Model Curriculum for UG Degree Course in

Computer Science and Engineering

Artificial Intelligence & Data Science (AI&DS)

2021

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org

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MESSAGE

The quality of technical education depends on many factors but largely on-outcome based socially and industrially relevant curriculum, good quality motivated faculty, teaching learning process, effective industry internship and evaluation of students based on desired outcomes. Therefore, it was imperative that a Model Curriculum be prepared by best experts from academia and industry, keeping in view the latest industry trends and market requirements and be made available to all universities / board of technical education and engineering institutions in the country. AICTE constituted team of experts to prepare the Model Curriculum of UG Degree Course in Computer Science and Engineering (Artificial Intelligence and Data Science (AI&DS)). Similar exercise is done for other UG, Diploma and PG level in engineering, MBA, PGDM, Architecture, etc.

It comprises of basic science and engineering courses, having focus on fundamentals, significant discipline level courses and ample electives both from the disciplines and cross disciplines including emerging areas all within a cumulative structure of 163 credits. Summer Internships have been embedded to make the student understand the industry requirements and have hands on experience. Virtual Labs has been introduced for few experiments. Also, most courses have been mapped to its equivalent SWAYAM/NPTEL Course to offer an alternative for learning that course online from SWAYAM. These features will allow students to develop a problem-solving approach to face the challenges in the future and develop outcome based learning approach.

As a major initiative by AICTE, a three-week mandatory induction program for students has also been designed and has to be given at the beginning of the course. The idea behind this is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.

AICTE places on record, special thanks to Prof. Rajat Moona, Prof. Uday B. Desai. We are sure that this Model Curriculum will help to enhance not just the employability skills but will also enable youngsters to become job creators.

We strongly urge the institutions / universities / boards of technical education in India to adopt this Model Curriculum at the earliest. This is a suggestive curriculum and the concerned university / institution / board should build on and exercise flexibility in readjustment of courses within the overall 163 credits.

(Prof. Anil D. Sahasrabudhe)
Chairman
All India Council for Technical Education

PREFACE

Taking cognizance of growing concern about quality of technical education in India, AICTE in its 49th council meeting held on 14.03.2017 approved a package of measures for improving quality of technical education - Revision of Curriculum, Mandatory Internship, and Student Induction Program were amongst the few.

AICTE constituted committee of academia industry experts to prepare model curriculum of UG Course in Computer Science and Engineering Artificial Intelligence and Data Science (AI&DS). During the development of curriculum, the employability and employment opportunities for graduates, future ready workforce who will be skilled enough to handle the rapid growth in the field of Computer Science and Engineering Artificial Intelligence and Data Science (AI&DS) were kept in mind.

AICTE has introduced mandatory internship in the new curriculum which will equip the students with practical understanding and training about industry practices in a suitable industry or organization. In the course of development of model curriculum, the committee took feedback of industry experts on the draft curriculum and accordingly modified the draft before finalization. This exercise has ensured that essential emphasis on industry requirements and market trends, employability and problem solving approach is given.

After due deliberations, the scheme and syllabus have been formulated. Salient features of this model curriculum are enumerated as under:

- Reduced number of credits.
- Introduction of Student Induction Program.
- Well defined learning objectives & outcomes for each course.
- Inclusion of courses on socially relevant topics.
- Built-in flexibility to the students in terms of professional elective and open elective courses.
- Mandatory internship to equip the students with practical knowledge and provide them exposure to real time industrial environments.
- Virtual Labs.
- Mapping of Courses to its equivalent NPTEL/SWAYAM Course.
- Course on 'Entrepreneurship and Startups' to encourage entrepreneurial mindset.
- Introduction of Design Thinking and Universal Human Value Course.

I gratefully acknowledge the time and efforts of the members of the working group namely Prof. Rajat Moona of IIT Bihali; Prof. Uday B. Desai of IIT Hyderabad.

Special thanks to Prof. Anil D. Sahasrabudhe, Chairman; Prof. M.P. Poonia, Vice-Chairman; and Prof. Rajive Kumar, Member Secretary, AICTE who all have been instrumental and encouraging throughout the process of development of this model curriculum.

I appreciate the dedication put by the Dr. Pradeep C. Bhaskar, Assistant Director (P&AP); Mr. Rakesh Kumar Pandit Young Professional (P&AP); and other office staff of AICTE.

(Col A. Shreenath)
Director
Policy and Academic Planning Bureau
All India Council for Technical Education

Committee for Model Curriculum

S. No.	Member Name	Designation & Organization
1	Prof. Rajat Moona	Director, IIT Bhilai
2	Prof. Uday B. Desai	Director, IIT Hyderabad

Table of Contents

GENERAL COURSE STRUCTURE &THEME

GENERAL COURSE STRUCTURE & THEME

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
1 Hr. Practical (P) per week	0.5 Credit
2 Hours Practical (P) per week	1 Credit

B. Range of Credits: In the light of the fact that a typical Model Four-year Under Graduate degree program in Engineering has about 163 credits, the total number of credits proposed for the four-year B. Tech/B.E. in Computer Science and Engineering (Artificial Intelligence and Data Science (AIDS)) is kept as 163.

C. Structure of UG Program in AIDS: The structure of UG program in Artificial Intelligence and Data Science shall have essentially the following categories of courses with the breakup of credits as given:

S. No.	Category	Breakup of Credits
1.	Humanities & Social Science Courses	15
2.	Basic Science Courses	23
3.	Engineering Science Courses	22
4.	Program Core Courses (Branch specific)	54
5.	Professional Elective Courses (Branch specific)	18
6.	Open Elective Courses (Cross Discipline Subjects)	15
7.	Project work, Seminar and Internship in Industry or elsewhere	16
8.	Audit Courses [Environmental Sciences, Indian Constitution]	0
	TOTAL	**163***

**Minor variation is allowed as per need of the respective disciplines.*

D. Course code and definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
HS	Humanities & Social Science Courses
BS	Basic Science Courses
ES	Engineering Science Courses
PC	Program Core Courses
PE	Program Elective Courses
OE	Open Elective Courses
AU	Audit Courses
EEC	Employment Enhancement Courses (Project/ Summer Internship/ Seminar)

- **Course level coding scheme:** Three-digit number (odd numbers are for the odd semester courses and even numbers are for even semester courses) used as suffix with the Course Code for identifying the level of the course. Digit at hundred's place signifies the year in which course is offered. e.g.
  101, 102 … etc. for first year.
  201, 202 …. Etc. for second year.
  301, 302 … for third year.

- **Category-wise Courses**

HUMANITIES & SOCIAL SCIENCES COURSES [HS]

(i) Number of Humanities & Social Science Courses: 6
(ii) Credits: 15

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	HS102	English	2	0	2	II	3
2	HS104	Design Thinking	0	0	2	II	1
3	HSMC (H-102)	Universal Human Values-II: Understanding Harmony and Ethical Human Conduct	2	1	0	II	3
4	HS201	Effective Technical Communication	3	0	0	III	3
5	HS202	Engineering Economics	2	0	0	IV	2
6	HS301	Entrepreneurship and Start-ups	3	0	0	V	3
Total Credits							**15**

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BASIC SCIENCE COURSES [BS]

(i) Number of Basic Sciences Courses: 5
(ii) Credits: 23

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	BS101	Physics-I	3	1	3	I	5.5
2	BS103	Mathematics-I	3	1	0	I	4
3	BS102	Chemistry-I	3	1	3	II	5.5
4	BS104	Mathematics-II	3	1	0	II	4
5	BS201	Mathematics-III	3	1	0	III	4
Total Credits							**23**

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ENGINEERING SCIENCE COURSES [ES]

(i) Number of Engineering Sciences Courses: 6
(ii) Credits: 22

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	ES101	Basic Electrical Engineering	3	1	2	I	5
2	ES103	Engineering Graphics & Design	1	0	4	I	3
3	ES102	Programming for Problem Solving	3	0	4	II	5
4	ES104	Workshop/Manufacturing Practices	1	0	4	II	3
5	ES201	Applied Digital Logic Design	2	0	2	III	3
6	ES203	Introduction to Data Structures and Algorithms	2	0	2	III	3
Total Credits							**22**

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PROGRAM CORE COURSES [PC]

(i) Number of Program Core Courses: 16
(ii) Credits: 55

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	PC201	Discrete Mathematics	3	0	0	III	3
2	PC203	Digital Signal Processing	3	0	0	III	3
3	PC205	Theory of Computation	3	0	0	III	3

4	PC207	Computer Organization and Design	3	0	0	III	3
5	PC209	Lab on Software tools and Techniques	1	0	3	III	2.5
6	PC202	Introduction to Artificial Intelligence	3	0	0	IV	3
7	PC204	Statistical Analysis and Computing	3	0	2	IV	4
8	PC206	Introduction to Data Analytics and Visualization	3	0	2	IV	4
9	PC208	Machine Learning	3	0	0	IV	3
10	PC210	Architectures for Management of Large Datasets	3	0	0	IV	3
11	PC301	Programming with large datasets lab	1	0	3	V	2.5
12	PC303	Introduction to IoT and Embedded Computing	3	0	3	V	4.5
13	PC305	Applied AI	3	0	3	V	4.5
14	PC302	Data and Internet Security	3	0	0	VI	3
15	PC304	Operating Systems	3	0	2	VI	4
16	PC306	Computer Networks	3	0	2	VI	4
Total Credits							**54**

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PROFESSIONAL ELECTIVE COURSES [PE]

(i) Number of Professional Elective Courses: 6
(ii) Credits: 18

S. No.	Course Code*	Course Title	L	T	P	Semester	Credits
1	XXNNN	Professional Elective – I	3	0	0	V	3
2	XXNNN	Professional Elective - II	3	0	0	VI	3
3	XXNNN	Professional Elective – III	3	0	0	VII	3
4	XXNNN	Professional Elective - IV	3	0	0	VII	3
5	XXNNN	Professional Elective - V	3	0	0	VIII	3
6	XXNNN	Professional Elective - VI	3	0	0	VIII	3
Total Credits							**18**

*The Course codes for the elective courses shall be the course code for the elective taken by the student.

For detailed list of Professional Elective Courses and syllabus, Refer Appendix I.

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OPEN ELECTIVE COURSES [OE]

The open elective courses in the curriculum are designed for a student to widen his knowledge from other areas of engineering, science or humanities. For these course the student can take any institute wide courses being offered in programs other than Computer Science and Engineering (AI&DS). In addition, the open elective courses are to be of the level as suitable for the level of the student. For example, the OE1 is slotted in the fifth semester (i.e. third year) of the program of the student. He should be able to take any institute wide course which is slated for the third year student of the corresponding department.

(i) Number of Open Elective Courses: 5
(ii) Credits: 15

S. No.	Course Code[$]	Course Title	L	T	P	Semester	Year	Credits
1	XXNNN	Open Elective - I	3	0	0	V	3rd	3
2	XXNNN	Open Elective – II	3	0	0	VI	3rd	3
3	XXNNN	Open Elective – III	3	0	0	VII	4th	3
4	XXNNN	Open Elective – IV	3	0	0	VII	4th	3
5	XXNNN	Open Elective - V	3	0	0	VIII	4th	3
Total Credits								**15**

[$]The Course codes for the elective courses shall be the course code for the elective taken by the student.

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PROJECT WORK, SEMINAR AND INTERNSHIP IN INDUSTRY OR ELSEWHERE [EEC]

(i) Number of EEC Courses: 5
(ii) Credits: 16

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	EEC202	Independent Project	-	-	-	III	1.5
2	EEC301	Summer Internship - I	-	-	-	V	1.5
3	EEC401	Project - I	-	-	-	VII	3
4	EEC403	Summer Internship - II	-	-	-	VII	3
5	EEC402	Project - II	-	-	-	VIII	7
Total Credits							**16**

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AUDIT COURSES [AU]

Note: These are mandatory non-credit courses.

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	AU101	Sports and Yoga	3	0	0	I	0
2	AU202	Environmental Science	3	0	0	IV	0
3	AU301	Indian Constitution	3	0	0	V	0
Total Credits							**0**

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INDUCTION PROGRAM

The Essence and Details of Induction program can also be understood from the 'Detailed Guide on Student Induction program', as available on AICTE Portal, (Link:https://www.aicteindia.org/sites/default/files/Detailed%20Guide%20on%20Student%20Induction%20program.pdf).

Induction program (mandatory)	Three-week duration
Induction program for students to be offered right at the start of the first year.	• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

E. Mandatory Visits/ Workshop/Expert Lectures:

a. It is mandatory to arrange one industrial visit every semester for the students of each branch.

b. It is mandatory to conduct a One-week workshop during the winter break after fifth semester on professional/ industry/ entrepreneurial orientation.

c. It is mandatory to organize at least one expert lecture per semester for each branch by inviting resource persons from domain specific industry.

F. Evaluation Scheme (Suggestive only):

a. **For Theory Courses:**

(The weightage of Internal assessment is 40% and for End Semester Exam is 60%)
The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

b. **For Practical Courses:**
(The weightage of Internal assessment is 60% and for End Semester Exam is 40%)
The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

c. **For Summer Internship / Projects / Seminar etc.**
Evaluation is based on work done, quality of report, performance in viva-voce, presentation etc.

Note: The internal assessment is based on the student's performance in mid semester tests (two best out of three), quizzes, assignments, class performance, attendance, viva-voce in practical, lab record etc.

G. Mapping of Marks to Grades

Each course (Theory/Practical) is to be assigned 100 marks, irrespective of the number of credits, and the mapping of marks to grades may be done as per the following table:

Range of Marks	**Assigned Grade**
91-100	AA/A^+
81-90	AB/A
71-80	BB/B^+
61-70	BC/B
51-60	CC/C^+
46-50	CD/C
40-45	DD/D
< 40	FF/F (Fail due to the obtained marks being less than the cutoff)
-	F^R (Fail due to shortage of attendance requiring, to repeat the course)

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SEMESTER WISE STRUCTURE

SEMESTER I

S. No.	Course Code	Course Title	L	T	P	Credit
3 WEEKS COMPULSORY INDUCTION PROGRAM						
1	BS101	Physics-I	3	1	3	5.5
2	BS103	Mathematics-I	3	1	0	4
3	ES101	Basic Electrical Engineering	3	1	2	5
4	ES103	Engineering Graphics & Design	1	0	4	3
5	AU101	Sports and Yoga	3^	0	0	0
6	HS104	Design Thinking	0	0	2	1
TOTAL			**10 + 3^**	**3**	**11**	**18.5**

^ represents related to Audit Course.

SEMESTER II

S. No.	Course Code	Course Title	L	T	P	Credit
1	BS102	Chemistry-I	3	1	3	5.5
2	BS104	Mathematics –II (Mathematical foundation of Data Science)	3	1	0	4
3	ES102	Programming for Problem Solving	3	0	4	5
4	HS102	English	2	0	2	3
5	ES104	Workshop/Manufacturing Practices	1	0	4	3
6	HSMC(H-102)	Universal Human Values-II: Understanding Harmony And Ethical Human Conduct	2	1	0	3
TOTAL			**14**	**3**	**13**	**23.5**

SEMESTER III

S. No.	Course Code	Course Title	Weekly Hours	L	T	P	C
1	HS201	Effective Technical Communication	3	3	0	0	3
2	BS201	Mathematics – III (Probability and Statistics)	4	3	1	0	4
3	ES201	Applied Digital Logic Design	4	2	0	2	3
4	ES203	Introduction to Data Structures and Algorithms	4	2	0	2	3
5	PC201	Discrete Mathematics	3	3	0	0	3
6	PC203	Digital Signal Processing	3	3	0	0	3
7	PC205	Theory of Computation	3	3	0	0	3
8	PC207	Computer Organization and Design	3	3	0	0	3
9	PC209	Lab on Software tools and Techniques	4	1	0	3	2.5
TOTAL			**31**	**23**	**1**	**7**	**27.5**

SEMESTER IV

S.No.	Course Code	Course Title	Weekly Hours	L	T	P	C
1	AU202	Environmental Science	3^	3^	0	0	0
2	PC202	Introduction to Artificial Intelligence	3	3	0	0	3
3	PC204	Statistical Analysis and Computing	5	3	0	2	4
4	PC206	Introduction to Data Analytics and Visualization	5	3	0	2	4
5	PC208	Machine Learning	3	3	0	0	3
6	PC210	Architectures for Management of Large Datasets	3	3	0	0	3
7	HS202	Engineering Economics	2	2	0	0	2
8	EEC202	Independent Project	-	-	-	-	1.5
TOTAL			**21+3^**	**17+3^**	**0**	**4**	**20.5**

^ represents related to Audit Course.

SEMESTER V

S.No.	Course Code	Course Title	Weekly Hours	L	T	P	C
1	PC301	Programming with Large datasets lab	4	1	0	3	2.5
2	PC303	Introduction to IoT and Embedded Computing	6	3	0	3	4.5
3	PC305	Applied AI	6	3	0	3	4.5
4	XXNNN	Professional Elective -I	3	3	0	0	3
5	XXNNN	Open Elective - I	3	3	0	0	3
6	HS301	Entrepreneurship and Startups	3	3	0	0	3
7	AU301	Indian Constitution	3^	3^	0	0	0
8	EEC301	Summer Internship – I	-	-	-	-	1.5
TOTAL			**25+3^**	**16+3^**	**0**	**9**	**22**

^ represents related to Audit Course.

SEMESTER VI

S.No.	Course Code	Course Title	Weekly Hours	L	T	P	C
1	PC302	Data and Internet Security	3	3	0	0	3
2	PC304	Operating Systems	5	3	0	2	4
3	PC306	Computer Networks	5	3	0	2	4
4	XXNNN	Professional Elective –II	3	3	0	0	3
5	XXNNN	Open Elective -II	3	3	0	0	3
TOTAL			**21**	**15**	**0**	**4**	**17**

SEMESTER VII

S.No	Course Code	Course Title	Weekly Hours	L	T	P	C
1	XXNNN	Professional Elective –III (At least one out of Computer Vision and Image Processing/NLP/Speech Processing)	3	3	0	0	3
2	XXNNN	Professional Elective – IV (At least of out of GA/HMM/ANN/SVM)	3	3	0	0	3
3	XXNNN	Open Elective - III	3	3	0	0	3
4	XXNNN	Open Elective - IV	3	3	0	0	3
5	EEC401	Project – I	-	-	-	-	3
6	EEC403	Summer Internship – II	-	-	-	-	3
TOTAL			**12**	**12**	**0**	**0**	**18**

SEMESTER VIII

S. No.	Course Code	Course Title	Weekly Hours	L	T	P	C
1	XXNNN	Professional Elective – V	3	3	0	0	3
2	XXNNN	Professional Elective - VI	3	3	0	0	3
3	XXNNN	Open Elective - V	3	3	0	0	3
4	EEC402	Project – II	-	-	-	-	7
TOTAL			**9**	**9**	**0**	**0**	**16**

SEMESTER – I

SEMESTER I

Course Code	:	BS101
Course Title	:	Physics- I
Number of Credits	:	5.5 (L: 3, T: 1, P: 3)
Course Category	:	BS
Course Contents in Physics **(Any One)**	:	**Anyone from the below options** i. Introduction to Electromagnetic Theory ii. Introduction to Mechanics iii. Quantum Mechanics for Engineers iv. Astronomy and Astrophysics v. Oscillation, Waves and Optics

COURSE OBJECTIVES: To enhance the fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology.

Introduction to Electromagnetic Theory
Pre-requisites (if any): Mathematics course with vector calculus

Module 1: Electrostatics in vacuum

Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential and uniqueness of their solution and connection with steady state diffusion and thermal conduction; Practical examples like Faraday's cage and coffee-ring effect; Boundary conditions of electric field and electrostatic potential; method of images; energy of a charge distribution and its expression in terms of electric field.

Module 2: Electrostatics in a linear dielectric medium

Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; Solving simple electrostatics problems in presence of dielectrics – Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab, dielectric slab and dielectric sphere in uniform electric field.

Module 3: Magnetostatics

Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes' theorem; the equation for the vector potential and its solution for given current densities.

Module 4: Magnetostatics in a linear magnetic medium

Magnetization and associated bound currents; auxiliary magnetic field H; Boundary conditions on B and H. Solving for magnetic field due to simple magnets like a bar magnet;

magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.

Module 5: Faraday's law

Faraday's law in terms of EMF produced by changing magnetic flux; equivalence of Faraday's law and motional EMF; Lenz's law; Electromagnetic breaking and its applications; Differential form of Faraday's law expressing curl of electric field in terms of time-derivative of magnetic field and calculating electric field due to changing magnetic fields in quasi-static approximation; energy stored in a magnetic field.

