Selected Topics in Mathematics

#### Teaching Scheme

Lectures: 3 hrs/week

#### Course Outcomes:

At the end of the course, students will be able to:

- Characterize and represent data collected from experiments using statistical methods.
- Model physical process/systems with multiple variables towards parameter estimation and prediction
- Represent systems/architectures using graphs and trees towards optimizing desired objective.

#### Syllabus Contents:

##### Unit 1: Probability and Statistics:

- Definitions, conditional probability, Bayes Theorem and independence.
- Random Variables: Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, moment generating function, Chebyshev inequality.

##### Unit 2: Special Distributions: Discrete uniform, Binomial, Geometric, Poisson, Exponential, Gamma, Normal distributions.

- Pseudo random sequence generation with given distribution, Functions of a Random Variable

##### Unit 3: Joint Distributions: Joint, marginal and conditional distributions, product moments, correlation, independence of random variables, bi-variate normal distribution.

- Stochastic Processes: Definition and classification of stochastic processes, Poisson process
- Norms, Statistical methods for ranking data

##### Unit 4: Multivariate Data Analysis

- Linear and non-linear models, Regression, Prediction and Estimation
- Design of Experiments – factorial method
- Response surface method

##### Unit 5: Graphs and Trees:

- Graphs: Basic terminology, multi graphs and weighted graphs, paths and circuits, shortest path Problems, Euler and Hamiltonian paths and circuits, factors of a graph, planar graph and Kuratowski’s graph and theorem, independent sets, graph colouring

##### Unit 6: Trees: Rooted trees, path length in rooted trees, binary search trees, spanning trees and cut set, theorems on spanning trees, cut sets, circuits, minimal spanning trees, Kruskal’s and Prim’s



algorithms for minimal spanning tree

**References:**

- Henry Stark, John W. Woods, “Probability and Random Process with Applications to Signal Processing”, Pearson Education, 3<sup>rd</sup> Edition
- C. L. Liu, “Elements of Discrete Mathematics”, Tata McGraw-Hill, 2<sup>nd</sup> Edition
- Douglas C. Montgomery, E.A. Peck and G. G. Vining, “Introduction to Linear Regression Analysis”, John Wiley and Sons, 2001.
- Douglas C. Montgomery, “Design and Analysis of Experiments”, John Wiley and Sons, 2001.
- B. A. Ogunnaike, “Random Phenomena: Fundamentals of Probability and Statistics for Engineers”, CRC Press, 2010.

**Elective IV Nanomaterials and Nanotechnology**

**Teaching Scheme**

Lectures: 3 hrs/week

**Course Outcomes:**

- At the end of the course, students will be able to:
  - CO1: To understand the basic science behind the design and fabrication of nano scale systems.
  - CO2: To understand and formulate new engineering solutions for current problems and competing technologies for future applications.
  - CO3: To be able make inter disciplinary projects applicable to wide areas by clearing and fixing the boundaries in system development.
  - CO4: To gather detailed knowledge of the operation of fabrication and characterisation devices to achieve precisely designed systems.

**Syllabus Contents:**

**Unit 1:** Nanomaterials in one and higher dimensions,

**Unit 2:** Applications of one and higher dimension nano-materials.

**Unit 3:** Nano-lithography, micro electro-mechanical system (MEMS) and nano-phonics.

**Unit 4:** carbon nanotubes – synthesis and applications

**Unit 5 and 6:** Interdisciplinary arena of nanotechnology.

**References:**

- Nanoscale Materials in Chemistry edited by Kenneth J. Klabunde and Ryan M. Richards, 2<sup>nd</sup>edn, John Wiley and Sons, 2009.
- Nanocrystalline Materials by A I Gusev and A A Rempel, Cambridge International Science Publishing, 1st Indian edition by Viva Books Pvt. Ltd. 2008.
- Springer Handbook of Nanotechnology by Bharat Bhushan, Springer, 3<sup>rd</sup>edn, 2010.
- Carbon Nanotubes: Synthesis, Characterization and Applications by Kamal K. Kar, Research Publishing Services; 1<sup>st</sup>edn, 2011, ISBN-13: 978-9810863975..

| <b>(Dissertation) Dissertation Phase – I and Phase - II</b>   |  |
|---|--|
| <b>Teaching Scheme</b>  |  |
| Lab work : 20 and 32 hrs/week   |  |
| <b>Course Outcomes:</b>   |  |
| <p>At the end of this course, students will be able to</p> <ul style="list-style-type: none"> <li>• Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.</li> <li>• Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.</li> <li>• Ability to present the findings of their technical solution in a written report.</li> <li>• Presenting the work in International/ National conference or reputed journals.</li> </ul>  |  |
| <b>Syllabus Contents:</b>   |  |
| <p>The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following</p> <ul style="list-style-type: none"> <li>• Relevance to social needs of society</li> <li>• Relevance to value addition to existing facilities in the institute</li> <li>• Relevance to industry need</li> <li>• Problems of national importance</li> <li>• Research and development in various domain</li> </ul> <p>The student should complete the following:</p> <ul style="list-style-type: none"> <li>• Literature survey Problem Definition</li> <li>• Motivation for study and Objectives</li> <li>• Preliminary design / feasibility / modular approaches</li> <li>• Implementation and Verification</li> <li>• Report and presentation</li> </ul> <p>The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:</p> <ul style="list-style-type: none"> <li>• Experimental verification / Proof of concept.</li> <li>• Design, fabrication, testing of Communication System.</li> <li>• The viva-voce examination will be based on the above report and work.</li> </ul> |  |
| <b>Guidelines for Dissertation Phase – I and II at M. Tech. (Electronics):</b>  |  |
| <ul style="list-style-type: none"> <li>• As per the AICTE directives, the dissertation is a year long activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.</li> <li>• The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T &amp; P coordinator.</li> <li>• After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.</li> </ul>   |  |

- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work

**OPEN ELECTIVES**  
**Business Analytics**

**Teaching scheme**  
**Lecture: - 3 h/week**

|                      |                           |
|----------------------|---------------------------|
| <b>Course Code</b>   |                           |
| <b>Course Name</b>   | <b>Business Analytics</b> |
| <b>Credits</b>       |                           |
| <b>Prerequisites</b> |                           |

Total Number of Lectures: 48

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|--|
| <b>Course objective</b>  |
| <ol style="list-style-type: none"> <li>1. Understand the role of business analytics within an organization.</li> <li>2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.</li> <li>3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.</li> <li>4. To become familiar with processes needed to develop, report, and analyze business data.</li> <li>5. Use decision-making tools/Operations research techniques.</li> <li>6. Mange business process using analytical and management tools.</li> <li>7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.</li> </ol> |

| LECTURE WITH BREAKUP   | NO. OF LECTURES |
|--|-----------------|
| <p><b>Unit1:</b><br/>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.<br/>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p>  | 9               |
| <p><b>Unit 2:</b><br/>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.<br/>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.</p>   | 8               |
| <p><b>Unit 3:</b><br/>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.<br/>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.</p>   | 9               |
| <p><b>Unit 4:</b><br/>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.<br/>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.</p> | 10              |
| <p><b>Unit 5:</b><br/>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.</p>   | 8               |
| <p><b>Unit 6:</b><br/>Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.</p>  | 4               |

| COURSE OUTCOMES   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. Students will demonstrate knowledge of data analytics.</li> <li>2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.</li> <li>3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.</li> </ol> |  |

4. Students will demonstrate the ability to translate data into clear, actionable insights.

**Reference:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

**OPEN ELECTIVES**  
**Industrial Safety**

**Teaching scheme**

**Lecture: - 3 h/week**

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**Reference:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.

4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

## **OPEN ELECTIVES**

### **Operations Research**

#### **Teaching Scheme**

Lectures: 3 hrs/week

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**Course Outcomes:** At the end of the course, the student should be able to

1. Students should be able to apply the dynamic programming to solve problems of discrete and continuous variables.
2. Students should be able to apply the concept of non-linear programming
3. Students should be able to carry out sensitivity analysis
4. Student should be able to model the real world problem and simulate it.