Module 6: Displacement current, Magnetic field due to time-dependent electric field and Maxwell's equations

Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displace current and magnetic field arising from time dependent electric field; calculating magnetic field due to changing electric fields in quasistatic approximation. Maxwell's equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Pointing vector with examples. Qualitative discussion of momentum in electromagnetic fields.

Module 7: Electromagnetic waves

The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarization; relation between electric and magnetic fields of an electromagnetic wave; energy carried by electromagnetic waves and examples. Momentum carried by electromagnetic waves and resultant pressure. Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence.

Laboratory - Introduction to Electromagnetic Theory

Choice of experiments from the following:

- Experiments on electromagnetic induction and electromagnetic breaking;
- LC circuit and LCR circuit;
- Resonance phenomena in LCR circuits;
- Magnetic field from Helmholtz coil;
- Measurement of Lorentz force in a vacuum tube.

TEXTBOOKS/REFERENCES:

i. David Griffiths, Introduction to Electrodynamics
ii. Halliday and Resnick, Physics
iii. A.B. Bhattacharya, Engineering Physics
iv. W. Saslow, Electricity, magnetism and light

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	INTRODUCTION TO ELECTROMAGNETIC THEORY	PROF. MANOJ HARBOLA	IIT KANPUR

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	LC circuit and LCR circuit;	1. http://vlab.amrita.edu/?sub=1&brch=75&sim=326&cnt=1 2. http://vlab.amrita.edu/?sub=1&brch=75&sim=330&cnt=1 3. http://vlab.amrita.edu/?sub=1&brch=75&sim=318&cnt=1 4. http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1 5. http://vlabs.iitkgp.ernet.in/asnm/exp12/index.htm
2	Resonance phenomena in LCR circuits	http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1

Introduction to Mechanics
Pre-requisites (if any): High School Education

Module 1

Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton's laws and its completeness in describing particle motion; Form invariance of Newton's Second Law; Solving Newton's equations of motion in polar coordinates; Problems including constraints and friction; Extension to cylindrical and spherical coordinates.

Module 2

Potential energy function; F = - Grad V, equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Elliptical, parabolic and hyperbolic orbits; Kepler problem; Application: Satellite manoeuvres;

Module 3

Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula. Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum;

Module 4

Harmonic oscillator; Damped harmonic motion – over-damped, critically damped and lightly-damped oscillators; Forced oscillations and resonance.

Module 5

Definition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a coordinate system rotating and translating in the plane; Angular momentum about a point of a rigid body in planar motion; Euler's laws of motion, their independence from Newton's laws, and their necessity in describing rigid body motion; Examples.

Module 6

Introduction to three-dimensional rigid body motion — only need to highlight the distinction from two-dimensional motion in terms of (a) Angular velocity vector, and its rate of change and (b) Moment of inertia tensor; Three-dimensional motion of a rigid body wherein all points move in a coplanar manner: e.g. Rod executing conical motion with center of mass fixed — only need to show that this motion looks two-dimensional but is three-dimensional, and two-dimensional formulation fails.

Laboratory - Introduction to Mechanics

1. Suggested list of experiments from the following:
2. Coupled oscillators;
3. Experiments on an air-track;
4. Experiment on moment of inertia measurement,
5. Experiments with gyroscope;
6. Resonance phenomena in mechanical oscillators.

TEXTBOOKS/REFERENCES:

1. Engineering Mechanics, 2nd ed. — MK Harbola
2. Engineering Mechanics, 2nd ed. – DS Bedi
3. Introduction to Mechanics — MK Verma
4. An Introduction to Mechanics — D Kleppner & R Kolenkow
5. Principles of Mechanics — JL Synge & BA Griffiths
6. Mechanics — JP Den Hartog
7. Engineering Mechanics - Dynamics, 7th ed. - JL Meriam
8. Mechanical Vibrations — JP Den Hartog
9. Theory of Vibrations with Applications — WT Thomson

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	ENGINEERING MECHANICS	PROF. MANOJ HARBOLA	IIT KANPUR

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	Experiment on moment of inertia measurement.	https://vlab.amrita.edu/?sub=1&brch=74&sim=571&cnt=1

Quantum Mechanics for Engineers
Pre-requisites (if any): Mathematics Course on Differential equations & linear algebra

Module 1: Wave nature of particles and the Schrodinger equation

Introduction to Quantum mechanics, Wave nature of Particles, Time-dependent and time independent Schrodinger equation for wave function, Born interpretation, probability current, Expectation values, Free-particle wave function and wave-packets, Uncertainty principle.

Module 2: Mathematical Preliminaries for quantum mechanics

Complex numbers, Linear vector spaces, inner product, operators, eigenvalue problems, Hermitian operators, Hermite polynomials, Legendre's equation, spherical harmonics.

Module 3: Applying the Schrodinger equation

Solution of stationary-state Schrodinger equation for one dimensional problems– particle in a box, particle in attractive delta-function potential, square-well potential, linear harmonic oscillator. Numerical solution of stationary-state Schrodinger equation for one dimensional problems for different potentials Scattering from a potential barrier and tunneling; related examples like alpha-decay, fieldionization and scanning tunneling microscope Three-dimensional problems: particle in three dimensional box and related examples, Angular momentum operator, Rigid Rotor, Hydrogen atom ground-state, orbitals, interaction with magnetic field, spin, Numerical solution stationary-state radial Schrodinger equation for spherically symmetric potentials.

Module 4: Introduction to molecular bonding

Particle in double delta-function potential, Molecules (hydrogen molecule, valence bond and molecular orbitals picture), singlet/triplet states, chemical bonding, hybridization.

Module 5: Introduction to solids

Free electron theory of metals, Fermi level, density of states, Application to white dwarfs and neutron stars, Bloch's theorem for particles in a periodic potential, Kronig-Penney model and origin of energy bands Numerical solution for energy in one-dimensional periodic lattice by mixing plane waves.

Laboratory - Quantum Mechanics for Engineers

Suggested list of experiments: Frank-Hertz experiment; photoelectric effect experiment; recording hydrogen atom spectrum.

TEXTBOOKS/REFERENCES:

1. Eisberg and Resnick, Introduction to Quantum Physics
2. A.B. Bhattacharya, Engineering Physics
3. D. J. Griffiths, Quantum mechanics
4. Richard Robinett, Quantum Mechanics
5. Daniel McQuarrie, Quantum Chemistry
6. Manisha Agrawal, Engineering Chemistry

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	INTRODUCTION TO ELECTROMAGNETIC THEORY	PROF. MANOJ HARBOLA	IIT KANPUR
2	QUANTUM MECHANICS I	PROF. P. RAMADEVI	IIT BOMBAY

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	Photoelectric effect experiment.	http://mpv-au.vlabs.ac.in/modern-physics/Photo_Electric_Effect/

Astronomy & Astrophysics
Pre-requisites (if any):

Module 1: Introduction to Cosmology, Big Bang Cosmology, Cosmological Red Shift, Hubble's Law,

Module 2: Matter and Radiation, Accelerating Universe and Dark Energy.

Module 3: Universe structure, the Early Universe, Primordial Nucleo synthesis, Cosmic Microwave Background Radiation (CMBR)

Module 4: Particle Physics and High Energy Physics: The Standard model of particle physics, elementary particle classification, fermions and bosons, electromagnetic, weak and strong processes. Introduction to Large Hadron Collider.

Text Books:

1. By Suresh Chandra, Mohit Kumar Sharma, "A Textbook of Astronomy and Astrophysics" 1st Edition, Dreamtech Press, 2019.
2. Arnab Rai Choudhuri, "Astrophysics for Physicists", 1st Edition, Cambridge University Press, 2012.
3. Dale A. Ostlie, Bradley W. Carroll, "An Introduction to Modern Stellar Astrophysics", 1st Edition Pearson Addison-Wesley, 2007
4. Pankaj Jain, "An Introduction to Astronomy and Astrophysics", 1st Edition, CRD Press.

Course Outcomes: The objective of this course is to familiarize the prospective engineers with basic understanding of concepts of physics as needed by engineers. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of physics and applications that they would find useful in their disciplines.

The students shall be able to

- define and use the terms star, planet, galaxy, universe
- define astronomical distances such as light year, astronomical unit and relate these to the size of the stellar objects
- describe the Cosmological Principle and its consequences
- explain the different possible expansion histories for the universe
- define redshift and Hubble constant
- explain Hubble's Law and interpret a Hubble diagram
- describe the relation between the universe's expansion rate and its age
- explain what is meant by Big Bang theory and list some evidence for it
- define and use the terms cosmic microwave background and recombination
- explain how the cosmic microwave background relates to the distribution of matter in the universe
- describe the general size, shapes and types of galaxies and their properties
- summarize the life cycle of stars
- list and explain at least two kinds of observational evidence for dark matter and dark energy
- compare and contrast the candidates for dark matter and dark energy, and the prospects for directly detecting them
- explain the relations between the cosmological constant vacuum energy and accelerating universe
- define concepts of particle physics such as electrons, protons, neutrons, fermions, bosons etc. and relate them to the cosmology and evolution of universe

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Oscillations, waves and optics
Pre-requisites (if any): Mathematics Course on Differential equations

Module 1: Simple harmonic motion, damped and forced simple harmonic oscillator
Mechanical and electrical simple harmonic oscillators, complex number notation and phasor representation of simple harmonic motion, damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator, quality factor, forced mechanical and electrical oscillators, electrical and mechanical impedance, steady state motion of forced damped harmonic oscillator, power absorbed by oscillator.

Module 2: Non-dispersive transverse and longitudinal waves in one dimension and introduction to dispersion

Transverse wave on a string, the wave equation on a string, Harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their Eigen frequencies, longitudinal waves and the wave equation for them, acoustics waves and speed of sound, standing sound waves. Waves with dispersion, water waves, superposition of waves and Fourier method, wave groups and group velocity.

Module 3: The propagation of light and geometric optics

Fermat's principle of stationary time and its applications e.g. in explaining mirage effect, laws of reflection and refraction, Light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster's angle, total internal reflection, and evanescent wave. Mirrors and lenses and optical instruments based on them, transfer formula and the matrix method.

Module 4: Wave optics

Huygens' principle, superposition of waves and interference of light by wave front splitting and amplitude splitting; Young's double slit experiment, Newton's rings, Michelson interferometer, Mach-Zehnder interferometer.

Farunhofer diffraction from a single slit and a circular aperture, the Rayleigh criterion for limit of resolution and its application to vision; Diffraction gratings and their resolving power.

Module 5: Lasers

Einstein's theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO2), solid-state lasers (ruby, Neodymium), dye lasers; Properties of laser beams: mono-chromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in science, engineering and medicine.

Laboratory - Oscillations, waves and optics

Suggested list of experiments from the following:

- Diffraction and interference experiments (from ordinary light or laser pointers); measurement of speed of light on a table top using modulation; minimum deviation from a prism.

TEXTBOOKS/REFERENCES:

1. Ian G. Main, Oscillations and waves in physics
2. H.J. Pain, The physics of vibrations and waves
3. E. Hecht, Optics
4. A. Ghatak, Optics
5. O. Svelto, Principles of Lasers

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	WAVES AND OSCILLATIONS	PROF. M. S. SANTHANAM	IISER PUNE

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	Diffraction and interference experiments (from ordinary light or laser pointers).	http://ov-au.vlabs.ac.in/optics/Diffraction_Grating/
2	Minimum deviation from a prism.	http://ov-au.vlabs.ac.in/optics/Spectrometer_i_d_Curve/

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Course Code	:	MT-102
Course Title	:	Mathematics- I
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	MT

Course Objectives: The goal of this course is to achieve conceptual understanding and to retain the best traditions of traditional calculus. The syllabus is designed to provide the basic tools of calculus mainly for the purpose of modelling the engineering problems mathematically and obtaining solutions. This is a foundation course which mainly deals with topics such as single variable and multivariable calculus and plays an important role in the understanding of science, engineering, economics and computer science, among other disciplines.

Course Contents:

Module I: Calculus

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions. Rolle's Theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; indeterminate forms and L'Hospital's rule; Maxima and minima.

Module II: Sequences and Series

Convergence of sequence and series, tests for convergence; Power series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Module III: Multivariable Calculus (Differentiation)

Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module IV: Matrices

Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.

TEXTBOOKS/REFERENCES:

1. Reena Garg, Engineering Mathematics - I, Khanna Book Publishing Company, 2020.
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
3. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
6. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
7. N.P. Bali and Manish Goyal, A textbook of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
8. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.
9. Reena Garg and Chandrika Prasad, Advanced Engineering Mathematics, Khanna Book Publishing Company, 2020.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	ENGINEERING MATHEMATICS - I	PROF. JITENDRA KUMAR	IIT KGP

Course Outcomes: The objective of this course is to familiarize the prospective engineers with techniques in calculus, multivariate analysis and linear algebra. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

The students will learn:

- To apply differential and integral calculus to notions of curvature and to improper integrals. Apart from some other applications they will have a basic understanding of Beta and Gamma functions.
- To explain the fallouts of Rolle's Theorem that is fundamental to application of analysis to Engineering problems.
- To discuss the tool of power series and Fourier series for learning advanced Engineering Mathematics.
- To deal with functions of several variables that are essential in most branches of engineering.
- To use the essential tool of matrices and linear algebra in a comprehensive manner.

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Course Code	:	ES101
Course Title	:	Basic Electrical Engineering
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	ES

Course Objective: The objective of this Course is to provide the students with an introductory and broad treatment of the field of Electrical Engineering.

Course Contents:

Module 1: D. C. Circuits covering, Ohm's Law and Kirchhoff's Laws; Analysis of series, parallel and series-parallel circuits excited by independent voltage sources; Power and energy; Electromagnetism covering, Faradays Laws, Lenz's Law, Fleming's Rules, Statically and dynamically induced EMF; Concepts of self-inductance, mutual inductance and coefficient of coupling; Energy stored in magnetic fields;

Module 2: Single Phase A.C. Circuits covering, Generation of sinusoidal voltage- definition of average value, root mean square value, form factor and peak factor of sinusoidal voltage and current and phasor representation of alternating quantities; Analysis with phasor diagrams of R, L, C, RL, RC and RLC circuits; Real power, reactive power, apparent power and power factor, series, parallel and series- parallel circuits; Three Phase A.C. Circuits covering, Necessity and Advantages of three phase systems, Generation of three phase power, definition of Phase sequence, balanced supply and balanced load; Relationship between line and phase values of balanced star and delta connections; Power in balanced three phase circuits, measurement of power by two wattmeter method;

Module 3: Transformers covering, Principle of operation and construction of single phase transformers (core and shell types). EMF equation, losses, efficiency and voltage regulation; Synchronous Generators covering, Principle of operation; Types and constructional features; EMF equation;

Module 4: DC Machines covering, Working principle of DC machine as a generator and a motor; Types and constructional features; EMF equation of generator, relation between EMF induced and terminal voltage enumerating the brush drop and drop due to armature reaction; DC motor working principle; Back EMF and its significance, torque equation; Types of D.C. motors, characteristics and applications; Necessity of a starter for DC motor;

Module 5: Three Phase Induction Motors covering; Concept of rotating magnetic field; Principle of operation, types and constructional features; Slip and its significance; Applications of squirrel cage and slip ring motors; Necessity of a starter, star-delta starter.

Module 6: Sources of Electrical Power covering, Introduction to Wind, Solar, Fuel cell, Tidal, Geo-thermal, Hydroelectric, Thermal-steam, diesel, gas, nuclear power plants; Concept of cogeneration, and distributed generation;

TEXT/REFERENCS BOOKS:

1. Nagrath I.J. and D. P. Kothari (2001), Basic Electrical Engineering, Tata McGraw Hill.
2. Hayt and Kimberly, Engineering Circuit Analysis, Tata McGraw Hill.
3. Ritu Sahdev (2019), Basic Electrical Engineering, Khanna Book Publishing Company
4. Kulshreshtha D.C. (2009), Basic Electrical Engineering, Tata McGraw Hill.
5. Rajendra Prasad (2009), Fundamentals of Electrical Engineering, Prentice Hall, India

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	BASIC ELECTRIC CIRCUITS	PROF. ANKUSH SHARMA	IIT KANPUR
2	BASIC ELECTRICAL CIRCUITS	PROF. NAGENDRA KRISHNAPURA	IITM
3	FUNDAMENTALS OF ELECTRICAL ENGINEERING	PROF. DEBAPRIYA DAS	IIT KGP

COURSE OUTCOMES:

1. Students will learn strong basics of Electrical Engineering and practical implementation of Electrical fundamentals.
2. Students will learn different applications of commonly used electrical machinery.

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Course Code	:	ES103
Course Title	:	Engineering Graphics & Design
Number of Credits	:	3 (L: 1, T: 0, P: 4)
Course Category	:	ES

COURSE OBJECTIVE: The objective of this Course is to provide the basic knowledge about Engineering Drawing. Detailed concepts are given in projections, technical drawing, dimensioning and specifications, so useful for a student in preparing for an engineering career.

COURSE CONTENTS:

Traditional Engineering Graphics: Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance.

Computer Graphics: Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly; Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling; Introduction to Building Information Modelling (BIM).

(Except the basic essential concepts, most of the teaching part can happen concurrently in the laboratory)

Module 1: Introduction to Engineering Drawing

Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales;

Module 2: Orthographic Projections

Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes;

Module 3: Projections of Regular Solids

Covering those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Module 4: Sections and Sectional Views of Right Angular Solids

Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only).

Module 5: Isometric Projections

Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

Module 6: Overview of Computer Graphics

Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids];

Module 7: Customisation & CAD Drawing

Consisting of set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

Module 8: Annotations, layering & other functions

Covering applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

Module 9: Demonstration of a simple team design project that illustrates

Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

Text/Reference Books:

1. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House.

2. Jain Pradeep, (2019) Engineering Graphics and Design, Khanna Book Publishing Company
3. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education.
4. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
5. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers.
6. (Corresponding set of) CAD Software Theory and User Manuals.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	PROF. RAJARAM LAKKARAJU	IIT KGP	ENGINEERING DRAWING AND COMPUTER GRAPHICS
2	PROF. NIHAR RANJAN PATRA	IIT KANPUR	ENGINEERING GRAPHICS

Course Outcomes:

All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software. This course is designed to address:

- to prepare you to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- to prepare you to communicate effectively
- to prepare you to use the techniques, skills, and modern engineering tools necessary for engineering practice

The student will learn:

- Introduction to engineering design and its place in society.
- Exposure to the visual aspects of engineering design.
- Exposure to engineering graphics standards.
- Exposure to solid modelling.
- Exposure to computer-aided geometric design.
- Exposure to creating working drawings.
- Exposure to engineering communication.

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Course Code	:	AU102
Course Title	:	Sports and Yoga
Number of Credits	:	0 (L: 3, T: 0, P: 0)
Course Category	:	AU

Course Objective(s):

- To make the students understand the importance of sound health and fitness principles as they relate to better health.
- To expose the students to a variety of physical and yogic activities aimed at stimulating their continued inquiry about Yoga, physical education, health and fitness.
- To create a safe, progressive, methodical and efficient activity based plan to enhance improvement and minimize risk of injury.
- To develop among students an appreciation of physical activity as a lifetime pursuit and a means to better health.

Course Contents:

- **Introduction to Physical Education**
  - Meaning & definition of Physical Education
  - Aims & Objectives of Physical Education
  - Changing trends in Physical Education
- **Olympic Movement**
  - Ancient & Modern Olympics (Summer & Winter)
  - Olympic Symbols, Ideals, Objectives & Values
  - Awards and Honours in the field of Sports in India (Dronacharya Award, Arjuna Award, Dhayanchand Award, Rajiv Gandhi Khel Ratna Award etc.)
- **Physical Fitness, Wellness & Lifestyle**
  - Meaning & Importance of Physical Fitness & Wellness
  - Components of Physical fitness
  - Components of Health related fitness
  - Components of wellness
  - Preventing Health Threats through Lifestyle Change
  - Concept of Positive Lifestyle
- **Fundamentals of Anatomy & Physiology in Physical Education, Sports and Yoga**
  - Define Anatomy, Physiology & Its Importance
  - Effect of exercise on the functioning of Various Body Systems. (Circulatory System, Respiratory System, Neuro-Muscular System etc.)
- **Kinesiology, Biomechanics & Sports**
  - Meaning & Importance of Kinesiology & Biomechanics in Physical Edu. & Sports
  - Newton's Law of Motion & its application in sports.
  - Friction and its effects in Sports.
- **Postures**
  - Meaning and Concept of Postures.
  - Causes of Bad Posture.

- Advantages & disadvantages of weight training.
- Concept & advantages of Correct Posture.
- Common Postural Deformities – Knock Knee; Flat Foot; Round Shoulders; Lordosis, Kyphosis, Bow Legs and Scoliosis.
- Corrective Measures for Postural Deformities

- **Yoga**
  - Meaning & Importance of Yoga
  - Elements of Yoga
  - Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas
  - Yoga for concentration & related Asanas (Sukhasana; Tadasana; Padmasana & Shashankasana)
  - Relaxation Techniques for improving concentration - Yog-nidra
- **Yoga & Lifestyle**
  - Asanas as preventive measures.
  - Hypertension: Tadasana, Vajrasana, Pavan Muktasana, Ardha Chakrasana, Bhujangasana, Sharasana.
  - Obesity: Procedure, Benefits & contraindications for Vajrasana, Hastasana, Trikonasana, Ardh Matsyendrasana.
  - Back Pain: Tadasana, Ardh Matsyendrasana, Vakrasana, Shalabhasana, Bhujangasana.
  - Diabetes: Procedure, Benefits & contraindications for Bhujangasana, Paschimottasana, Pavan Muktasana, Ardh Matsyendrasana.
  - Asthema: Procedure, Benefits & contraindications for Sukhasana, Chakrasana, Gomukhasana, Parvatasana, Bhujangasana, Paschimottasana, Matsyasana.
- **Training and Planning in Sports**
  - Meaning of Training
  - Warming up and limbering down
  - Skill, Technique & Style
  - Meaning and Objectives of Planning.
  - Tournament – Knock-Out, League/Round Robin & Combination.
- **Psychology & Sports**
  - Definition & Importance of Psychology in Physical Edu. & Sports
  - Define & Differentiate Between Growth & Development
  - Adolescent Problems & Their Management
  - Emotion: Concept, Type & Controlling of emotions
  - Meaning, Concept & Types of Aggressions in Sports.
  - Psychological benefits of exercise.
  - Anxiety & Fear and its effects on Sports Performance.
  - Motivation, its type & techniques.
  - Understanding Stress & Coping Strategies.
- **Doping**
  - Meaning and Concept of Doping
  - Prohibited Substances & Methods

- Side Effects of Prohibited Substances

- **Sports Medicine**
  - First Aid – Definition, Aims & Objectives.
  - Sports injuries: Classification, Causes & Prevention.
  - Management of Injuries: Soft Tissue Injuries and Bone & Joint Injuries
- **Sports / Games**

  Following subtopics related to any one Game/Sport of choice of student out of: Athletics, Badminton, Basketball, Chess, Cricket, Kabaddi, Lawn Tennis, Swimming, Table Tennis, Volleyball, Yoga etc.
- History of the Game/Sport.
- Latest General Rules of the Game/Sport.
- Specifications of Play Fields and Related Sports Equipment.
- Important Tournaments and Venues.
- Sports Personalities.
- Proper Sports Gear and its Importance.

Text Books/References:

1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Light On Yoga by B.K.S. Iyengar.
3. Health and Physical Education – NCERT (11th and 12th Classes).

Course Outcomes: On successful completion of the course the students will be able to:

1. Practice Physical activities and Hatha Yoga focusing on yoga for strength, flexibility, and relaxation.
2. Learn techniques for increasing concentration and decreasing anxiety which leads to stronger academic performance.
3. Learn breathing exercises and healthy fitness activities
4. Understand basic skills associated with yoga and physical activities including strength and flexibility, balance and coordination.
5. Perform yoga movements in various combination and forms.
6. Assess current personal fitness levels.
7. Identify opportunities for participation in yoga and sports activities.
8. Develop understanding of health-related fitness components: cardiorespiratory endurance, flexibility and body composition etc.
9. Improve personal fitness through participation in sports and yogic activities.
10. Develop understanding of psychological problems associated with the age and lifestyle.
11. Demonstrate an understanding of sound nutritional practices as related to health and physical performance.
12. Assess yoga activities in terms of fitness value.
13. Identify and apply injury prevention principles related to yoga and physical fitness activities.
14. Understand and correctly apply biomechanical and physiological principles elated to exercise and training.

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Course Code	:	HS104
Course Title	:	Design Thinking
Number of Credits	:	1 (L: 0, T: 0, P: 2)
Course Category	:	HS

COURSE OBJECTIVE(S):

The objective of this Course is to provide the new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products which useful for a student in preparing for an engineering career.

COURSE CONTENTS:

Unit 1: An Insight to Learning

Understanding the Learning Process, Kolb's Learning Styles, Assessing and Interpreting

Unit 2: Remembering Memory

Understanding the Memory process, Problems in retention, Memory enhancement techniques

Unit 3: Emotions: Experience & Expression

Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers

Unit 4: Basics of Design Thinking

Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – **Empathize, Define, Ideate, Prototype, Test**

Unit 5: Being Ingenious & Fixing Problem

Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving

Unit 6: Process of Product Design

Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, **Assignment – Engineering Product Design**

Unit 7: Prototyping & Testing

What is Prototype? Why Prototype? Rapid Prototype Development process, Testing, **Sample Example**, Test Group Marketing

Unit 8: Celebrating the Difference

Understanding Individual differences & Uniqueness, Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences

Unit 9: Design Thinking & Customer Centricity

Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design

Unit 10: Feedback, Re-Design & Re-Create

Feedback loop, Focus on User Experience, Address "ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – **"Solving Practical Engineering Problem through Innovative Product Design & Creative Solution".**

Course Outcomes (CO):

Student will able to

1. Compare and classify the various learning styles and memory techniques and Apply them in their engineering education
2. Analyze emotional experience and Inspect emotional expressions to better understand users while designing innovative products
3. Develop new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products
4. Propose real-time innovative engineering product designs and Choose appropriate frameworks, strategies, techniques during prototype development
5. Perceive individual differences and its impact on everyday decisions and further Create a better customer experience

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SEMESTER – II

SEMESTER II

Course Code	:	BS102
Course Title	:	Chemistry- I
Number of Credits	:	5.5 (L: 3, T: 1, P: 3)
Course Category	:	BS

Course Objective: The objective of the Chemistry I is to acquaint the students with the basic phenomenon/concepts of chemistry, the student faces during course of their study in the industry and Engineering field. The student with the knowledge of the basic chemistry, will understand and explain scientifically the various chemistry related problems in the industry/engineering field. The student will able to understand the new developments and breakthroughs efficiently in engineering and technology. The introduction of the latest (R&D oriented) topics will make the engineering student upgraded with the new technologies.

Course Content:

(i) Atomic and Molecular Structure

Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicentre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

(ii) Spectroscopic techniques and applications

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques. Diffraction and scattering.

(iii) Intermolecular forces and potential energy surfaces

Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H3, H2F and HCN and trajectories on these surfaces.

(iv) Use of free energy in chemical equilibria

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Water chemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

(v) Periodic properties

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.

(vi) Stereochemistry

Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds.

(vii) Organic reactions and synthesis of a drug molecule

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

LABORATORY

Choice of 10-12 experiments from the following:

1. Determination of surface tension and viscosity.
2. Thin layer chromatography.
3. Ion exchange column for removal of hardness of water.
4. Determination of chloride content of water.
5. Colligative properties using freezing point depression.
6. Determination of the rate constant of a reaction.
7. Determination of cell constant and conductance of solutions.
8. Potentiometry - determination of redox potentials and emfs.
9. Synthesis of a polymer/drug.
10. Saponification/acid value of an oil.
11. Chemical analysis of a salt.
12. Lattice structures and packing of spheres.
13. Models of potential energy surfaces.
14. Chemical oscillations- Iodine clock reaction.
15. Determination of the partition coefficient of a substance between two immiscible liquids.
16. Adsorption of acetic acid by charcoal.
17. Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg.

Text/Reference Books:

1. Engineering Chemistry, by Manisha Agrawal
2. University chemistry, by B. H. Mahan
3. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane
4. Fundamentals of Molecular Spectroscopy, by C. N. Banwell
5. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
6. Physical Chemistry, by P. W. Atkins
7. Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition http://bcs.whfreeman.com/vollhardtschore5e/default.asp

Course Outcomes: The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the 10+2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications. Quantum theory is more than 100 years old and to understand phenomena at nanometer levels, one has to base the description of all chemical processes at molecular levels. The course will enable the student to:

- Analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.
- Rationalise bulk properties and processes using thermodynamic considerations.
- Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques
- Rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.
- List major chemical reactions that are used in the synthesis of molecules.

LABORATORY OUTCOMES:

The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn to:

- Estimate rate constants of reactions from concentration of reactants/products as a function of time.
- Measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc.
- Synthesize a small drug molecule and analyse a salt sample.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	CHEMISTRY - I	PROF. MANGALA SUNDER KRISHNAN	IITM

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	Determination of surface tension and viscosity.	http://pcv-au.vlabs.ac.in/physical-chemistry/Determination_of_Viscosity_of_Organic_Solvents/
2	Ion exchange column for removal of hardness of water.	http://icv-au.vlabs.ac.in/inorganic-chemistry/Water_Analysis_Determination_of_Chemical_Parameters/

3	Determination of chloride content of water.	http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determination-of-chloride-nitk/simulation.html
4	Colligative properties using freezing point depression.	http://pcv-au.vlabs.ac.in/physical-chemistry/Cryoscopy/
5	Determination of the rate constant of a reaction.	http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/
6	Determination of cell constant and conductance of solutions.	http://icv-au.vlabs.ac.in/inorganic-chemistry/Water_Analysis_Determination_of_Physical_Parameters/
7	Potentiometry - determination of redox potentials and emfs.	http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/
8	Saponification/acid value of an oil.	http://biotech01.vlabs.ac.in/bio-chemistry/Estimation_of_Saponification_Value_of_Fats_or_Oils/
9	Lattice structures and packing of spheres.	https://vlab.amrita.edu/?sub=1&brch=282&sim=370&cnt=1

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Course Code	:	BS104
Course Title	:	Mathematics- II (Mathematical foundation of Data Science)
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	BS

Course Objective: Mathematics fundamental necessary to formulate, solve and analyze engineering problems.

Complex analysis: Real and complex numbers, basic properties and geometry. Analytic functions, Cauchy-Riemann equations, Harmonic functions, Derivatives of analytic functions, Taylor's, Maclaurin's, Laurent's series. Zeros and poles, Residue Theorems.

Difference equations and chaos: Recursion and iteration, First and second order difference equations. Homogeneous and Non-homogeneous difference equations, generating functions. Systems of difference equations, Logistic Eqn. / Logistic map

Transfer functions and Dynamical systems: First and second order differential equations, System of differential equations, Laplace transforms to solve differential equations, transfer functions, impulse functions, frequency response.

Game theory: Introduction, Strategic games, Nash equilibrium, mixed strategy, auctions.

Text/Reference Books:

1. Reena Garg and Chandrika Prasad, Advanced Engineering Mathematics, Khanna Book Publishing Company, 2020.
2. R.V. Churchill and J.W. Brown, Complex Variables and Applications, 5th edition, McGraw Hill, 1990.
3. I. N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006
4 A. D. Poularikas, The Transforms and Applications Handbook, CRC Press, 1996.

Course Outcomes: The objective of this course is to familiarize the prospective engineers with techniques in multivariate integration, ordinary and partial differential equations and complex variables. It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

The students will learn:

- To illustrate the mathematical tools needed in evaluating multiple integrals and their usage.
- To categories the effective mathematical tools for the solutions of differential equations that model physical processes.
- To explain the tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.

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Course Code	:	ES102
Course Title	:	Programming for Problem Solving
Number of Credits	:	5 (L: 3, T: 0, P: 4)
Course Category	:	ES

Course Objectives:

1. To learn the fundamentals of computers.
2. To understand the various steps in program development.
3. To learn the syntax and semantics of C programming language.
4. To learn the usage of structured programming approach in solving problems.
5. To understated and formulate algorithm for programming script
6. To analyze the output based on the given input variables

Course Contents:

Unit 1: Introduction to Programming**;** Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.)
Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples.
From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.

Unit 2: Arithmetic expressions and precedence.

Unit 3: Conditional Branching and Loops. Writing and evaluation of conditionals and consequent branching. Iteration and loops.

Unit 4: Arrays, Arrays (1-D, 2-D), Character arrays and Strings

Unit 5: Basic Algorithms, Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

Unit 6: Function, Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

Unit 7: Recursion, Recursion as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

Unit 8: Structures, Defining structures and Array of Structures

Unit 9: Pointers, Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation)

Unit 10: File handling (only if time is available, otherwise should be done as part of the lab).

PRACTICALS:

1. Familiarization with programming environment
2. Simple computational problems using arithmetic expressions
3. Problems involving if-then-else structures
4. Iterative problems e.g., sum of series
5. 1D Array manipulation
6. Matrix problems, String operations
7. Simple functions
8. Programming for solving Numerical methods problems
9. Recursive functions
10. Pointers and structures
11. File operations

TEXT/REFERENCE BOOKS:

1. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill.
2. R.S. Salaria, Programming for Problem Solving, Khanna Publishing House.

3. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	INTRODUCTION TO PROGRAMMING IN C	PROF. SATYADEV NANDAKUMAR	IITK
2	PROBLEM SOLVING THROUGH PROGRAMMING IN C	PROF. ANUPAM BASU	IIT KGP

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	Simple computational problems using arithmetic expressions.	http://ps-iiith.vlabs.ac.in/exp7/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab
2	Iterative problems e.g., sum of series.	http://ps-iiith.vlabs.ac.in/exp4/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab
3	1D Array manipulation.	http://cse02-iiith.vlabs.ac.in/exp4/index.html
4	Matrix problems, String operations.	http://ps-iiith.vlabs.ac.in/exp5/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab
5	Simple functions.	http://cse02-iiith.vlabs.ac.in/exp2/index.html
6	Programming for solving Numerical methods problems.	http://ps-iiith.vlabs.ac.in/exp1/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab
7	Recursive functions.	http://ps-iiith.vlabs.ac.in/exp6/Introduction.html?domain=Computer%20Science&lab=Problem%20Solving%20Lab

COURSE OUTCOMES: The student will learn following through lectures:

- To formulate simple algorithms for arithmetic and logical problems.
- To translate the algorithms to programs (in C language).

- To test and execute the programs and correct syntax and logical errors.
- To implement conditional branching, iteration and recursion.
- To decompose a problem into functions and synthesize a complete program using divide and conquer approach.
- To use arrays, pointers and structures to formulate algorithms and programs.
- To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.
- To apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration.

The student will learn following through Practicals:

- To formulate the algorithms for simple problems.
- To translate given algorithms to a working and correct program.
- To be able to correct syntax errors as reported by the compilers.
- To be able to identify and correct logical errors encountered at run time.
- To be able to write iterative as well as recursive programs.
- To be able to represent data in arrays, strings and structures and manipulate them through a program.
- To be able to declare pointers of different types and use them in defining self-referential structures.
- To be able to create, read and write to and from simple text files.

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Course Code	:	HS102
Course Title	:	English
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	HS

Course Objective:

- To provide learning environment to practice listening, speaking, reading and writing skills.
- To assist the students to carry on the tasks and activities through guided instructions and materials.
- To effectively integrate English language learning with employability skills and training.
- To provide hands-on experience through case-studies, mini-projects, group and individual presentations.

Course Content:

Module I: Vocabulary Building

1.1. The concept of Word Formation
1.2. Root words from foreign languages and their use in English
1.3. Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.

1.4. Synonyms, antonyms, and standard abbreviations.

Module II: Basic Writing Skills
1.1. Sentence Structures
1.2. Use of phrases and clauses in sentences
1.3. Importance of proper punctuation
1.4. Creating coherence
1.5. Organizing principles of paragraphs in documents
1.6. Techniques for writing precisely

Module III: Identifying Common Errors in Writing
1.1. Subject-verb agreement
1.2. Noun-pronoun agreement
1.3. Misplaced modifiers
1.4. Articles
1.5. Prepositions
1.6. Redundancies
1.7. Clichés

Module IV: Nature and Style of sensible Writing
1.1. Describing
1.2. Defining
1.3. Classifying
1.4. Providing examples or evidence
1.5. Writing introduction and conclusion

Module V: Writing Practices
1.1. Comprehension
1.2. Précis Writing
1.3. Essay Writing

Module VI: Oral Communication
(This Module involves interactive practice sessions in Language Lab)

- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations: Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

SUGGESTED READINGS:

1. Practical English Usage. Michael Swan. OUP. 1995.
2. Remedial English Grammar. F.T. Wood. Macmillan.2007
3. On Writing Well. William Zinsser. Harper Resource Book. 2001
4. Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
5. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
6. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press.
7. Effective Communication Skills. Kulbhushan Kumar. Khanna Publishing House.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	ENGLISH LANGUAGE FOR COMPETITIVE EXAMS	PROF. AYSHA IQBAL	IIT MADRAS
2.	TECHNICAL ENGLISH FOR ENGINEERS	PROF. AYSHA IQBAL	IITM

COURSE OUTCOMES: The student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

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Course Code	:	ES104
Course Title	:	Workshop/Manufacturing Practices
Number of Credits	:	3 (L: 1, T: 0, P: 4)
Course Category	:	ES

Course Objective:

1. To provide exposure to the students with hands on experience on various basic engineering practices in Civil, Mechanical, Electrical and Electronics Engineering.
2. To have a study and hands-on-exercise on plumbing and carpentry components.
3. To have a practice on gas welding, foundry operations and fitting
4. To have a study on measurement of electrical quantities, energy and resistance to earth.
5. To have a practice on soldering.

COURSE CONTENTS:

Module I: Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods.
Module II: CNC machining, Additive manufacturing.
Module III: Fitting operations & power tools.
Module IV: Electrical & Electronics.
Module V: Carpentry.
Module VI: Plastic moulding, glass cutting.
Module VII: Metal casting.
Module VIII: Welding (arc welding & gas welding), brazing.

PRACTICALS:

1. Machine shop
2. Fitting shop
3. Carpentry
4. Electrical & Electronics
5. Welding shop (Arc welding + Gas welding)
6. Casting
7. Smithy

8. Plastic molding & Glass Cutting

Examinations could involve the actual fabrication of simple components, utilizing one or more of the techniques covered above.

Suggested Text/Reference Books:

1. Veerana D.K., Workshop Manufacturing Practices, AICTE-Khanna Publishing Published
2. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
3. Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.
4. Gowri P. Hariharan and A. Suresh Babu," Manufacturing Technology – I" Pearson Education, 2008.
5. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.
6. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw Hill House, 2017.

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	Welding shop (Arc welding + Gas welding).	http://mm-coep.vlabs.ac.in/LaserSpotWelding/Theory.html?domain=Mechanical%20Engineering&lab=Welcome%20to%20Micromachining%20laboratory
2	Casting	http://fab-coep.vlabs.ac.in/exp7/Theory.html?domain=Mechanical%20Engineering&lab=Welcome%20to%20FAB%20laboratory

Course Outcomes: Upon completion of this course, the students will gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.

Laboratory Outcomes:

- Upon completion of this laboratory course, students will be able to fabricate components with their own hands.
- They will also get practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes.
- By assembling different components, they will be able to produce small devices of their interest.

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Course code	**UHV-II or HSMC (H-102)**				
Category	**Universal Human Values (UHV)**				
Course Title	**Universal Human Values-II: Understanding Harmony And Ethical Human Conduct**				
Scheme and Credits	**L**	**T**	**P**	**C**	
	2	**1**	**0**	**3**	
Pre-requisites (if any)	**None.** **Desirable – UHV-I: Universal Human Values-Introduction**				

1-COURSES ON HUMAN VALUES

During the Induction Program, students would get an initial exposure to human values through Universal Human Values-I. This exposure is to be augmented by this compulsory full semester foundation course.

Objectives of UHV-II Course

This introductory course input is intended:

1. To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
2. To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
3. To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature.

Thus, this course is intended to provide a much-needed orientational input in value education to the young enquiring minds.

Salient Features of the Course

The salient features of this course are:

1. It presents a universal approach to value education by developing the right understanding of reality (i.e. a worldview of the reality “as it is”) through the process of self-exploration.
2. The whole course is presented in the form of a dialogue whereby a set of proposals about various aspects of the reality are presented and the students are encouraged to self-explore the proposals by verifying them on the basis of their natural acceptance within oneself and validate experientially in living.
3. The prime focus throughout the course is toward affecting a qualitative transformation in the life of the student rather than just a transfer of information.
4. While introducing the holistic worldview and its implications, a critical appraisal of the prevailing notions is also made to enable the students discern the difference on their own right.