#### **Syllabus Contents:**

##### **Unit 1:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

##### **Unit 2**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

##### **Unit 3:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

##### **Unit 4**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

##### **Unit 5**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

#### **References:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

**Open Elective**  
**Cost Management of Engineering Projects**

**Teaching scheme**

**Lecture: - 3 h/week**

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Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**References:**

2. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
3. Charles T. Horngren and George Foster, Advanced Management Accounting
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
5. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

**Open Elective**  
**Composite Materials**

**Teaching scheme**

**Lecture: - 3 h/week**

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**UNIT-I: INTRODUCTION:** Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT – II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT – III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT–IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT – V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

#### **TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

#### **References:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

### **Open Elective Waste to Energy**

#### **Teaching scheme**

**Lecture: - 3 h/week**

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**Unit-I:** Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**Unit-III:** Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit-IV:** Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**Unit-V:** Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

#### **References:**

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.



2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

**AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING**

|  |  |              |
|--|--|--------------|
| <b>Course objectives:</b>  |  |              |
| Students will be able to:  |  |              |
| <ol style="list-style-type: none"> <li>1. Understand that how to improve your writing skills and level of readability</li> <li>2. Learn about what to write in each section</li> <li>3. Understand the skills needed when writing a Title</li> </ol> |  |              |
| Ensure the good quality of paper at very first-time submission   |  |              |
| <b>Syllabus</b>  |  |              |
| <b>Units</b>   | <b>CONTENTS</b>  | <b>Hours</b> |
| 1  | Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                        | 4            |
| 2  | Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction  | 4            |
| 3  | Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.  | 4            |
| 4  | key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, | 4            |
| 5  | skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                      | 4            |
| 6  | useful phrases, how to ensure paper is as good as it could possibly be the first- time submission  | 4            |

**Suggested Studies:**

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman’s book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

**AUDIT 1 and 2: DISASTER MANAGEMENT**

|  |
|--|
| <b>Course Objectives:</b> -Students will be able to:   |
| <ol style="list-style-type: none"> <li>1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.</li> <li>2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.</li> </ol> |

| <p>3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.</p> <p>4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in</p> |  |              |
|---|--|--------------|
| <b>Syllabus</b>   |  |              |
| <b>Units</b>  | <b>CONTENTS</b>  | <b>Hours</b> |
| 1   | <p><b>Introduction</b><br/>                     Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.</p>  | 4            |
| 2   | <p><b>Repercussions Of Disasters And Hazards:</b> Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.<br/>                     Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.</p> | 4            |
| 3   | <p><b>Disaster Prone Areas In India</b><br/>                     Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics</p>  | 4            |
| 4   | <p><b>Disaster Preparedness And Management</b><br/>                     Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.</p>   | 4            |
| 5   | <p><b>Risk Assessment</b><br/>                     Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.</p>   | 4            |
| 6   | <p><b>Disaster Mitigation</b><br/>                     Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.</p>   | 4            |

**SUGGESTED READINGS:**

1. R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies” ,Deep &Deep Publication Pvt. Ltd., New Delhi.

## AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

### Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

### Syllabus

| Unit | Content   | Hours |
|------|---|-------|
| 1    | <ul style="list-style-type: none"> <li>• Alphabets in Sanskrit,</li> <li>• Past/Present/Future Tense,</li> <li>• Simple Sentences</li> </ul>          | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Order</li> <li>• Introduction of roots</li> <li>• Technical information about Sanskrit Literature</li> </ul> | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics</li> </ul>               | 8     |