Course Methodology

1. The methodology of this course is explorational and thus universally adaptable. It involves a systematic and rational study of the human being vis-à-vis the rest of existence.
2. The course is in the form of 28 lectures (discussions) and 14 practice sessions.
3. It is free from any dogma or value prescriptions.
4. It is a process of self-investigation and self-exploration, and not of giving sermons. Whatever is found as truth or reality is stated as a proposal and the students are facilitated to verify it in their own right, based on their Natural Acceptance and subsequent Experiential Validation – the whole existence is the lab and every activity is a source of reflection.
5. This process of self-exploration takes the form of a dialogue between the teacher and the students to begin with, and then to continue within the student in every activity, leading to continuous self-evolution.
6. This self-exploration also enables them to critically evaluate their pre-conditionings and present beliefs.

2-COURSE TOPICS

The course has 28 lectures and 14 tutorials in 5 modules. The lectures and tutorials are of 01-hour duration. Tutorial sessions are to be used to explore and practice what has been proposed during the lecture sessions.

The Teacher's Manual provides the outline for lectures as well as practice sessions. The teacher is expected to present the issues to be discussed as propositions and encourage the students to have a dialogue.

The syllabus for the lectures and practice sessions is given below:

Module 1 – Introduction to Value Education (6 lectures and 3 tutorials for practice session)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)
Lecture 2: Understanding Value Education
Tutorial 1: **Practice Session PS1** Sharing about Oneself
Lecture 3: Self-exploration as the Process for Value Education
Lecture 4: Continuous Happiness and Prosperity – the Basic Human Aspirations
Tutorial 2: Practice Session PS2 Exploring Human Consciousness
Lecture 5: Happiness and Prosperity – Current Scenario
Lecture 6: Method to Fulfill the Basic Human Aspirations
Tutorial 3: Practice Session PS3 Exploring Natural Acceptance

Expected outcome:

The students start exploring themselves: get comfortable with each other and with the teacher; they start appreciating the need and relevance for the course.

The students start finding that technical education without study of human values can generate more problems than solutions. They also start feeling that lack of understanding of human values is the root cause of most of the present-day problems; and a sustained solution could emerge only through understanding of value-based living. Any solution brought out through fear, temptation of dogma will not be sustainable.

The students are able to see that verification on the basic of natural acceptance and experiential validation through living is the only way to verify right or wrong, and referring to any external source like text or instrument or any other person cannot enable them to verify with authenticity; it will only develop assumptions.

The students are able to see that their practice in living is not in harmony with their natural acceptance most of the time, and all they need to do is to refer to their natural acceptance to overcome this disharmony.

The students are able to see that lack of right understanding leading to lack of relationship is the major cause of problems in their family and not the lack of physical facility in most of the cases, while they have given higher priority to earning of physical facility in their life giving less value to or even ignoring relationships and not being aware that right understanding is the most important requirement for any human being.

Module 2 – Harmony in the Human Being (6 lectures and 3 tutorials for practice session)

Lecture 7: Understanding Human being as the Co-existence of the Self and the Body
Lecture 8: Distinguishing between the Needs of the Self and the Body
Tutorial 4: Practice Session PS4 Exploring the difference of Needs of Self and Body
Lecture 9: The Body as an Instrument of the Self
Lecture 10: Understanding Harmony in the Self
Tutorial 5: Practice Session PS5 Exploring Sources of Imagination in the Self
Lecture 11: Harmony of the Self with the Body
Lecture 12: Programme to ensure self-regulation and Health
Tutorial 6: Practice Session PS6 Exploring Harmony of Self with the Body

Expected outcome:

The students are able to see that they can enlist their desires and the desires are not vague. Also they are able to relate their desires to 'I' and 'Body' distinctly. If any desire appears related to both, they are able to see that the feeling is related to I while the physical facility is related to the body. They are also able to see that 'I' and Body are two realities, and most of their desires are related to 'I' and not body, while their efforts are mostly centered on the fulfilment of the needs of the body assuming that it will meet the needs of 'I' too.

The students are able to see that all physical facility they are required for a limited time in a limited quantity. Also, they are able to see that in case of feelings, they want continuity of

the naturally acceptable feelings and they do not want feelings which are not naturally acceptable even for a single moment.

The students are able to see that activities like understanding, desire, though and selection are the activities of 'I' only the activities like breathing, palpitation of different parts of the body are fully the activities of the body with the acceptance of 'I' while the activities they do with their sense organs like hearing through ears, seeing through eyes, sensing through touch, tasting through tongue and smelling through nose or the activities they do with their work organs like hands, legs etc. are such activities that require the participation of both 'I' and body.

The students become aware of their activities of 'I' and start finding their focus of attention at different moments. Also they are able to see that most of their desires are coming from outside (through preconditioning or sensation) and are not based on their natural acceptance.

The students are able to list down activities related to proper upkeep of the body and practice them in their daily routine. They are also able to appreciate the plants wildly growing in and around the campus which can be beneficial in curing different diseases.

Module 3 – Harmony in the Family and Society (6 lectures and 3 tutorials for practice session)

Lecture 13: Harmony in the Family – the Basic Unit of Human Interaction
Lecture 14: 'Trust' – the Foundational Value in Relationship
Tutorial 7: Practice Session PS7 Exploring the Feeling of Trust
Lecture 15: 'Respect' – as the Right Evaluation
Tutorial 8: Practice Session PS8 Exploring the Feeling of Respect
Lecture 16: Other Feelings, Justice in Human-to-Human Relationship
Lecture 17: Understanding Harmony in the Society
Lecture 18: Vision for the Universal Human Order
Tutorial 9: Practice Session PS9 Exploring Systems to fulfil Human Goal

Expected outcome:
The students are able to note that the natural acceptance (intention) is always for living in harmony, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others' intention as a result we conclude that I am a good person and other is a bad person.

The students are able to see that respect is right evaluation, and only right evaluation leads to fulfillment in relationship. Many present problems in the society are an outcome of differentiation (lack of understanding of respect), like gender biasness, generation gap, caste conflicts, class struggle, dominations through power play, communal violence, clash of isms and so on so forth. All these problems can be solved by realizing that the other is

like me as he has the same natural acceptance, potential and program to ensure a happy and prosperous life for them and for others through he may have different body, physical facility or beliefs.

The students are able to use their creativity for education children. The students are able to see that they can play a role in providing value education for children. They are able to put in simple words the issues that are essential to understand for children and comprehensible to them. The students are able to develop an outline of holistic model for social science and compare it with the existing model.

Module 4 – Harmony in the Nature/Existence (4 lectures and 2 tutorials for practice session)

Lecture 19: Understanding Harmony in the Nature
Lecture 20: Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature
Tutorial 10: Practice Session PS10 Exploring the Four Orders of Nature
Lecture 21: Realizing Existence as Co-existence at All Levels
Lecture 22: The Holistic Perception of Harmony in Existence
Tutorial 11: Practice Session PS11 Exploring Co-existence in Existence

Expected outcome:
The students are able to differentiate between the characteristics and activities of different orders and study the mutual fulfilment among them. They are also able to see that human being s are not fulfilling to other orders today and need to take appropriate steps to ensure right participation (in terms of nurturing, protection and right utilization) in the nature.

The students feel confident that they can understand the whole existence; nothing is a mystery in this existence. They are also able to see the interconnectedness in the nature, and point out how different courses of study relate to the different units and levels. Also, they are able to make out how these courses can be made appropriate and holistic.

Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics (6 lectures and 3 tutorials for practice session)

Lecture 23: Natural Acceptance of Human Values
Lecture 24: Definitiveness of (Ethical) Human Conduct
Tutorial 12: Practice Session PS12 Exploring Ethical Human Conduct
Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order
Lecture 26: Competence in Professional Ethics
Tutorial 13: Practice Session PS13 Exploring Humanistic Models in Education
Lecture 27: Holistic Technologies, Production Systems and Management Models-Typical Case Studies
Lecture 28: Strategies for Transition towards Value-based Life and Profession

Tutorial 14: Practice Session PS14 Exploring Steps of Transition towards Universal Human Order

Expected outcome:

The students are able to present sustainable solutions to the problems in society and nature. They are also able to see that these solutions are practicable and draw roadmaps to achieve them.

The students are able to grasp the right utilization of their knowledge in their streams of Technology/Engineering/Management/any other area of study to ensure mutual fulfilment. E.g. mutually enriching production system with rest of nature.

The students are able to sincerely evaluate the course and share with their friends. They are also able to suggest measures to make the course more effective and relevant. They are also able to make use of their understanding in the course for the happy and prosperous family and society.

Guidelines and Content for Practice Sessions (Tutorials)

In order to connect the content of the proposals with practice (living), 14 practice sessions have been designed. The full set of practice sessions is available in the Teacher's Manual as well as the website.

Practice Sessions for Module 1 – Introduction to Value Education

PS1 Sharing about Oneself

PS2 Exploring Human Consciousness

PS3 Exploring Natural Acceptance

Practice Sessions for Module 2 – Harmony in the Human Being

PS4 Exploring the difference of Needs of Self and Body

PS5 Exploring Sources of Imagination in the Self

PS6 Exploring Harmony of Self with the Body

Practice Sessions for Module 3 – Harmony in the Family and Society

PS7 Exploring the Feeling of Trust

PS8 Exploring the Feeling of Respect

PS9 Exploring Systems to fulfil Human Goal

Practice Sessions for Module 4 – Harmony in the Nature (Existence)

PS10 Exploring the Four Orders of Nature

PS11 Exploring Co-existence in Existence

Practice Sessions for Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics

PS12 Exploring Ethical Human Conduct

PS13 Exploring Humanistic Models in Education

PS14 Exploring Steps of Transition towards Universal Human Order

As an example, PS 7 is a practice session in module 3 regarding trust. It is explained below:

PS 7: Form small groups in the class and in that group initiate dialogue and ask the eight questions related to trust. The eight questions are:

1a. Do I want to make myself happy?	1b. Am I able to make myself always happy?
2a. Do I want to make the other happy?	2b. Am I able to make the other always happy?
3a. Does the other want to make him happy?	3b. Is the other able to make him always happy?
4a. Does the other want to make me happy?	4b. Is the other able to make me always happy?
Intention (Natural Acceptance)	Competence
What is the answer?	What is the answer?

Let each student answer the questions for himself/herself and everyone else. Discuss the difference between intention and competence. Observe whether you evaluate your intention and competence as well as the others' intention and competence.

Expected outcome of PS 7: The students are able to see that the first four questions are related to our Natural Acceptance i.e. intention and the next four to our Competence. They are able to note that the intention is always correct, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others' intention, as a result we conclude that I am a good person and other is a bad person.

3-READINGS:

3-1-Text Book and Teachers Manual

a. The Textbook

A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1

b. The Teacher's Manual

Teachers' Manual for A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-

3-2-Reference Books

1. JeevanVidya: EkParichaya, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).

4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj – Pandit Sunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

4-MODE OF CONDUCT (L-T-P-C 2-1-0-3)

Lecture hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.

Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and self-exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up" ordinary" situations rather than" extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department.

Teacher preparation with a minimum exposure to at least one 8-day Faculty Development Program on Universal Human Values is deemed essential.

5-SUGGESTED ASSESSMENT:

This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:

Assessment by faculty mentor: 10 marks
Self-assessment: 10 marks
Assessment by peers: 10 marks
Socially relevant project/Group Activities/Assignments: 20 marks
Semester End Examination: 50 marks
The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

6-OUTCOME OF THE COURSE:

By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

Therefore, the course and further follow up is expected to positively impact common graduate attributes like:

1. Holistic vision of life
2. Socially responsible behaviour
3. Environmentally responsible work
4. Ethical human conduct
5. Having Competence and Capabilities for Maintaining Health and Hygiene
6. Appreciation and aspiration for excellence (merit) and gratitude for all

This is only an introductory foundational input. It would be desirable to follow it up by
a) Faculty-student or mentor-mentee programs throughout their time with the institution
b) Higher level courses on human values in every aspect of living.

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SEMESTER – III

SEMESTER III

Course Code	:	HS201
Course Title	:	Effective Technical Communication
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	HS

COURSE CONTENT:

Module 1: Information Design and Development- Different kinds of technical documents, Information development life cycle, Organization structures, factors affecting information and document design, Strategies for organization, Information design and writing for print and for online media.

Module 2: Technical Writing, Grammar and Editing- Technical writing process, forms of discourse, Writing drafts and revising, Collaborative writing, creating indexes, technical writing style and language. Basics of grammar, study of advanced grammar, editing strategies to achieve appropriate technical style. Introduction to advanced technical communication, Usability, Human factors, Managing technical communication projects, time estimation, Single sourcing, Localization.

Module 3: Self Development and Assessment- Self assessment, Awareness, Perception and Attitudes, Values and belief, Personal goal setting, career planning, Self-esteem. Managing Time; Personal memory, Rapid reading, taking notes; Complex problem solving; Creativity.

Module 4: Communication and Technical Writing- Public speaking, Group discussion, Oral; presentation, Interviews, Graphic presentation, Presentation aids, Personality Development. Writing reports, project proposals, brochures, newsletters, technical articles, manuals, official notes, business letters, memos, progress reports, minutes of meetings, event report.

Module 5: Ethics- Business ethics, Etiquettes in social and office settings, Email etiquettes, Telephone Etiquettes, Engineering ethics, managing time, Role and responsibility of engineer, Work culture in jobs, Personal memory, Rapid reading, Taking notes, Complex problem solving, Creativity.

TEXT BOOKS/REFERENCES:

1. David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004.
2. Kulbhushan Kumar, Effective Communication Skills, Khanna Publishing House, 2019.
3. Diane Hacker, Pocket Style Manual, Bedford Publication, New York, 2003. (ISBN 0312406843).
4. Shiv Khera, You Can Win, Macmillan Books, New York, 2003.
5. Raman Sharma, Technical Communications, Oxford Publication, London, 2004.
6. Dale Jungk, Applied Writing for Technicians, McGraw Hill, New York, 2004. (ISBN: 07828357-4)

7. Sharma, R. and Mohan, K. Business Correspondence and Report Writing, TMH New Delhi 2002.
8. Xebec, Presentation Book, TMH New Delhi, 2000 (ISBN 0402213).

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Course Code	:	BS201
Course Title	:	Mathematics III (Probability and Statistics)
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	BS

Course Objective: The main objective of this course is to provide students with the foundations of probabilistic and statistical methods and analysis techniques mostly used in various applications in engineering and science like modelling of processes and predictions based on processes.

Course Content: Probability spaces, conditional probability, Bayes' theorem; random variables, probability distribution functions, joint distributions, independence, mathematical expectations, Chebyshev's inequality; special distributions: binomial, hypereometric, Poisson, exponential, uniform, normal distributions. Random sampling, sample mean, sample variance, weak law of large numbers and central limit theorems; estimation of parameters, the method of maximum likelihood estimation, confidence intervals, testing of hypotheses, goodness of fit, nonparametric tests, correlation analysis.

Text Books:

1. A. Papoulis and S.U. Pillai, Probability Random Variables and Stochastic Processes, 4th Ed., McGraw-Hill, 2002.
2. L. Garcia, Probability and Random Processes for Electrical Engineering, 2nd Ed., Addison-Wesley, 1993.
3. Reena Garg and Chandrika Prasad, Advanced Engineering Mathematics, Khanna Book Publishing Company, 2020.

References:

1. P.Z. Peebles, Probability, Random Variables and Random Signal Principles, 4th Ed., Mc-Graw Hill, 2000.
2. H. Stark and J.W. Woods, Probability and Random Processes with Applications to Signal Processing, Prentice Hall, 2002.
3. K. L. Chung and F. AitSahlia, Elementary Probability Theory with Stochastic Processes
4. Introduction to Mathematical Finance, 4th Ed., Springer-Verlag, 2003.
5. Amit Gupta, Manish Sharma, The Practice of Business Statistics, Khanna Book Publishing, 2010.

Course Outcomes:

Students will be able to use appropriate statistical terms to describe data and understand probability space and conditional probability applications.

- Identify the types of data (qualitative, quantitative, discrete, and continuous).
- Identify the types of sampling (random, stratified, systematic, cluster).

- Identify the misuses of statistics.

Student will use appropriate statistical methods to collect, organize, display, and analyse relevant data.

- Apply graphical methods of displaying data.
- Construct frequency distributions, histograms, frequency polygons, pareto charts, ogives, pie charts, and box-and-whisker plots.
- Read and analyze frequency distributions, histograms, frequency polygons, pie charts, and box-and-whisker plots.

Students will apply basic concepts of probability.

- Calculate combinations and permutations.
- Apply the rules of probability (addition, conditional, multiplication).
- Apply the terms of probability (mutually exclusive, independent, and dependent)

Students will apply concepts of various probability distributions and understand probability distribution for discrete random variables (general, binomial, hypergeometric, Poisson, multinomial) and use them to make predictions about the probability of certain events.

Students will apply concepts of the normal distribution to apply the central limit theorem, Apply Chebyshev's Theorem and Use normal distribution to find probabilities for continuous random variables.

Students will make estimations for a mean, variance, standard deviation and proportions. Will understand methods for maximum likelihood estimation. Will be able to calculate estimations for a mean (large or small samples), variance (large or small samples), standard deviation (large or small samples) and a proportion (large samples)

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Course Code	:	ES201
Course Title	:	Applied Digital Logic Design
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	ES

Course Objective: This course is aimed for the first year students to learn and implement hardware designs with rapid prototyping. The course will cover basics of digital circuits and detailed concepts of implementing those using Hardware Definition Languages like Verilog. The students will implement the designs on FPGA based platform. This course will provide an insight to hardware level implementation of digital systems, which will pave the way for practical understanding of Computer Architecture, Microprocessors, Communications, Controls, Digital Signal Processing and Embedded Systems etc.

Course Contents: Introduction to FPGA and Hardware Description Languages (HDLs), Combinational Circuits – Logic gates, Boolean Algebra, gate-level minimization, Circuit design and implementation, Adders, Comparators, Multiplexers, Decoders/encoders, Applications, Data storage elements – Latches, Flip-Flops, Register, Memory, Applications, Sequential Circuits – State tables and diagrams, State representation in HDLs, Timing in sequential circuits, Shift register, Counters.

The course shall be based on HDL programming and synthesis of digital circuits on various basic FPGA based learning boards.

List of Practical: The course shall have a weekly lab associated with about 10 experiments to program hardware circuits leading up to a fairly complex circuit such as CPU. Some of the labs are the following

1. Familiarization with the synthesis tools and FPGA board. A simple sample HDL code shall be given to the students for them to key it in, simulate and synthesize for FPGA, download on FPGA and observer the behavior of the program.
2. Use of FPGA board. 7 segment decoder where the students shall make a simple combinatorial circuit for given two binary numbers (each 4-bit, a total of 8 bits) through flip switches on the board and see the output on the 7 segment displays by decoding them to light appropriate set of segments on the display.
3. Use of FPGA board for implementing arithmetic circuits such as 4-bit binary adder. The inputs shall be taken from the flip switches and the output displayed on the 7 segment display.
4. Make a digital clock by taking appropriate frequency division such that the output is changed each second. The clock should display hh.mm.ss format and in case the FPGA boards do not have sufficient 7 segment displays, seconds may be shown on a blinking LEDs with output in hh.mm format.
5. Implementation of a digital shift-and-add multiplier where the inputs are taken on the flip switches and outputs are shown on seven segment displays (one operation as a time). A press switch may be used to cycle through the steps of the multiplier.
6. Implementation of a bit-restoring division circuit with inputs given on flip switches (one input at a time) and the steps of the division circuit cycled through the press switch on the board.
7. Implementation on an ALU whose inputs are from the flip switches and outputs on the 7-segment display. The operations to be performed is fed thorough another set of switches. (two labs)
8. Implementation of a simple 8-bit counter using de-bouncing logic and a press switch to cycle through the count. The counter can be enhanced to count in steps of 3, in steps of 5 etc.
9. Implementation of a simple traffic controller which will simulate and cycle through the red, green, yellow lights on a cross junction of roads. The lights may be shown on the LEDs.

Text/Reference Books:

1. M. Morris R. Mano and Michael D. Ciletti, “Digital Design”, Prentice Hall; 5th Edition 2012.
2. Samir Palnitkar, “Verilog HDL”, 2nd Edition, Pearson Education, 2003.

Course Outcomes: By the end of this course, students will be able to:

1. Describe basic Combinational and Sequential circuits using Verilog;
2. Describe the circuits in behavioral and structural paradigm;
3. Test the circuits using test benches;
4. Synthesize the Verilog models on FPGAs (using standard CAD software) and test the implementations.

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Course Code	:	ES203
Course Title	:	Introduction to Data Structure and Algorithms
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	ES

Course Objective: To introduce the fundamental concept of data structures and to emphasize the importance of choice of correct data structures in developing and implementing efficient algorithms and to introduce simple data structure and algorithms which are the building blocks for more complex data structures used in problem solving using programming. Further the students should be able to decompose bigger problems using abstractions such as object oriented designs and programming and develop effective techniques of software engineering such as decomposition, procedural abstraction, and software reuse.

Course Contents: Stacks, Queues, Lists; Sorting and Searching; Trees, Tree Traversals, Heaps; Binary Search, Binary Search Trees; Graphs: Representations, Depth First Search, Breadth First Search. Abstract data types and uses in designs, Introduction to OOD and OOP, templates and STL, Algorithm analysis; worst and average case; Recurrences and asymptotes; Algorithms for sorting and selection; Randomized techniques; Search structures: heaps, balanced trees, skip lists, hash tables; Dynamic programming and greedy algorithms; Graph algorithms: breadth- and depth-first search, MSTs, shortest paths; NP-Complete problems.

List of Practicals:

The practice problems should be given in the class (at least one set of problems, usually one or two programming problems, per week). Normally, there is no defined lab hours for the practice problems. Institutes may, however depending upon the local conditions, choose to have three-hour lab per week for students to solve the practice problems.

The practice problems should be in synch with the class room teaching and should cover the concepts of data structures to be implemented in the programming problems such as implementation of data structures using OOD methods and abstraction of data structures using operations defined on them and then using these data structures build a problem solution that the instructor may choose.

Text/Reference Books:

1. T. H. Cormen, C. E. Leiserson, R L Rivest and C Stein, "Introduction to Algorithms" 3rd Edition, MIT press, 2009.
2. R.S. Salaria, "Data Structures", Khanna Publishing House, 2021.
3. Seymour Lipschutz, "Data Structures", McGraw Hill Education; 1st edition, 2014.
4. R.B. Patel, "Expert Data Structures with C", Khanna Book Publishing Company, 2020.
5. M. A. Weiss, Data Structures and Problem Solving Using Java, Addison-Wesley, 1997.
6. M. Tannenbaum, Y Langsam and M J Augenstein, Data Structures Using C++, Prentice Hall India, 1996.
7. A. H. Aho, J. E. Hopcroft and J. Ullman, Data Structures and Algorithms, Addison-Wesley, 1987.

Course Outcomes:

The students will be able to:

- Assess how the choice of data structures and algorithm design methods impacts the performance of programs.
- Choose the appropriate data structure and algorithm design method for a specified application.
- Write programs using object-oriented design principles.
- Solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, tournament trees, binary search trees, and graphs and writing programs for these solutions.
- Solve problems using algorithm design methods such as the greedy method, divide and conquer, dynamic programming, backtracking, and branch and bound and writing programs for these solutions.

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Course Code	:	PC201
Course Title	:	Discrete Mathematics
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

Course Objective:

The course aims for students to develop logical thinking and its application to computer science, especially to emphasize the importance of proving statements correctly and de-emphasize the hand-waving approach towards correctness of an argument. The subject enhances one's ability to reason and ability to present a coherent and mathematically accurate argument. The course also aims as building theoretical concepts behind various higher level concepts such as graphs. The course shall cover proof systems, combinatorics, number theory and graph theory and their relevance for the computer science.

Course Contents: Text/ Sets, relations, functions, Notion of proof: proof by counter-example, the contrapositive, proof by contradiction, inductive proofs. Combinatorics: Basic counting techniques, pigeon-hole principle, recurrence relations, generating functions, Polya's counting theorem. Introduction to probabilistic method in combinatorics, Inclusion-exclusion principle, Introduction to number theory and group theory. Introduction to graph theory, graph representation, tree, weighted trees, simple graph

theory problems including minimal spanning tree, graph coloring problems, min cut max flow problems etc.

Text Books:

1. C. L. Liu, Elements of Discrete Mathematics, 2nd Ed., Tata McGraw-Hill, 2000.
2. R. C. Penner, Discrete Mathematics: Proof Techniques and Mathematical Structures, World Scientific, 1999.
3. S.B. Singh, Discrete Structures, Khanna Book Publishing Company, 2019.

References:

1. R. L. Graham, D E Knuth, and O Patashnik, Concrete Mathematics, 2nd Ed., Addison-Wesley, 1994.
2. K. H. Rosen, Discrete Mathematics & its Applications, 6th Ed., Tata McGraw-Hill, 2007.
3. J. L. Hein, Discrete Structures, Logic, and Computability, 3rd Ed., Jones and Bartlett, 2010.
4. N. Deo, Graph Theory, Prentice Hall of India, 1974.
5. S. Lipschutz and M. L. Lipson, Schaum's Outline of Theory and Problems of Discrete Mathematics, 2nd Ed., Tata McGraw-Hill, 1999.
6. J. P. Tremblay and R. P. Manohar, Discrete Mathematics with Applications to Computer Science, Tata McGraw-Hill, 1997.

Course Outcomes:

The students will be:

- Be able to construct simple mathematical proofs and to verify them
- Have substantial experience to comprehend formal logical arguments
- Be skillful in expressing mathematical properties formally via the formal language of propositional logic and predicate logic
- Be able to specify and manipulate basic mathematical objects using sets, functions etc.
- Be able to apply the knowledge of combinatorics and its applications such as pigeon hole principles, recurrence relations, generator functions, counting principles etc.
- Acquire ability to describe computer programs (e.g. recursive functions) in a formal mathematical manner
- Gain experience in using various techniques of mathematical induction (weak, strong and structural induction) to prove simple mathematical properties of a variety of discrete structures
- Build upon the graph theory principles to solve a variety of computing applications.

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Course Code	:	PC203
Course Title	:	Digital Signal Processing
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

Course Objective:

The objective of this course is to familiarize students with the concept of digital signal and processing of these signals using building blocks of linear systems, time invariant systems,

conversion from time domain to frequency domain and vice versa, discrete systems and application of sampling on continuous signals to discrete domain. Various transformation techniques such as digital filter design, adaptive filtering etc. shall also be introduced.

Course Contents: Introduction to Signal and Systems, Discrete systems, Linear systems, time invariant systems, time and frequency representation of signals, sampling and data reconstruction processes, Z-transforms, Discrete-Time Fourier Transform (DTFT), Frequency Domain Analysis of LTI Systems, Discrete Fourier transform and FFT algorithms, linear phase systems, FIR and IIR filters, Digital Filter Design principle with examples, Quantization effects in digital filters, Multi-rate signal processing: sampling rate conversion, adaptive filtering.

Text Books:

1. A. V. Oppenheim and R. W. Shafer, Discrete-Time Signal Processing, Prentice Hall India, 2nd Ed., 2004.
2. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4th Ed., Pearson Education, 2007.

References:

1. V.K. Ingle and J.G. Proakis, Digital signal processing with MATLAB, Cengage, 2008.
2. S. K. Mitra, Digital Signal Processing: A Computer-Based Approach, 3rd Ed., Tata McGraw Hill, 2006.
3. T. Bose, Digital Signal and Image Processing, John Wiley and Sons, Inc., Singapore, 2004.
4. L. R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall India, 2005.
5. A. Antoniou, Digital Filters: Analysis, Design and Applications, Tata McGraw-Hill, New Delhi, 2003.
6. T. J. Cavicchi, Digital Signal Processing, John Wiley and Sons, Inc., Singapore, 2002.
7. E. C. Ifeachor and B. W. Jervis, Digital Signal Processing, Pearson Education, 2006.

Course Outcomes:

At the end of the course, a student will be able to:

- Understand the notion of discrete signals and use concepts such as sampling theorem etc. of define the sampling rates for conversion of a continuous signal to discrete signal.
- Understand and apply the concept of time domain signals to frequency domain and vice versa including conversions.
- Select proper tools for analog-to-digital and digital-to-analog conversion. Also select proper tools for time domain and frequency domain implementation.
- Use concepts of complex algebra, Fourier transform, Z-transform etc. to analyze the operations on signals and acquire knowledge about Systems
- Design, implementation, analysis and comparison of digital filters for processing of discrete time signals
- Integrate computer-based tools of digital signal processing for engineering applications

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Course Code	:	PC205
Course Title	:	Theory of Computation
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

Course Objective:
The objectives of this course are to make students understand the mathematical foundations of computation including automata theory; the theory of formal languages and grammars; the notions of algorithm, decidability, complexity, and computability and to enhance/develop students' ability to understand and conduct mathematical proofs for computation and algorithms.

Course Contents: Alphabets, languages, finite state machines - deterministic and non-deterministic finite automata. Context Free Grammars, Context Free Languages, Parse trees, push down Automata, pumping lemma for CFLs and applications, CYK algorithm Turing machines, Variants, Undecidability theory, Time and Space bounded computation. Reductions, theory of NP completeness. Introduction to linear and non-linear optimization: Formulation and geometrical ideas of linear programming problems, simplex Method, duality, method of Lagrange multipliers, KKT conditions, convex optimization, quadratic optimization, numerical methods for constrained optimization, dynamic programming.

Text Books:
1. J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, 2nd Ed., Pearson Education, 2000.
2. Prem Nath, R.B. Patel, Theory of Computation, 2nd Ed., Khanna Book Publishing Company, 2020.

References:
1. M. Sipser, Introduction to the Theory of Computation, Thomson, 2004.
2. H. R. Lewis and C. H. Papadimitriou, Elements of the Theory of Computation, Pearson Education Asia, 2001.
3. D. C. Kozen, Automata and Computability, Springer-Verlag, 1997.

Course Outcomes:

Upon successful completion of this course, the students will be able to

- discuss key notions of computation, such as algorithm, computability, decidability, reducibility, and time and space complexity.
- explain the models of computation, including formal languages, grammars and automata, and their connections.
- analyze and design finite automata, pushdown automata, Turing machines, formal languages, and grammars.
- solve computational problems regarding their computability and complexity and prove the basic results of the theory of computation.

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Course Code	:	PC207
Course Title	:	Computer Organization and Design
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

Course Objective:
This course introduces the principles of computer organization and the basic architecture and design concepts of a computer. The course also introduced the machine instructions and programming of a computer using its assembly language. It also describes the arithmetic circuits which are used in the model processors to implement the computer arithmetic and introduces the control circuits and execution of instructions on the processor. The course also introduces the memory technology, memory hierarchy, caches to bridge the speed gap between memory and the processor and various I/O techniques and concepts including interrupt and direct memory transfer.

Course Content: Introduction, Overview of basic digital building blocks; truth tables; basic structure of a digital computer, Number representation, Assembly language programming for some processor, Basic building blocks for the ALU, Adder, Subtractor, Shifter, Multiplication and division circuits, Control path microprogramming (only the idea), hardwired, logic; External interface, Memory organization; Technology-ROM, RAM, EPROM, Flash etc. Cache; Cache coherence protocol for uniprocessor (simple), I/O Subblock, I/O techniques -interrupts, polling, DMA.

Text Books:
1. William Stallings, Computer Organization and Architecture: Designing for Performance, 8/e, Pearson Education India. 2010.
2. D. A. Patterson and J. L. Hennessy, Computer Organization and Design, 4/e, Morgan Kaufmann, 2008.

References:
- A. S. Tanenbaum, Structured Computer Organization, 5/e, Prentice Hall of India, 2009.
- V. C. Hamacher, Z. G. Vranesic and S. G. Zaky, Computer Organization, 5/e, McGraw Hill, 2002.
- J. L. Hennessy and D. A. Patterson, Computer Architecture: A Quantitative Approach, 4/e, Morgan Kaufmann, 2006.
- D. V. Hall, Microprocessors and Interfacing, 2/e, McGraw Hall, 2006.

Course Outcomes:

The students having completed this course shall be able to

- Describe the fundamental organization of a computer system including processor, memory and I/O subsystem.
- Illustrate the mechanisms of instruction execution including fetch, decode and operate
- Explain the functional units of a processor including ALU, register files, control path.
- Explain various components of the machine instructions and addressing modes for operands, instruction formats and program control statements
- Distinguish the organization of various parts of a system memory hierarchy

- Relate the instructions to its execution through the understanding of the hardware for basic arithmetic
- Explain the I/O mechanisms and various modes including polling, interrupt driven and DMA.

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Course Code	:	PC209
Course Title	:	Lab on Software Tools and Techniques
Number of Credits	:	2.5 (L: 1, T: 0, P: 3)
Course Category	:	PC

Course Objective:

The objective of this course is to introduce the contemporary tools and develop skills to be able to use such tools for productivity and various computing mechanisms.

Course Content:

Scripting Languages (shell programming, python, Java Script), Web programming, GUI programming tools, Document Processing tools, Software Management tools, CVS, lab exercise for developing large system and application programs.

List of Practicals:

- A lab each on (a) Linux based Shell programming to carry out bigger tasks including command line inputs, (b) Python based program to do tasks such as finding out if the network external interfaces are working or not (c) Javascript based Web-browser application of dynamic pages.
- Web programming using Python to be able to create forms and submit inputs to the server where they are processed and results are produced
- GUI programming tools using Python and an exercise to be able to create a GUI (in other than an HTML form) and take inputs and process them on the local machine/server.
- LaTeX based document structuring and encouraging the students to write their own CV in LaTeX, compile and view in PDF.
- Software management tools such as version control (SVN), Bug reporting (Bugzila) etc.
- A project worth three labs to build at least 5000 line worth project using the tools covered in this course.

Text Books/ References:

1. E. Nemeth, G. Snyder and T. R. Hein, Linux Administration Handbook, Prentice Hall PTR, 2002.
2. L. Wall, T. Christainsen and J. Orwant, Programming PERL, 3rd Ed, O Reilly, 1999.
3. D. Curry, UNIX Systems Programming for SVR4, O Reilly, 1996.
4. S. Kochan and P. Wood, Unix Shell programming, 3rd Ed, SAMS, 2003.
5. S. Das, Unix System V.4 Concepts and Applications, 3rd Ed, Tata Mcgraw-Hill, 2003.
6. Rubini and J. Corbet, Linux Device Drivers, 2nd Ed, OReilly, 2001.
7. D. Flanagan, Javascript: The Definitive Guide, Fifth Edition, O'REILLY, 2006.
8. D. Gosselin, PHP Programming with MySQL, Course Technology, 2006.

Course Outcomes:

A student after completion of this course will be able to

- Apply the knowledge of software version control to manage big software
- Develop simple web-based applications to handle GUI related software applications.
- Prepare professional looking documents using document management software
- Develop skills to handle power tools for building applications.

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SEMESTER – IV

SEMESTER IV

Course Code	:	AU202
Course Title	:	Environmental Science
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	AU

Course Objective: People working in industries or elsewhere essentially require the knowledge of environmental science so as to enable them to work and produce most efficient, economical and eco-friendly finished products.

- Solve various engineering problems applying ecosystem to produce eco – friendly products.
- Use relevant air and noise control method to solve domestic and industrial problems.
- Use relevant water and soil control method to solve domestic and industrial problems.
- To recognize relevant energy sources required for domestic and industrial applications.
- Solve local solid and e-waste problems.

Course Content:

Unit-1: Ecosystem

- Structure of ecosystem, Biotic & Abiotic components.
- Food chain and food web.
- Aquatic (Lentic and Lotic) and terrestrial ecosystem.
- Carbon, Nitrogen, Sulphur, Phosphorus cycle.
- Global warming -Causes, effects, process, Green House Effect, Ozone depletion.

Unit–2: Air and, Noise Pollution

- Definition of pollution and pollutant, Natural and manmade sources of air pollution (Refrigerants, I.C., Boiler).
- Air Pollutants: Types, Particulate Pollutants: Effects and control (Bag filter, Cyclone separator, Electrostatic Precipitator).
- Gaseous Pollution Control: Absorber, Catalytic Converter, Effects of air pollution due to Refrigerants, I.C., Boiler.
- Noise pollution: sources of pollution, measurement of pollution level, Effects of Noise pollution, Noise pollution (Regulation and Control) Rules, 2000.

Unit-3: Water and Soil Pollution

- Sources of water pollution, Types of water pollutants, Characteristics of water pollutants Turbidity, pH, total suspended solids, total solids BOD and COD: Definition, calculation.
- Waste Water Treatment: Primary methods: sedimentation, froth floatation, Secondary methods: Activated sludge treatment, Trickling filter, Bioreactor, Tertiary Method: Membrane separation technology, RO (reverse osmosis).
- Causes, Effects and Preventive measures of Soil Pollution: Causes-Excessive use of Fertilizers, Pesticides and Insecticides, Irrigation, E-Waste.

Unit– 4: Renewable sources of Energy

- Solar Energy: Basics of Solar energy. Flat plate collector (Liquid & Air). Theory of flat plate collector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills.
- Biomass: Overview of biomass as energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilization and storage of biogas.
- Wind energy: Current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy.
- New Energy Sources: Need of new sources. Different types new energy sources. Applications of (Hydrogen energy, Ocean energy resources, Tidal energy conversion.) Concept, origin and power plants of geothermal energy.

Unit-5: Solid Waste Management, ISO 14000 & Environmental Management

- Solid waste generation- Sources and characteristics of: Municipal solid waste, E-waste, biomedical waste.
- Metallic wastes and Non-Metallic wastes (lubricants, plastics, rubber) from industries. Collection and disposal: MSW (3R, principles, energy recovery, sanitary landfill), Hazardous waste.
- Air quality act 2004, air pollution control act 1981 and water pollution and control act1996. Structure and role of Central and state pollution control board.
- Concept of Carbon Credit, Carbon Footprint.
- Environmental management in fabrication industry.
- ISO14000: Implementation in industries, Benefits.

Text Books/References:

1. S.C. Sharma & M.P. Poonia, Environmental Studies, Khanna Publishing House, New Delhi.
2. C.N. R. Rao, Understanding Chemistry, Universities Press (India) Pvt. Ltd., 2011.
3. Arceivala, Soli Asolekar, Shyam, Waste Water Treatment for Pollution Control and
4. Reuse, Mc-Graw Hill Education India Pvt. Ltd., New York, 2007, ISBN:978-07-062099-
5. Nazaroff, William, Cohen, Lisa, Environmental Engineering Science, Willy, New York, 2000, ISBN 10: 0471144940.
6. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi
7. Rao, C. S., Environmental Pollution Control and Engineering, New Age International Publication, 2007, ISBN: 81-224-1835-X.
8. Rao, M. N.Rao, H.V.N, Air Pollution, Tata Mc-Graw Hill Publication, New delhi, 1988, ISBN: 0-07- 451871-8.
9. Frank Kreith, Jan F Kreider, Principles of Solar Engineering, McGraw-Hill, New York; 1978, ISBN: 9780070354760.
10. Aldo Vieira, Da Rosa, Fundamentals of renewable energy processes, Academic Press Oxford, UK; 2013. ISBN: 9780123978257.
11. Patvardhan, A.D, Industrial Solid Waste, Teri Press, New Delhi, 2013, ISBN:978-81-7993-502-6
12. Metcalf & Eddy, Waste Water Engineering, Mc-Graw Hill, New York, 2013, ISBN: 077441206.

13. Keshav Kant, Air Pollution & Control, Khanna Publishing House, New Delhi (Edition 2018)

Open source software and website address:

1. www.eco-prayer.org
2. www.teriin.org
3. www.cpcp.nic.in
4. www.cpcp.gov.in
5. www.indiaenvironmentportal.org.in
6. www.whatis.techtarget.com
7. www.sustainabledevelopment.un.org
8. www.conserve-energy-future.com

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- 15-20% of the topics which are relatively simpler of descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations.
- Micro-projects may be given to group of students for hand-on experiences.
- Encouraging students to visit to sites such as Railway station and research establishment around the institution.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL ID	NPTEL Course Name	Instructor	Host Institute
1	127105018	Introduction to Environmental Engineering and Science - Fundamental and Sustainability Concepts	Prof. Brajesh Kumar Dubey	IIT KGP

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

1. Understand the ecosystem and terminology and solve various engineering problems applying ecosystem knowledge to produce eco – friendly products.
2. Understand the suitable air, extent of noise pollution, and control measures and acts.
3. Understand the water and soil pollution, and control measures and acts.
4. Understand different renewable energy resources and efficient process of harvesting.
5. Understand solid Waste Management, ISO 14000 & Environmental Management.

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Course Code	:	PC202
Course Title	:	Introduction of Artificial Intelligence
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

Course Objective:
The primary objective of this course is to introduce the basic principles, techniques, and applications of Artificial Intelligence with the following goals.