### Suggested reading

1. “Abhyastakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

### Course Output

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

## AUDIT 1 and 2: VALUE EDUCATION

### Course Objectives

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

**Syllabus**

| <b>Unit</b> | <b>Content</b>   | <b>Hours</b> |
|-------------|--|--------------|
| 1           | <ul style="list-style-type: none"> <li>• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.</li> <li>• Moral and non- moral valuation. Standards and principles.</li> <li>• Value judgements</li> </ul>  | 4            |
| 2           | <ul style="list-style-type: none"> <li>• Importance of cultivation of values.</li> <li>• Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.</li> <li>• Honesty, Humanity. Power of faith, National Unity.</li> <li>• Patriotism.Love for nature ,Discipline</li> </ul>  | 6            |
| 3           | <ul style="list-style-type: none"> <li>• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline.</li> <li>• Punctuality, Love and Kindness.</li> <li>• Avoid fault Thinking.</li> <li>• Free from anger, Dignity of labour.</li> <li>• Universal brotherhood and religious tolerance.</li> <li>• True friendship.</li> <li>• Happiness Vs suffering, love for truth.</li> <li>• Aware of self-destructive habits.</li> <li>• Association and Cooperation.</li> <li>• Doing best for saving nature</li> </ul> | 6            |
| 4           | <ul style="list-style-type: none"> <li>• Character and Competence –Holy books vs Blind faith.</li> <li>• Self-management and Good health.</li> <li>• Science of reincarnation.</li> <li>• Equality, Nonviolence ,Humility, Role of Women.</li> <li>• All religions and same message.</li> <li>• Mind your Mind, Self-control.</li> <li>• Honesty, Studying effectively</li> </ul>  | 6            |

**Suggested reading**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

**Course outcomes**

Students will be able to

- 1.Knowledge of self-development
- 2.Learn the importance of Human values
- 3.Developing the overall personality

**AUDIT 1 and 2: CONSTITUTION OF INDIA**

| <b>Course Objectives:</b>   |  |       |
|---|--|-------|
| Students will be able to:   |  |       |
| <ol style="list-style-type: none"> <li>1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</li> <li>3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ol> |  |       |
| <b>Syllabus</b>   |  |       |
| Units   | Content  | Hours |
| 1   | <ul style="list-style-type: none"> <li>• <b>History of Making of the Indian Constitution:</b></li> <li>History</li> <li>Drafting Committee, ( Composition &amp; Working)</li> </ul>  | 4     |
| 2   | <ul style="list-style-type: none"> <li>• <b>Philosophy of the Indian Constitution:</b></li> <li>Preamble</li> <li>Salient Features</li> </ul>  | 4     |
| 3   | <ul style="list-style-type: none"> <li>• <b>Contours of Constitutional Rights &amp; Duties:</b></li> <li>• Fundamental Rights</li> <li>• Right to Equality</li> <li>• Right to Freedom</li> <li>• Right against Exploitation</li> <li>• Right to Freedom of Religion</li> <li>• Cultural and Educational Rights</li> <li>• Right to Constitutional Remedies</li> <li>• Directive Principles of State Policy</li> <li>• Fundamental Duties.</li> </ul>  | 4     |
| 4   | <ul style="list-style-type: none"> <li>• <b>Organs of Governance:</b></li> <li>• Parliament</li> <li>• Composition</li> <li>• Qualifications and Disqualifications</li> <li>• Powers and Functions                             <ul style="list-style-type: none"> <li>• Executive</li> </ul> </li> <li>• President</li> <li>• Governor</li> <li>• Council of Ministers</li> <li>• Judiciary, Appointment and Transfer of Judges, Qualifications</li> <li>• Powers and Functions</li> </ul>   | 4     |
| 5   | <ul style="list-style-type: none"> <li>• <b>Local Administration:</b></li> <li>• District's Administration head: Role and Importance,</li> <li>• Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.</li> <li>• Pachayati raj: Introduction, PRI: Zila Pachayat.</li> <li>• Elected officials and their roles, CEO Zila Pachayat: Position and role.</li> <li>• Block level: Organizational Hierarchy (Different departments),</li> <li>• Village level: Role of Elected and Appointed officials,</li> <li>• Importance of grass root democracy</li> </ul> | 4     |
| 6   | <ul style="list-style-type: none"> <li>• <b>Election Commission:</b></li> <li>• Election Commission: Role and Functioning.</li> <li>• Chief Election Commissioner and Election Commissioners.</li> <li>• State Election Commission: Role and Functioning.</li> <li>• Institute and Bodies for the welfare of SC/ST/OBC and women.</li> </ul>   | 4     |

### Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

### Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

### AUDIT 1 and 2: PEDAGOGY STUDIES

| <b>Course Objectives:</b><br>Students will be able to:   |   |              |
|--|---|--------------|
| <ol style="list-style-type: none"> <li>4. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.</li> <li>5. Identify critical evidence gaps to guide the development.</li> </ol> |   |              |
| <b>Syllabus</b>  |   |              |
| <b>Units</b>   | <b>Content</b>  | <b>Hours</b> |
| <b>1</b>   | <ul style="list-style-type: none"> <li>• <b>Introduction and Methodology:</b></li> <li>• Aims and rationale, Policy background, Conceptual framework and terminology</li> <li>• Theories of learning, Curriculum, Teacher education.</li> <li>• Conceptual framework, Research questions.</li> <li>• Overview of methodology and Searching.</li> </ul>  | 4            |
| <b>2</b>   | <ul style="list-style-type: none"> <li>• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.</li> <li>• Curriculum, Teacher education.</li> </ul>  | 2            |
| <b>3</b>   | <ul style="list-style-type: none"> <li>• Evidence on the effectiveness of pedagogical practices</li> <li>• Methodology for the in depth stage: quality assessment of included studies.</li> <li>• How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?</li> <li>• Theory of change.</li> <li>• Strength and nature of the body of evidence for effective pedagogical practices.</li> <li>• Pedagogic theory and pedagogical approaches.</li> <li>• Teachers' attitudes and beliefs and Pedagogic strategies.</li> </ul> | 4            |
| <b>4</b>   | <ul style="list-style-type: none"> <li>• Professional development: alignment with classroom practices and follow-up support</li> <li>• Peer support</li> </ul>  | 4            |

|          |   |   |
|----------|---|---|
|          | <ul style="list-style-type: none"> <li>• Support from the head teacher and the community.</li> <li>• Curriculum and assessment</li> <li>• Barriers to learning: limited resources and large class sizes</li> </ul>  |   |
| <b>5</b> | <ul style="list-style-type: none"> <li>• <b>Research gaps and future directions</b></li> <li>• Research design</li> <li>• Contexts</li> <li>• Pedagogy</li> <li>• Teacher education</li> <li>• Curriculum and assessment</li> <li>• Dissemination and research impact.</li> </ul> | 2 |

### Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal Educational Development*, 33 (3): 272-282.
5. Alexander RJ (2001) *Culture and pedagogy: International comparisons in primary education*. Oxford and Boston: Blackwell.
6. Chavan M (2003) *Read India: A mass scale, rapid, 'learning to read' campaign*.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf).

### Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?
- 4.

### AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

#### Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

#### Syllabus

| Unit | Content  | Hours |
|------|--|-------|
| 1    | <ul style="list-style-type: none"> <li>• Definitions of Eight parts of yog. ( Ashtanga )</li> </ul>  | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Yam and Niyam.</li> </ul> Do`s and Don`t`s in life.<br>i) Ahinsa, satya, astheya, bramhacharya and aparigraha | 8     |

|   |   |   |
|---|---|---|
|   | ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan   |   |
| 3 | <ul style="list-style-type: none"> <li>• Asan and Pranayam</li> </ul> i) Various yog poses and their benefits for mind & body<br>ii) Regularization of breathing techniques and its effects-Types of pranayam | 8 |

**Suggested reading**

1. ‘Yogic Asanas for Group Training-Part-I’ : Janardan Swami Yogabhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**Course Outcomes:**

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

**AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**

**Course Objectives**

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

**Syllabus**

| Unit | Content  | Hours |
|------|--|-------|
| 1    | Neetisatakam-Holistic development of personality <ul style="list-style-type: none"> <li>• Verses- 19,20,21,22 (wisdom)</li> <li>• Verses- 29,31,32 (pride &amp; heroism)</li> <li>• Verses- 26,28,63,65 (virtue)</li> <li>• Verses- 52,53,59 (dont’s)</li> <li>• Verses- 71,73,75,78 (do’s)</li> </ul>   | 8     |
| 2    | <ul style="list-style-type: none"> <li>• Approach to day to day work and duties.</li> <li>• Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,</li> <li>• Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,</li> <li>• Chapter 18-Verses 45, 46, 48.</li> </ul>  | 8     |
| 3    | <ul style="list-style-type: none"> <li>• Statements of basic knowledge.</li> <li>• Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68</li> <li>• Chapter 12 -Verses 13, 14, 15, 16,17, 18</li> <li>• Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,</li> <li>• Chapter 4-Verses 18, 38,39</li> <li>• Chapter18 – Verses 37,38,63</li> </ul> | 8     |



***Suggested reading***

1. “Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

***Course Outcomes***

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.



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