1. Become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
2. Investigate applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.
3. Experiment with a machine learning model for simulation and analysis.
4. Explore the current scope, potential, limitations, and implications of intelligent systems.

Course Content: Problem solving, search techniques, control strategies, game playing (mini-max), reasoning, knowledge representation through predicate logic, rule-based systems, semantic nets, frames, conceptual dependency formalism. Planning. Handling uncertainty: Bayesian Networks, Dempster-Shafer theory, certainty factors, Fuzzy logic, learning through Neural nets -- Backpropagation, radial basis functions, Neural computational models - Hopfield Nets, Bolzman machines, MATLAB programming, introduction to Machine Learning, Supervised and Unsupervised Learning, Introduction to Machine Learning libraries.

Text Books/References:
1. Peter Norvig and Stuart J. Russell, Artificial Intelligence: A Modern Approach, Prentice Hall, 3rd Edition.
2. Kevin Knight, Elaine Rich, B. Nair, Artificial Intelligence, The McGraw-Hill, 3rd Edition.
3. M.C. Trivedi, A classical approach to Artificial Intelligence, Khanna Book Publishing Company Private Limited.

Course Outcomes:

After completion of this course, a student should be able to

- Demonstrate fundamental understanding of artificial intelligence (AI) especially the notion of problem solving using AI techniques, current scope and limitations thereof.
- Apply basic principles of AI in solutions that require problem solving, knowledge representation, and learning.
- Demonstrate awareness and a fundamental understanding of applying AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.
- Demonstrate proficiency developing AI applications using MATLAB.
- Demonstrate proficiency in applying models of machine learning such as supervised and unsupervised learning and use of software libraries for the same.

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Course Code	:	PC204
Course Title	:	Statistical analysis and computing
Number of Credits	:	4 (L: 3, T: 0, P: 2)
Course Category	:	PC

Course Objective:
This course is intended for students to get introduced to methods and tools for statistical computing. The course aims at the contemporary tools and languages for the same using languages such as R, Python and MATLAB. The course shall be accompanied by computational lab for statistical analysis.

Course Content: Probability and statistics: Review, Statistical measures and tests, Statistical analyses using R and Python, and MATLAB, Linear And Polynomial Regression, Hypothesis Testing, Resampling Techniques, and Bootstrapping, Introduction to contemporary statistical packages.

List of Practicals:
1. Implement random number generation using R/Python or MATLAB drawn from various distributions such as Uniform, Normal, Exponential etc. Plot the histograms of the generated numbers and compute the mean and standard deviations.
2. Implement the sampling and verify the central limit theorem.
3. Use the generators for certain distribution and compute the various moments and measures of the central tendency and statistical tests of significance.
4. Use census data from the Govt. of India and perform statistical analysis as defined by the instructor (for example multivariate analysis to find correlation between various attributes of data)
5. Perform linear regression to study the dependency of a dependent variable on various input/predictor variables.
6. Study various types of regularizations and determine which predictor variables are significant.
7. Form a hypothesis and using the given dataset perform hypothesis testing (as defined by the instructor)
8. Perform various types of resampling to address mixed distributions, removing bias.

Text Books / References:
1. B. L. S. Prakasa Rao, A First Course in Probability and Statistics, World Scientific/Cambridge University Press India, 2009.
2. R. V. Hogg, J. W. McKean and A. Craig, Introduction to Mathematical Statistics, 6th Ed., Pearson Education India, 2006.
3. Gareth M. James, Introduction to statistical learning: With applications to R, Springer 2013.
4. Manish Sharma, Amit Gupta, The Practice of Business Statistics, Khanna Book Publishing House, 2010.

Course Outcomes:
At the end of this course a student should be able to
- Process datasets via statistical packages
- Apply various statistical tests to determine the measures of central tendency

- Identify the distribution of the datasets and perform statistical measurements.
- Understand multivariate analysis and perform the same
- Determine the important predictor variables in a regression analysis of the dataset
- Formulate hypothesis and perform a suitable hypothesis test
- Apply resampling to address mixed data distributions, identify and remove biases from the datasets.

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Course Code	:	PC206
Course Title	:	Introduction to Data Analytics and Visualisation
Number of Credits	:	4 (L: 3, T: 0, P: 2)
Course Category	:	PC

Course Objective: This course is intended to provide a broad overview of data analysis and visualization techniques. Students will be given hands-on training in data analytics to build descriptive and predictive models, and validating their models against the actual outcomes. The course will provide various techniques and tools for data analysis of noisy, real life data. Students will be taught how to perform data wrangling, cleaning, and sampling to get a suitable data set; exploratory data analysis; generating hypotheses and building intuition; prediction or statistical learning; communication – summarizing results through various visualization techniques and providing interpretable summaries.

Course Contents: Data science workflow, Automated methods for data collection, Data and Visualization Models, Data wrangling and cleaning, Exploratory data analysis, Dimensionality Reduction. Building and evaluation of models for: Association Analysis, Recommendation Systems, Time-series data, Text Analysis.
Visualization Software and Tools, Visualization Design, Multidimensional Data,
Graphical Perception, Interaction dynamics for Visual Analysis, Using Space
Effectively, Stacked Graphs, Geometry & Aesthetics. Networks, Graph Visualization and navigation in information Visualization, mapping & Cartography, Text Visualization

List of Practicals:
1. Learn how to collect data via web-scraping, APIs and data connectors from suitable sources as specified by the instructor.
2. Perform various types of data cleaning operations on the data collected in previous lab using data exploration, imputation etc.
3. Perform dimensionality reduction on a given dataset and create various visualizations like histograms, scatter-plots, etc.
4. Perform association analysis on a given dataset and evaluate its accuracy.
5. Build a recommendation system on a given dataset and evaluate its accuracy.
6. Build a time-series model on a given dataset and evaluate its accuracy.
7. Build cartographic visualization for multiple datasets involving various countries of the world; states and districts in India etc.
8. Perform text mining on a set of documents and visualize the most important words in a visualization such as word cloud.

Text Books / References:
1. Skiena, Steven S, The Data Science Design Manual, CRC press

2. Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, Introduction to Data Mining (Second Edition)
3. V.K. Jain, Data Science and Analytics (with Python, R and SPSS Programming), Khanna Book Publishing Company.
4. V.K. Jain, Big Data and Hadoop, Khanna Book Publishing Company, 2022.
5. Tamara Munzner, "Visualization Analysis and Design", A K Peters/CRC Press; 1st edition (December 1, 2014)
6. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
7. Matthew O. Ward, Georges Grinstein, Daniel Keim, "Interactive Data Visualization: Foundations, Techniques, and Applications", 2nd Edition, CRC press, 2015.

Course Outcomes:

At the end of this course a student should be able to

- Explain and demonstrate various techniques for automatic data collection, data cleaning and exploration using visualizations.
- Implement data collection, data cleaning and exploration techniques in a programming language.
- Understand and apply modeling and analysis techniques for various types of datasets including e-commerce transactions, review datasets, time series datasets, text documents etc.
- Evaluate different models and their strengths and weakness for a given dataset and task.
- Select methods and create effective visualizations to explain the artifacts in the data, distributions of attributes, relationships between the attributes, efficacy of the models and predictions generated by it.
- Become proficient in data analysis tasks involving real-life datasets with noise.

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Course Code	:	PC208
Course Title	:	Machine Learning
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

Course Objective:

This course builds on the knowledge of AI techniques to the next level of machine learning. In particular, the course aims as providing knowledge for supervised learning, reinforced learning and various advanced techniques of machine learning. The course also looks at several regression models, support vector machines, the classification techniques and clustering mechanisms and various problem solving techniques using advanced computing hardware. The course also provides an introduction to the deep learning.

Course Content: Supervised Learning (Regression/Classification), Linear models: Linear Regression, Logistic Regression, Generalized Linear Models, Support Vector Machines, Nonlinearity and Kernel Methods, Multi-class/Structured Outputs, Bayes Classifier, Reinforcement Learning, Transfer Learning, Ranking, Unsupervised Learning, Clustering: K-means/Kernel K-means, K-NN classifier Dimensionality Reduction: PCA and kernel PCA,

Matrix Factorization and Matrix Completion, Generative Models (mixture models and latent factor models), Assorted Topics, Evaluating Machine Learning algorithms and Model Selection, Ensemble Methods (Boosting, Bagging, Random Forests), Sparse Modeling and Estimation, Introduction to Deep Learning and Feature Representation Learning, How GPUs are used in Deep Learning Networks.

Text Books:

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
2. Jeeva Jose, Introduction to Machine Learning, Khanna Book Publishing Company, 2020

References:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009.
2. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

Course Outcomes:

A student after completing this course should be able to:

- Identify instance based learning algorithms
- Design neural network to solve classification and function approximation problems
- Build optimal classifiers using genetic algorithms
- Analyze probabilistic methods for learning

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Course Code	:	PC210
Course Title	:	Architecture for Management of Large Datasets
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

Course Objective: This course provides an introduction to large scale distributed data analysis abstractions such as MapReduce, a highly successful and widely adopted datacentre-scale programming abstraction. Beginning with quick introduction to relational databases and understanding their limitations, the students will be made familiar with the challenges of unstructured big-data and the tools to handle them. A major focus of this course is distributed/parallel algorithm design to process massive datasets in this new paradigm. Students will learn how to solve problems from a variety of domains: web search, e-commerce, social-networking, machine learning etc.

Students will also be given an overview of the distributed software architectures and how they allow programmers to reason about computations at a massive scale, hiding low-level details such as synchronization, data movement, and fault tolerance. The course will also provide motivation and high-level overview of some of the important and next generation systems like Spark, Storm, Giraph and Hive etc. that are vying to replace Hadoop (a popular implementation of MapReduce) as the de-facto big data processing platform of tomorrow.

Course Content: Introduction to relational databases, database normalizations, limitations of relational databases, structured vs. unstructured data, design of distributed program models and abstractions, such as MapReduce, Dataflow and Vertex-centric models, for processing volume, velocity and linked datasets, and for storing and querying over NoSQL datasets.

Approaches and design patterns to translate existing data-intensive algorithms and analytics into these distributed programming abstractions.

Distributed software architectures, runtime and storage strategies used by Big Data platforms such as Apache Hadoop, Spark, Storm, Giraph and Hive to execute applications developed using these models on commodity clusters and Clouds in a scalable manner.

Text Books:

1. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
2. V.K. Jain, Big Data and Hadoop, Khanna Book Publishing Company 2020.
3. V.K. Jain, Data Science and Analytics (with Python, R and SPSS Programming), Khanna Book Publishing Company.
4. P. J. Sadalage, M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
5. Tom White, "Hadoop: The Definitive Guide", 3/e, O'Reilly, 2012.

Course Outcomes:

At the end of this course a student should be able to

- Understand the pros and cons of the traditional relational databases and need for distributed architecture for data processing of large datasets.
- Implement map reduce programs to solve data analysis tasks.
- Understand and explain distributed software architectures, runtime and storage strategies used by Apache Hadoop.
- Explain the need and use cases for emerging architectures such as Spark, Storm, Giraph, Hive etc. and how they differ from Apache Hadoop.

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Course Code	:	HS202
Course Title	:	Engineering Economics
Number of Credits	:	2 (L: 2, T: 0, P: 0)
Course Category	:	HS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s):

1. This course aims at providing the student with advanced concepts of engineering economic analysis and its role in engineering decision making.
2. Additionally, the course also covers topics such as depreciation, after tax analysis, replacement analysis, uncertainty, inflation, deflation, and estimation of future events.

Course Contents:

- **Introduction:** Definition – Nature – Scope and Significance of Economics for Engineers.
- **Demand and Supply:** Demand – Types – Determinants – Law of Demand – Elasticity of Demand – Types – Significance – Supply – Market price determination – Case Study in Demand Forecasting –- Meaning – Methods – Consumer Survey – Trend Projections – Moving average.
- **Cost and Revenue:** Concepts – Classifications – Short run and long run cost curves – Revenue – Concepts – Measurement of Profit (Case Study).
- **Market Structure:** Perfect Competition – Characteristics – Price and output determination in short run and long run – Monopoly – Price Discrimination – Monopolistic Competition – Product Differentiation – Oligopoly and Duopoly.
- **Market Failure:** Causes – Type of Goods – Rivalrous and Non-rivalrous goods – Excludable and Non-excludable goods – Solutions – Government Intervention.
- **Money and Banking:** Money – Functions – Quantity theory of money – Banking – Commercial Banks – Functions – Central Bank (RBI) – Functions – Role of Banks in Economic Development.
- **Foreign Exchange:** Balance of Payments – Exchange rate determination – Methods of foreign payments – International Institutions – IMF, IBRD.
- **Business Cycle and National Income:** Meaning –Phases of business cycle - Inflation – Causes – Control measures - Deflation - National Income – Concepts – Methods of calculating national income – Problems in calculating national income.

Text Books:

1. Dewett. K.K., Navalur M. H., "Modern Economic Theory", S. Chand and Company Ltd, New Delhi, 24thEdn., 2014.
2. Lipsey & Chrystal, "Economics", Oxford University Press, 2010.
3. Premvir Kapoor, "Sociology and Economics for Engineers", Khanna Book Publishing Company Private Limited, 2018.

References:

1. Paul A Samuelson & William, "Economics", Tata McGraw Hill, New Delhi, 2012.

2. Francis Cherinullem “International Economics”, McGraw Hill Education, 2011.
3. William A McEachern and Simrit Kaur, “Micro ECON”, Cengage Learning, 2013.
4. William A McEachern and Indira A., “Macro ECON”, Cengage Learning, 2014.

Course Outcomes:

1. Describe the role of economics in the decision making process and perform calculations in regard to interest formulas.
2. Estimate the Present, annual and future worth comparisons for cash flows.
3. Calculate the rate of return, depreciation charges and income taxes.
4. Enumerate different cost entities in estimation and costing.
5. Explain the importance of finance functions, financial ratios and solve related problems.
6. Explain the elements of budgeting and benchmarking.

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Course Code	:	EEC 202
Course Title	:	Independent project
Number of Credits	:	1.5
Course Category	:	EEC

Guidance/Remarks: An independent project for the software development for AI and DS related areas. The course should allow students to explore various different applications of the AI and DS. The applications may include from areas such as image processing, natural language processing, speech processing, data analytics, big data problems etc.

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SEMESTER – V

SEMESTER V

Course Code	:	PC301
Course Title	:	Programming with Large Datasets Lab
Number of Credits	:	2.5 (L: 1, T: 0, P: 3)
Course Category	:	PC

Course Objective: The objective of this course is to provide hands-on training in writing programs to analyze, model and visualize large datasets. In particular, the students will learn programming using Map-reduce, Python, R etc. to solve. Students will learn how to solve common data analysis problems using datasets from a variety of domains: web search, e-commerce, social-networking, machine learning etc.

Course Content: The lab (with contemporary languages such as Python, R etc. for platforms like Hadoop, Spark) using large data set problems in the areas including web search, e-commerce, social-networking, machine learning etc.

Data analysis techniques would include: Descriptive Statistics, Probability Distributions, Sampling Distributions, Statistical Inference, Clustering, Statistical Tables Relation Analysis, Bayesian Classifier, Information Based Classification, Support Vector Machine Sensitivity Analysis, Similarity Measures.

List of Practicals:

1. Write a map reduce program to compute descriptive statistics such as mean, median, mode, standard deviation from a large dataset. Measure the runtime and study its scaling behaviour as more nodes are added to the cluster.
2. Write a map-reduce program to compute box-plots and histograms of all the numerical variables in a large multi-variate dataset. Measure the runtime and study its scaling behaviour as more nodes are added to the cluster.
3. Write a map-reduce program to compute correlation metrics between pairs of all the numerical variables in a large multi-variate dataset. Measure the runtime and study its scaling behaviour as more nodes are added to the cluster.
4. Write a map-reduce program to perform clustering of a large multi-variate dataset. Measure the runtime and study its scaling behaviour as more nodes are added to the cluster.
5. Write a map-reduce program to perform classification of a large multi-variate dataset into two or more classes. Measure the runtime and study its scaling behaviour as more nodes are added to the cluster.
6. Write a spark program to compute box-plots and histograms of all the numerical variables in a large dataset. Measure the runtime and study its scaling behaviour as more nodes are added to the cluster.
7. Write a spark program to perform classification in a large dataset. Measure the runtime and study its scaling behaviour as more nodes are added to the cluster.
8. Write a spark program to perform regression in a large dataset. Measure the runtime and study its scaling behaviour as more nodes are added to the cluster.

Text Books:

1. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
2. P. J. Sadalage, M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
3. Tom White, "Hadoop: The Definitive Guide", 3/e, O'Reilly, 2012.

Course Outcomes: At the end of this course a student should be able to

- Write, run and debug Map reduce programs to solve a variety data analysis tasks.
- Write, run and debug programs to analyze and build models from streaming and non-streaming data efficiently using systems like Apache Spark.

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Course Code	:	PC303
Course Title	:	Introduction to IoT and Embedded Computing
Number of Credits	:	4.5 (L: 3, T: 0, P: 3)
Course Category	:	PC

Course Objective:

1. To understand the fundamental of IoT and appreciate the importance of communication between machines with reference to IoT.
2. To understand the embedded systems including design techniques, control-driven architectures, and use of Internet for communication.
3. See the mechanism of controls and sensing and use of Internet to take global decisions using IoT technology and see how it works.
4. To understand, appreciate and develop ability to use various contemporary IOT communication protocols for transport, discovery and routing.
5. To understand the methodologies to implement the software systems for embedded computing and methods of programming them.
6. To appreciate the utilities of IoT through case studies.

Course Content:

Introduction: Definition, Characteristics and Architecture of IOT Devices, Trends in the Adoption of IoT in modern applicants, Risks, Privacy, and Security.

IoT Enabling Technologies: Sensor Networks, Sensors and actuators, Analog/Digital Conversion, Communication Protocols, Embedded Computing Systems, Cloud Computing.

IoT Communication Protocols: Communication stack for IoT, Machine to machine communication (M2M), Introduction to various protocols such as Message Queue Telemetry Transport (MQTT), Constrained Application Protocol (CoAP), 6LoPAN

Routing protocols, autonomous routing, hierarchical architectures and routing protocols to connect with infrastructure networks.

Applications of IoT, case studies.

Software development systems, embedded software, programming environments for IoT software development.

List of Practicals:

IoT Labs using Raspberry Pi and Arduino: Introduction to Raspberry Pi and Arduino Kits, Programming Raspberry Pi with Python, Arduino Programming IDE, Use Cases: Home Automation (e.g., Smart Lighting), City Applications (e.g., Smart Parking Smart Lighting), Environment (e.g., Pollution Monitoring, Weather Monitoring), Agriculture (e.g., Smart Irrigation) etc.

Overview of IoT Architecture, IoT Protocols: HTTP, CoAP, MQTT, AMQP, 6LoWPAN, IoT Cloud Infrastructure, Performance and Security in IoT, Programming with Advanced C / Embedded C / Python, Micro-controller programming using Arduino, Building IoT Applications using Raspberry Pi.

Text Books:

1. Jeeva Jose, "Internet of Things", Khanna Book Publishing Company, 2021.
2. Samuel Greengard, "The Internet of Things", 1st Edition, MIT Press, 2015.
3. Peter Waher, "Mastering Internet of Things: Design and create your own IoT applications using Raspberry Pi 3", 1st Edition, Packt Publishing Ltd, 2018.
4. Peter Waher, Pradeeka Seneviratne, Brian Russell, Drew Van Duren, "IoT: Building Arduino-Based Projects", 1st Edition, Packt Publishing Ltd, 2016.

Course Outcomes:

After completion of this course, a student should be able to

- Program an embedded computing devide such as Arduino and Raspberry Pi
- Build an IoT system for sensing and decision making.
- Implement standard communication protocols for IoT to build large systems
- Appreciate and understand the use of IoT in systems such as home automation, smart lighting, smart parking etc.

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Course Code	:	PC305
Course Title	:	Applied AI
Number of Credits	:	4.5 (L: 3, T: 0, P: 3)
Course Category	:	PC

Course Objective: The objective of this course is to acquaint the students with various applications of AI to a variety of fields. Common problems in each of the field are introduced, the specific techniques such data pre-processing steps, feature engineering, model building and model evaluation techniques are explained in lecture sessions, implemented and evaluated through the practical labs.

Course Content: The applications of AI. Introduction to problems such as Speech analytics, graph analytics, Image Analytics, Video Analytics, Natural Language Processing etc. Accompanied labs should use corresponding tools in the area.

List of Practicals:

1. Acquire, clean and pre-process a speech recognition dataset, compute features and develop models to recognize words.
2. Tune the models in the previous lab to improve its accuracy.
3. Acquire, clean and pre-process a graph dataset, compute features and develop models to identify clusters/communities.
4. Tune the models in the previous lab to improve its accuracy.
5. Acquire, clean and pre-process an image dataset(s), compute features and develop models to identify various classes such as hand-written numerals or characters, objects etc.
6. Tune the models in the previous lab to improve its accuracy.
7. Acquire, clean and pre-process document dataset, compute features and develop models for sentiment analysis
8. Tune the models in the previous lab to improve its accuracy.

Text Books:

1. Bernhard G. Humm, "Applied Artificial Intelligence - An Engineering Approach", Leanpub, Victoria, British Columbia, Canada.
2. Adelyn Zhou, "Applied Artificial Intelligence: A Handbook for Business Leaders", Topbots 2018.
3. M.C. Trivedi, A classical approach to Artificial Intelligence, Khanna Book Publishing Company, 2020.

Course Outcomes:

After this course, the students should be able to:

1. describe the various applications of AI in several fields
2. formulate problems in specific fields of interest such as Speech analytics, graph analytics, Image Analytics, Video Analytics, Natural Language Processing etc.

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Course Code	:	XXNNN
Course Title	:	Professional Elective I
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Refer Appendix I on Professional Electives.

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Course Code	:	XXNNN
Course Title	:	Open Elective I
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Note: Students may opt the courses as "**OPEN ELECTIVE**" as provided by the respective Universities

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Course Code	:	HS301
Course Title	:	Entrepreneurship and Startups
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	HS

Course Objective:

- Acquiring Entrepreneurial spirit and resourcefulness.
- Familiarization with various uses of human resource for earning dignified means of living.
- Understanding the concept and process of entrepreneurship - its contribution and role in the growth and development of individual and the nation.
- Acquiring entrepreneurial quality, competency, and motivation.
- Learning the process and skills of creation and management of entrepreneurial venture.

Course Content:

Module I: Introduction to Entrepreneurship and Start – Ups

- Definitions, Traits of an entrepreneur, Intrapreneurship, Motivation
- Types of Business Structures, Similarities/differences between entrepreneurs and managers.

Module II: Business Ideas and their implementation

- Discovering ideas and visualizing the business
- Activity map
- Business Plan

Module III: Idea to Start-up

- Market Analysis – Identifying the target market,
- Competition evaluation and Strategy Development,
- Marketing and accounting,
- Risk analysis

Module IV: Management

- Company's Organization Structure,
- Recruitment and management of talent.
- Financial organization and management

Module V: Financing and Protection of Ideas

- Financing methods available for start-ups in India
- Communication of Ideas to potential investors – Investor Pitch
- Patenting and Licenses

Module VI: Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy.

Text Books/References:

S. No.	Title of Book	Author	Publication
1	The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company	Steve Blank and Bob Dorf	K & S Ranch ISBN – 978-0984999392
2	The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses	Eric Ries	Penguin UK ISBN – 978-0670921607
3	Demand: Creating What People Love Before They Know They Want It	Adrian J. Slywotzky with Karl Weber	Headline Book Publishing ISBN – 978-0755388974
4	The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business	Clayton M. Christensen	Harvard business ISBN: 978-142219602

Websites:

1. https://www.fundable.com/learn/resources/guides/startup
2. https://corporatefinanceinstitute.com/resources/knowledge/finance/corporate-structure/
3. https://www.finder.com/small-business-finance-tips
4. https://www.profitbooks.net/funding-options-to-raise-startup-capital-for-your-business/

Course Outcomes: Upon completion of the course, the student will be able:

1. To Understand the dynamic role of entrepreneurship and small businesses
2. To Organize and Managing a Small Business
3. To do Financial Planning and Control
4. To Forms of Ownership for Small Business
5. To develop Strategic Marketing Planning
6. To illustrate New Product or Service Development
7. To illustrate Business Plan Creation

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Course Code	:	AU301
Course Title	:	Indian Constitution
Number of Credits	:	0 (L: 3, T: 0, P: 0)
Course Category	:	AU

Course Content

Module I: **The Constitution - Introduction**

- The History of the Making of the Indian Constitution
- Preamble and the Basic Structure, and its interpretation
- Fundamental Rights and Duties and their interpretation
- State Policy Principles

Module II – Union Government

- Structure of the Indian Union
- President – Role and Power
- Prime Minister and Council of Ministers
- Lok Sabha and Rajya Sabha

Module III – State Government

- Governor – Role and Power
- Chief Minister and Council of Ministers
- State Secretariat

Module IV – Local Administration

- District Administration
- Municipal Corporation
- Zila Panchayat

Module V – Election Commission

a. Role and Functioning
b. Chief Election Commissioner
c. State Election Commission

Text Books/Suggested Learning Resources:

S. No.	Title of Book	Author	Publication
1	Ethics and Politics of the Indian Constitution	Rajeev Bhargava	Oxford University Press, New Delhi, 2008
2	The Constitution of India	B.L. Fadia	Sahitya Bhawan; New edition (2017)
3	Introduction to the Constitution of India	DD Basu	Lexis Nexis; Twenty-Third 2018 edition

Suggested Software/Learning Websites:

1. https://www.constitution.org/cons/india/const.html
2. http://www.legislative.gov.in/constitution-of-india
3. https://www.sci.gov.in/constitution
4. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL ID	NPTEL Course Name	Instructor	Host Institute
1	12910600	CONSTITUTION OF INDIA AND ENVIRONMENTAL GOVERNANCE: ADMINISTRATIVE AND ADJUDICATORY PROCESS	PROF. SAIRAM BHAT, PROF. M. K. RAMESH	NATIONAL LAW SCHOOL OF INDIA UNIVERSITY

Course Outcomes: Upon completion of this course, the students will be able:

1 To Understand the emergence and evolution of Indian Constitution.
2 To Understand the structure and composition of Indian Constitution

3 To Understand and analyse federalism in the Indian context.
4 To Analyse Panchayati Raj institutions as a medium of decentralization
5 To Understand and analyse the three organs of the state in the contemporary scenario.
6 To Understand and Evaluate the Indian Political scenario amidst the emerging challenges.

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Course Code	:	EEC301
Course Title	:	Summer Internship – I
Number of Credits	:	1.5
Course Category	:	EEC

Guidelines/Remarks: Internship of 3 to 4 Weeks to be performed by student in the summer break between Semester IV and V. Internship can be done preferably in an Artificial Intelligence or Data Science related industry or in a Start-up or a Social Internship or Work from Home Internship etc.
For more guidance regarding internship, refer AICTE Internship Policy and AICTE Internship Portal (www.internship.aicte-india.org).

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SEMESTER – VI

SEMESTER VI

Course Code	:	PC302
Course Title	:	Data and Internet Security
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

Course Objective:
This course is primarily aims at introducing the concepts of data security starting with the goals of data security, mechanisms for implementing data security and associated problems of identity establishment, access controls. The course also provides introduction to cryptographic techniques for confidentiality and integrity and associated mechanisms such as session key establishment.

The course also introduces the concepts of data security as applicable for Internet based access to data using mechanisms such as VPN, IPSec, SSL etc. and the IT infrastructure to identify the attacks and safeguard the IT infrastructure from such threats using mechanism such firewall, IPS, IDS etc.

Course Content: Introduction to Data Security, Data Security Goals of Confidentiality, Integrity and Availability, Access Control, Attacks and threats, Chosen Plaintext Attack, Chosen Ciphertext Attacks, attack vectors, Basics of Symmetric Key Cryptography, Basics of Asymmetric Key Cryptography and the applications of cryptography for establishing trust. Brief introduction of common symmetric key ciphers such as AES and asymmetric key ciphers such as RSA and ECC.

Hash functions One-way functions: Weak and Strong one way functions, Pseudo-random Generators (PRG), True random number generators, use of Hash functions in random number generations etc. Algorithms such as MD5, SHA1, SHA2 and SHA3 series of hashing algorithms, compute power vs. weakness of hashing.

Block Ciphers, stream ciphers, modes of encryption – ECB, CBC, Counter mode etc., Message Authentication Codes (MACs): Formal Definition of Weak and Strong MACs. Mechanisms of symmetric ciphers of confidentiality: encryption and decryption; integrity: cryptographic checksums, use of key hashes such as HMAC or encrypted hashes, authentication mechanism such as passwords and secrets, challenge response and biometrics.

Public Key Signature Schemes: Formal Definitions, Signing and Verification, Public Key Signature Schemes: One way functions Imply Secure One-time Signatures, Shamir's Secret Sharing Scheme, Zero Knowledge Proofs and Protocols. Key exchange and Session keys, authentication and access control mechanisms. Internet protocols such as PGP, IPSEC, SSL etc.

Public key infrastructure: solution for the key distribution problem, public key trust establishment, notion of third party or trust, certifying authority, X.509 certificates, concept of self-signed certificate, root CA, protocols that use the CA infrastructure and

certificates such as HTTPS etc. Certificate revocation process and certificate revocation lists (CRLs)

Network threats and protection against them. Port scanning and exploitation of weaknesses of the server misconfigurations, denial of service attacks, protection against such attacks, firewall and protection mechanisms for unauthorized/malicious access. Intrusion detection and Intrusion prevention: Issues related to such mechanism.

Text Books:

1. William Stallings, "Cryptography and Network Security: Principles and Practice", 4th edition, Prentice Hall.
2. Yuri Diogenes (Author), Dr. Erdal Ozkaya (Author), "Cybersecurity - Attack and Defense Strategies: Infrastructure security with Red Team and Blue Team tactics", Packt Publishing; 1 edition, 2018.
3. V.K. Jain, Cryptography and Network Security, Khanna Book Publishing Company, Delhi.
4. Gupta & Gupta, Information Security and Cyber Laws, Khanna Book Publishing Company, Delhi.

Course Outcomes:

At the end of this course, a student should be able to

- Understand and explain with examples the concepts of confidentiality, integrity and availability
- Explain the use of cryptography to achieve the goals of security
- Analyze symmetric and asymmetric key cryptography
- Appreciate the different between attack, vulnerabilities ad threats.
- Apply encryption systems for large data using various modes of encryption
- Evaluate the digital signature mechanisms using the public key cryptosystems
- Evaluate the threats to a computer network and protection mechanisms for them including Firewall, IDS, IPS etc.

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Course Code	:	PC304
Course Title	:	Operating Systems
Number of Credits	:	4 (L: 3, T: 0, P: 2)
Course Category	:	PC

Course Objective:

The major objective of this course is that the students will learn the importance of an Operating System in order to provide runtime supports for applications esp. in general purpose computing. The major objectives are the following.

- To introduce the difference between a process and a program and how an Operating System provides its services through system calls.
- To introduce and get the appreciation of processes and threads, virtual components of a compute machines for a process.
- Introduce the concepts of CPU Scheduling and explain the method of evaluations of various scheduling algorithms vis-à-vis optimality in terms of SJF scheduling.
- Explain and build applications using inter-process communication mechanisms.

- To learn different synchronization techniques and build concurrent process executions.
- To understand the deadlocks and livelock mechanisms between processes and how to build systems to avoid deadlocks.
- To learn about memory management, memory allocation by an OS to processes, virtual memory concepts including paging, segmentation and demand paging.
- To understand the concepts of files and directories and build systems around these constructions. To understand the disk storage organization and file allocations on the disk.
- To appreciate the concerns of data security and protection of resources.
- To appreciate the operating system complexities with reference to contemporary case studies.

Course Content: Introduction, System Calls; Processes and Threads Concepts; CPU Scheduling, Process Synchronization; Classical Problems (Producer Consumer, dining philosophers etc.); Deadlocks: Detection, Prevention and avoidance mechanisms. Memory Management, Segmentation and Paging Demand Paging; Files and Directories organization, Security and Protection Mechanisms; System Threats, Case studies: UNIX and NT.

List of Practicals:

- Familiarity of Linux Operating system environment.
- Use of system calls in Linux operating systems
- Building IPC mechanisms to develop producer consumer applications.
- Use of an OS emulator such as NachOS to build CPU scheduling
- Use of OS emulator to build Virtual Memory
- Use of OS emulator to build File and Directories
- Use of synchronization primitives to build simple applications with synchronization.

Text Books:

1. A. Silberschatz and P.B. Galvin, Operating System Concepts, 8th Ed., Wiley, 2008.
2. W. Stalling, Operating Systems: Internals and Design Principles, 6th ed., Pearson Education, 2008.
3. A.S. Tanenbaum, Modern Operating System, 3rd Ed., Pearson, 2007.
4. Ekta Walia, Operating System Concepts, Khanna Book Publishing, 2019.
5. D.M. Dhamdhere, Operating Systems-A Concept Based Approach, McGraw-Hill, 2008.

Course Outcomes: At the end of the course a student shall be able to

- Understand and build applications using inter-process and inter-thread data sharing and communication mechanisms.
- Understand the concepts of memory managements and appreciate the need of memory management from the view point of safety, separation of memory spaces etc.
- Understand the concepts related to files and directories and the disk allocation and scheduling algorithms and appreciate the ways to optimize the storage utilization and random access to files.
- Appreciate the concerns of data security and mechanisms to implement data safety and security including access controls.
- Understand the features of contemporary operating systems through case studies.

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Course Code	:	PC306
Course Title	:	Computer Networks
Number of Credits	:	4 (L: 3, T: 0, P: 2)
Course Category	:	PC

Course Objective:

The objectives of this course include learning about computer network organization and implementation. If also aims to provide theoretical understanding of data communication and computer networks. Students are introduced to computer communication network design and its operations. Basic principles of network design and operations and development of programs to handle client server based computations shall also be introduced. The course will also aim to explain various protocols related to computer communication and introduce the network security aspects and basic primitives to build security.

Course Content:

Layer approach, Packet switching techniques, Performance metrics; Applications: FTP, SSH, DNS, WWW; Transport Layer: TCP flow control, error control, congestion control, congestion control, UDP; Network Layer: Internetworking, Tunnelling, Encapsulation, Fragmentation, IP, Routing and the related protocols, ICMP, ARP, RARP, DHCP, IPv6, RIP, OSPF; Advanced Internetworking, Multicast routing, Queuing disciplines and buffer management techniques; Data link layer: framing, medium access mechanism; Network security: Public key and private key cryptography, digital signature, firewalls; Advanced topics: SDN and Open flow Architectures, Unix socket programming and labs using sockets.

List of Practicals:

The course will have several practical sessions including but not limited to the following.

- Set up a mall computer communication network using switches, routers etc. and verify that it is functional.
- Use variety of debugging tools such as arp, ping, traceroute etc. and understand the output of the same, correlate with the actual physical status of the network.
- Set the network routing tables on the computer and routers using multicast, net mask, default routing etc. Perform experiments to collect the statistics of routing tables and provide interpretation of the same.
- Implement a client server protocol using TCP socket programming. At the server side the processing may be minimal.

Text Books:

1. L. L. Peterson and B. S. Davie, Computer Networks: A Systems Approach, 4th Ed., Elsevier India, 2007.
2. A. S. Tanenbaum, Computer Networks, 4th Ed., Pearson India, 2003.
3. B. Forouzan, Data Communications and Networking, 4th Ed., Tata Mc-Graw Hill, 2006.
4. Bhavneet Sidhu, An integrated approach to Computer Networks, Khanna Book Publishing Company, 2021.

Course Outcomes:

Upon completion of the course, students should be able,

- Understand the basics of data communication, networking, internet and their importance.
- Understand and appreciate the computer communication protocols
- Analyze the services and features of various protocol layers in data networks.
- Evaluate the design of a computer communication networks and understand the concepts and implement/ maintain a typical computer network (LAN).
- Recognize the different internet devices and their functions.
- Identify the basic security threats of a network and appreciate the solutions for the same.

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Course Code	:	XXNNN
Course Title	:	Professional Elective II
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Refer Appendix I on Professional Electives.

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Course Code	:	XXNNN
Course Title	:	Open Elective II
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Note: Students may opt the courses as "**OPEN ELECTIVE**" as provided by the respective Universities

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SEMESTER – VII

SEMESTER VII

Course Code	:	XXNNN
Course Title	:	Professional Elective III
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

This professional elective should be one out of Computer Vision and Image processing / Natural Language Processing / Speech Processing.

Refer Appendix I on Professional Electives.

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Course Code	:	XXNNN
Course Title	:	Professional Elective IV
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

This professional elective should be one out of Genetic Algorithms / Hidden Markov Models / Artificial Neural Networks / Support Vector Machines.

Refer Appendix I on Professional Electives.

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Course Code	:	XXNNN
Course Title	:	Open Elective III
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Note: Students may opt the courses as "**OPEN ELECTIVE**" as provided by the respective Universities

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Course Code	:	XXNNN
Course Title	:	Open Elective IV
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Note: Students may opt the courses as "**OPEN ELECTIVE**" as provided by the respective Universities

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Course Code	:	EEC401
Course Title	:	Project I
Number of Credits	:	3
Course Category	:	EEC

Guidelines/Remarks: In this course the students are expected to develop a solution to a reasonable applied problem. The project should envisage the documentation of the problem, software engineering approaches for requirement analysis etc. and building the understanding of problem definition. It should also involve designing the solution for the problem and implementing the same using contemporary tools.

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Course Code	:	EEC403
Course Title	:	Summer Internship – II
Number of Credits	:	3
Course Category	:	EEC

Guidance for Summer Internship: Internship of 3 to 4 Weeks may be taken up by the student in the summer break between Semester VI and VII. Internship can be done in an industry OR Start-up OR at research laboratories OR centres of excellence in own institute or other institutions outside, working preferably in the field related to Artificial Intelligence and Data Science.

For more guidance regarding internship, refer AICTE Internship Policy. You may apply to internship opportunities available on AICTE Internship Portal (www.internship.aicte-india.org).

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SEMESTER – VIII

SEMESTER VIII

Course Code	:	XXNNN
Course Title	:	Professional Elective V
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Note: This professional elective should be one out of Computer Vision and Image processing / Natural Language Processing / Speech processing.

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Course Code	:	XXNNN
Course Title	:	Professional Elective VI
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Note: This professional elective should be one out of Genetic Algorithms / Hidden Marcov Models / Artificial Neural Networks / Support Vector Machines.

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Course Code	:	XXNNN
Course Title	:	Open Elective V
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Note: Students may opt the courses as "**OPEN ELECTIVE**" as provided by the respective Universities

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Course Code	:	EEC402
Course Title	:	Project II
Number of Credits	:	7.5
Course Category	:	EEC

Guidelines/Remarks: In this course the students are expected to develop a sufficiently complex problem solution including the understanding of problem definition, devising a solution for the problem and implementing the same using contemporary programming tools for data science or Artificial Intelligence. For example, a student should be able to take unstructured data and develop a meaningful data model, data extraction and data visualization out of this for a specific objective. The course is expected to build upon the knowledge and project done using Project I.

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Appendix – I

Professional Electives

The curriculum has specified several slots wherein the students can take electives to broaden their grasp on the subjects related to Artificial Intelligence as well as to Data Science. Some suggest elective are listed here.

1. Image Processing and Computer Vision
2. Natural Language Processing
3. Speech Processing
4. Applications of Artificial Intelligence in Healthcare
5. Information retrieval
6. Mining of Massive Datasets (or, Techniques of Data Mining)
7. Mathematics for Machine Learning
8. Web Technologies for Advanced Data Visualization
9. Introduction to toolkits for Machine Learning
10. Advanced Machine Learning
11. Neural Networks Architectures for Data Analysis

Professional Elective I

Course Code	:	XXNNN
Course Title	:	Image Processing and Computer Vision
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:
This course gives an introduction to the concepts and applications of image processing and computer vision. This course teaches the fundamental techniques for image processing tasks such as image restoration, segmentation and compression. Computer Vision is a field that spans multiple disciplines and draws links to several traditional fields such as image processing, optics, probability, and statistics. After introducing image processing techniques, vision tasks such as shape reconstruction, object and scene recognition etc. are taught.

Course Content:
Fundamentals – Visual perception, image sampling and quantization;
Intensity transformations – nonlinear transformations for enhancement, histogram equalization;
Image restoration – using spatial filters, Wiener filter; Introduction to colour spaces and colour image processing; Morphological image processing – erosion and dilation, opening and closing, hit-or-miss transform, thinning and shape decomposition;
Image segmentation – edge detection, thresholding, region-based segmentation;
Image compression – fundamentals, lossless coding, predictive coding, transform coding.
Vision- Cameras and projection models, clustering; shape reconstruction from stereo, object recognition, scene recognition, face detection and human motion categorization.

Text Books:
1. Gonzales R. C. and Woods R. E., Digital Image Processing, Prentice-Hall, 4 ed, 2018
2. Computer Vision: Algorithms and Applications, by Richard Szeliski, Springer, 2010.
3. Learning OpenCV, by Gary Bradski & Adrian Kaehler, O'Reilly Media, 2008.

References:
1. Multiple View Geometry in Computer Vision, 2nd Edition, by R. Hartley, and A. Zisserman, Cambridge University Press, 2004.
2. Computer Vision: A Modern Approach, by D.A. Forsyth and J. Ponce, Prentice Hall, 2002.
3. Pattern Classification (2nd Edition), by R.O. Duda, P.E. Hart, and D.G. Stork, Wiley-Interscience, 2000.
4. Pratt W. K., Digital Image Processing, 4 ed, Wiley, 2007
5. Bovik, A. C., The essential guide to image processing, Academic Press, 2009
6. Forsyth D. A. and Ponce J., Computer Vision - A Modern Approach, 2 ed, 2012.
7. M Sonka, V Hlavac, and R Boyle: Image Processing, Analysis, and Machine Vision, Thomson, Toronto, 4 ed, 2015.

Course Outcomes:

At the end of the course, a student will be able to:

- Understand the fundamentals of image processing such as sampling and quantization
- Process image datasets in tools such as OpenCV and perform key image processing tasks such as transformations, restoration, segment and compression
- Learn the algorithms and techniques used in image processing
- Understand the fundamentals of computer vision such as Cameras and projection models
- Process image and video datasets in tools such as OpenCV and perform key computer vision tasks such as clustering; shape reconstruction from stereo, object recognition, scene recognition, face detection and human motion categorization.
- Implement the algorithms and techniques used in computer vision.

*****

Course Code	:	XXNNN
Course Title	:	Natural Language Processing
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

Natural language processing (NLP) is one of the most important technologies of the information age. In this course, students will gain a thorough introduction to classical and modern techniques in NLP. They will also learn how to evaluate the strengths and weaknesses of various NLP technologies and frameworks as they gain practical experience in the NLP toolkits available. Students will also learn how to employ literary-historical NLP-based analytic techniques like stylometry, topic modeling and named entity recognition. Through lectures, assignments and a final project, students will learn the necessary skills to design, implement, and understand their own machine learning models for NLP.

Course Content:

Tokenization, N-grams, TF-IDF, Features, Word Vectors; Data Collection using API, Social Media, Web scraping; Software tools such as NLTK; Parts of Speech Tagging; Named Entity Recognition; Sentiment Analysis; Topic Modeling; Stylometry; Text Visualization (Dendograms, PCA, Plotting the Text); Document Clustering; Robust and Scalable Machine Translation; Question Answering in Multilingual Setting; Cross Lingual Information Retrieval (CLIR).

Text Books:

- **Dan Jurafsky and James H. Martin.** Speech and Language Processing (3rd ed. draft)
- **Jacob Eisenstein.** Natural Language Processing
- **Delip Rao and Brian McMahan.** Natural Language Processing with PyTorch

References:

- **Yoav Goldberg.** A Primer on Neural Network Models for Natural Language Processing
- **Ian Goodfellow, Yoshua Bengio, and Aaron Courville.** Deep Learning

Course Outcomes:

At the end of the course, a student will be able to:

- Understand the fundamentals of natural language processing such as word and document models with the help of n-grams, word vectors
- Learn how to collect data from social media, web and other sources using APIs, web-scraping etc.
- Perform various NLP tasks such as Named Entity Recognition and Sentiment Analysis
- Visualize text datasets using PCA, word cloud etc.
- Perform document clustering and other topic modeling tasks
- Apply machine learning to perform translation
- Learn how to build real NLP system using software tools and technologies and build a project.

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Course Code	:	XXNNN
Course Title	:	Speech Processing
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

This this course, students will be given an introduction to spoken language technology. They will be taught how to apply deep learning and other methods for automatic speech recognition, speech synthesis, emotion detection, dialogue management, and applications to digital assistants and spoken language understanding systems.

Course Content:

Biology of Speech Processing; Place and Manner of Articulation; Word Boundary Detection; Argmax based computations; Feature Extraction: MFCC; Speech recognition overview: Noisy channel model. Word error rate metrics. Hidden Markov models (HMMs), Finite state transducers; Text to Speech (TTS): Overview. Text normalization. Letter-to-sound. Prosody. Concatenative and parametric approaches; Social meaning extraction: Emotion detection, Interpersonal stance. Flirtation. Intoxication; Spoken dialog systems.

Text Books:

- Dan Jurafsky and James H. Martin. Speech and Language Processing (3rd ed. draft)

References:

- Mark Gales and Steve Young, The application of hidden Markov models in speech recognition, Foundations and Trends in Signal Processing, 1(3):195-304, 2008.
- Geoffrey Hinton, Li Deng, Dong Yu, George E. Dahl, Abdel-rahman Mohamed, Navdeep Jaitly, Andrew Senior, Vincent Vanhoucke, Patrick Nguyen, Tara N. Sainath, and Brian Kingsbury, Deep Neural Networks for Acoustic Modeling in Speech Recognition, IEEE Signal Processing Magazine, 29(6):82-97, 2012.
- Wang, Y., Skerry-Ryan, R.J., Stanton, D., Wu, Y., Weiss, R.J., Jaitly, N., Yang, Z., Xiao, Y., Chen, Z., Bengio, S. and Le, Q., Tacotron: Towards end-to-end speech synthesis. arXiv. 2017.
- Scherer, K. R., Vocal communication of emotion: A review of research paradigms. Speech Communication. 2003.
- Rajesh Ranganath, Dan Jurafsky, and Daniel A. McFarland, Detecting friendly, flirtatious, awkward, and assertive speech in speed-dates. Computer Speech and Language. 2013.
- F. Mairesse, M. Walker, M. Mehl, and R. Moore. Using linguistic cues for the automatic recognition of personality in conversation and text. Journal of Artificial Intelligence Research. 2007.
- Yoav Goldberg. A Primer on Neural Network Models for Natural Language Processing
- Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Deep Learning

Course Outcomes:

At the end of the course, a student will be able to:

- Understand the fundamentals of speech processing, its models and feature extraction
- Appreciate various applications of speech recognition and synthesis in daily lives
- Apply machine learning to perform speech recognition, convert text to speech
- Perform sentiment analysis on speech
- Learn the fundamental challenges of building a dialog system

- Learn how to build real speech processing system using software tools and technologies and build a project

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Course Code	:	XXNNN
Course Title	:	Applications of Artificial Intelligence in Healthcare
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

This course will discuss the potential of Artificial intelligence (AI) to benefit the field of healthcare. It would teach how to analyze medical images such as X-Ray, CT-Scan, and data of patient visits to the clinic, medications prescribed, lab tests, and procedures performed, as well as data outside the health system -- such as social media, purchases made using credit cards, census records, Internet search activity logs etc. that contain valuable health information. The aim is to teach students advanced technology in processing and analysis of medical images, other electronic health records and other related datasets.

Course Content:

Introduction to data generated inside and outside health system: Images, Electronic Health Records, Wearables and other sensors; social media etc.; Medical image and video analysis: X-Ray, CT-Scan, Ultrasound; Segmentation, Classification, Vision Models; Electronic Health Records and their analysis; Genomics; Multi-modal data; Epidemics; Interpretability, Fairness, and Ethics.

Text Books:

- Deep Learning in Healthcare, Paradigms and Applications, Chen, Yen-Wei, Jain, Lakhmi C., Springer 2020.
- Artificial Intelligence in Healthcare, Adam Bohr, Kaveh Memarzadeh, Academic Press, 21-Jun-2020
- M.C. Trivedi, A classical approach to Artificial Intelligence, Khanna Book Publishing Company, 2020.
- Machine Learning, Deep Learning, Rajiv Chopra, Khanna Publishing, 2021.

References:

- List of contemporary research papers prescribed by the instructor

Course Outcomes:

At the end of the course, a student will be able to:

- Gain broad knowledge of opportunities for AI in healthcare
- Understand data techniques in healthcare data analysis, including machine learning and data mining
- Apply cutting edge deep learning algorithms, and develop practical ability to develop models for diverse types of healthcare data
- Understand different applications and challenges across the design, implementation and management of intelligent systems and healthcare data networks
- Understanding of real-world considerations and challenges for deploying AI algorithms in healthcare
- Develop an application or perform a case study as a course project

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Course Code	:	XXNNN
Course Title	:	Information Retrieval
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

This course will discuss the techniques for information retrieval which is the process through which a computer system can respond to a user's query for text-based information on a specific topic. This course will teach the students techniques for efficient text indexing, Boolean and vector-space retrieval models, evaluation and interface issues, IR techniques for the web, including crawling, link-based algorithms, and metadata usage, Document clustering and classification and Traditional and machine learning-based ranking approaches.

Course Content:

Introduction to Information retrieval; Document Indexing, Storage and Compression, Retrieval Models, Spelling Correction, Performance Evaluation, Text Categorization and Filtering, Text Clustering, Web Information Retrieval, learning to rank, Link Analysis, Crawling and near duplicate pages, Advanced Topics (Text Summarization, Question answering, Recommender Systems)

Text Books:

1. “Introduction to Information Retrieval” by Manning, Raghavan and Schutze, Cambridge University Press, 2008.

2. “Search Engines: Information Retrieval in Practice” by W. Bruce Croft, D. Metzler, T. Strohman, Pearson, 2009.

3. "Information Retrieval: Implementing and Evaluating Search Engines" by Stefan Büttcher, Charles L. A. Clarke and Gordon V. Cormack, MIT Press, 2010.

References:

- List of research papers prescribed by the instructor

Course Outcomes:

At the end of the course, a student will be able to:

- Develop broad knowledge of the field of information retrieval
- Understand techniques to efficiently index text-based data and retrieve based on user queries
- Learn how to perform performance evaluation of systems
- Apply various tasks like text filtering, categorization, clustering etc. to text corpus
- Learn information retrieval techniques for web content, crawling, how to rank it etc.
- Develop an application or perform a case study as a course project

*****

Course Code	:	XXNNN
Course Title	:	Mining of massive Datasets (*or,* Techniques of Data Mining)
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

This course will discuss the techniques for data mining from large amounts of data. Students would be taught how in the modern industry, data from its operations and customers are mined for gaining business insight. Data mining is an interdisciplinary topic involving, databases, machine learning and algorithms. The course will explain the basic algorithms like data pre-processing, association rules, classification, clustering, sequence mining and visualization. It will also explain implementations in open-source software. Finally, case studies on industrial problems will be demonstrated.

Course Content:

Introduction to Data Mining, Frequent item sets and Association rules, Near Neighbor Search in High Dimensional Data, Locality Sensitive Hashing (LSH), Dimensionality

reduction, Recommendation Systems, Clustering, Classification, Mining the Web for Structured Data, Web Advertising.

Text Books:

1. "Introduction to Information Retrieval" by Manning, Raghavan and Schutze, Cambridge University Press, 2008.

2. "Search Engines: Information Retrieval in Practice" by W. Bruce Croft, D. Metzler, T. Strohman, Pearson, 2009.

3. "Information Retrieval: Implementing and Evaluating Search Engines" by Stefan Büttcher, Charles L. A. Clarke and Gordon V. Cormack, MIT Press, 2010.

References:

- List of contemporary research papers prescribed by the instructor

Course Outcomes:

At the end of the course, a student will be able to:

- Develop Broad knowledge of the field of data mining
- Understand techniques to extract association rules from data and analyze frequent item sets etc.
- Learn techniques like LSH for searching in high dimensional data
- Perform dimensionality reduction on real-life datasets while preserving most of their information
- Learn how to design recommendation systems
- Understand the model and techniques used in the modern web-advertising industry
- Apply machine learning techniques like clustering and classification on real-life datasets and develop valuable insights
- Develop an application or perform a case study as a course project

*****

Course Code	:	XXNNN
Course Title	:	Mathematics for Machine Learning
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

This course will discuss the rich mathematical theory needed for developing efficient, accurate and robust machine learning algorithms. This course will focus on selected advanced topics from linear algebra, calculus, optimization, probability theory and statistics with strong linkage with machine learning. Applications of these topics will be introduced in ML with help of some real-life examples.

Course Content:

Introduction to Theory of Learning: meaning of learning, overfitting etc.,

Convex functions and sets, Convex Optimization, Optimization Formulations of Data Analysis Problems, Regularization, Lasso, Gradient and Sub-gradient descent for non-smooth functions e.g.: SVM, Online Gradient Descent e.g.: Stochastic Gradient Descent and its applications (NN), Duality and its examples, Accelerating Gradient Descent,

Randomized Linear Algebra and applications to machine learning,

Maximum likelihood estimation (MLE) in Binomial, Multinomial, Gaussian, models in exponential family.

Expectation Maximization (EM) based learning in Mixture models, Hidden Markov Model, Dirichlet processes (Clustering).

Bayesian Machine Learning, estimating decisions using posterior distributions, Model selection: Variational Inference.

Text Books:

1. Introduction to Machine Learning, by Jeeva Jose, Khanna Book Publishing, 2020.

2. Linear Algebra and Learning from Data (2019), Gilbert Strang, Wellesley Cambridge Press

3. “Machine Learning: A Probabilistic Perspective” By Kevin P. Murphy (MIT Press), 2021 edition

References:

- List of papers prescribed by the instructor

Course Outcomes:

At the end of the course, a student will be able to:

- Understand the mathematics behind core machine learning algorithms such as gradient descent, maximum likelihood estimation, expectation maximization
- Solve practical data analysis problems using the techniques taught in the course
- Learn the importance of regularization for machine learning models and various methods to perform it
- Understand the mathematics behind linear algebra solvers used for machine learning
- Perform variational inference on a dataset
- Develop an application or perform a case study as a course project

*****

Course Code	:	XXNNN
Course Title	:	Web Technologies for Advanced Data Visualization
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

This course is designed to provide students with the foundations necessary for understanding and extending the current state of the art in data visualization. In this course we will study techniques for creating effective visualizations based on principles from graphic design, perceptual psychology, and cognitive science. The course is targeted both towards students interested in using visualization in their own work, as well as students interested in building better visualization tools and systems. In addition to class discussions, students will complete visualization design and data analysis assignments, as well as a final project. Students will share the results of their final project as both an interactive website and a video presentation.

Course Content:

Topics: data and image models, exploratory data analysis, visual encoding, graphical perception, color, animation, graph layout.

Introduction and interaction design: reactivity, responsiveness, and selection. Interactive navigation: panning, zooming, and other changes of viewpoint. Multiple view coordination:

juxtaposing, partitioning and layering. Data reduction: filtering and aggregation of items. Perceptual principles, color theory. Rules of thumb, usability testing. Design and justification exercises.

Text Books:

- Interactive Data Visualization for the Web, 2nd Edition. Scott Murray, O'Reilly Press.

References:

- The Visual Display of Quantitative Information, E. Tufte. Graphics Press, 2001.
- Envisioning Information, E. Tufte. Graphics Press, 1990.

Course Outcomes:

By the end of the course, students will have gained:

- An understanding of key visualization techniques and theory, including data models, graphical perception and methods for visual encoding and interaction.
- Exposure to a number of common data domains and corresponding analysis tasks, including multivariate data, geo-spatial data, and networks.
- Practical experience building and evaluating visualization systems.
- The ability to read and discuss research papers from the visualization literature.

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Course Code	:	XXNNN
Course Title	:	Introduction to toolkits for Machine Learning
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

The purpose of this course is to provide hands-on training with some of the important software libraries used in machine learning, e.g., Scikit-learn, Tensorflow, Pytorch. Students will get practical experience with PyTorch through coding exercises and projects implementing state-of-the-art AI applications such as style transfer and text generation. Students will get hands-on experience building state-of-the-art image classifiers and other deep learning models. They will also use TensorFlow to build and deploy models in the real world on mobile devices, in the cloud, and in browsers.

Course Content:

Software for machine learning: Scikit-learn, Tensorflow, Pytorch

Basics of TensorFlow, Neural networks that recognize objects, improve accuracy of object recognition using CNN, use pre-trained models to build state-of-the-art classifiers, Saving and Loading models, Time series forecasting with RNNs, Perform NLP tasks using word embeddings, LSTMs, Introduction to TensorFlow Lite

Basics of PyTorch, perform style transfer of one image to another, Perform text generation, sentiment analysis with PyTorch.

Instructors can introduce different ML tasks or assign course projects.

Text Books:

1. Natural Language Processing with PyTorch, Delip Rao, Brian McMahan, O'Reilly Press 2019.

2. Introduction to Machine Learning, by Jeeva Jose, Khanna Book Publishing, 2020.

3. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurelien Geron, O'Reilly 2019.

References:

- List of software and tools provided by the instructor.

Course Outcomes:

At the end of the course, a student will be able to:

- Understand the basics of important and useful software libraries for machine learning
- Learn to build their own neural networks in PyTorch and Tensorflow
- Learn how to debug models, visualize information etc.
- Practice building models for object recognition, style transfer, image classification
- Improve accuracy of their models by using transfer learning from pre-trained models
- Design neural networks for NLP tasks like sentiment analysis
- Develop an application or perform a case study as a course project and deploy it in the cloud or a mobile device

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Course Code	:	XXNNN
Course Title	:	Advanced Machine Learning
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

This course is an introduction to the techniques for improving the Fairness, Accountability, and Transparency and Security of a machine learning model in addition to its performance. It would discuss the difficulties in achieving these objectives and the emerging technical approaches in this topic. In this course, we will study the rigorous computer science techniques necessary and dive into the technical underpinnings of topics including fairness, robustness, interpretability, accountability, and privacy. We will also discuss several application areas where we can apply these techniques. This course requires students to have intermediate mathematical and programming backgrounds in machine learning and deep learning.

Course Content:

Biases and Fairness, Fair representation learning, fairness through input manipulation, Fair NLP, Fairness in vision representations, Fair causal reasoning

Interpretability and transparency, feature interaction for interpretability, Example and visualization-based methods, interpreting deep neural networks,

Robustness and adversarial attacks, adversarial defence,

Privacy of data, differential privacy, federated learning

Text Books:

- **Barocas, Solon, Moritz Hardt, and Arvind Narayanan.** Fairness and Machine Learning**, 2018.**
- **Molnar, Christoph.** Interpretable machine learning**, 2019.**
- Rajiv Chopra, Machine Learning, Khanna Book Publishing, 2020.

References:

- List of papers prescribed by the instructor

Course Outcomes:

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

a. Appreciate the need for incorporating and addressing the concerns/objective of fairness, accountability, transparency and security in machine learning models

b. Implement fairness techniques in NLP and vision-based models

c. Interpret deep learning models

d. Detect simple adversarial attacks and implement defence against them

e. Build a project incorporating some of the techniques learnt during the course.

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Course Code	:	XXNNN
Course Title	:	Neural Networks Architectures for Data Analysis
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

Course Objective:

The aim of this course is to teach the various neural network architectures that have been developed for different types of data. Beginning with multi-layer perceptrons (MLP) and dense neural nets (DNN), the student will be introduced to convolutional neural networks (CNN), recurrent neural networks (RNN) and graph neural networks (GNN). Some of the standard neural networks which have achieved the state-of-the-art performance in their respective domains will be highlighted in the course.

Course Content:

Introduction to neural networks, deep neural networks, MLP architecture, forward and backward propagation, automatic differentiation, loss functions, regularization, dense neural networks.

Convolutional neural networks (CNN): LeNet-5, AlexNet, Inception, Resnet

Recurrent neural networks (RNN), LSTMs, GRU

Graph neural networks (GNN).

Text Books:

1. Dive into deep learning, Aston Zhang, Z. Lipton, M Li and Alex Smola, Open source book

2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurelien Geron, O'Reilly 2019.

3. Introduction to Machine Learning, by Jeeva Jose, Khanna Book Publishing, 2020.

References:

- List of papers prescribed by the instructor

Course Outcomes:

At the end of this course, the student will be able:

a. Understand the various kinds of neural network architectures and the various techniques and tricks involved in training them effectively

b. Design a suitable neural network for a given machine learning task

c. Understand the computational challenges involved in training neural networks

d. Compare the performance of different neural network designs

e. Build a project based on the techniques taught in the course

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Appendix – II

A Guide to Induction Program

Appendix – II: A Guide to Induction Program

Introduction

In its 49th meeting, held on 14th March 2017, AICTE approved a package of measures for further improving the quality of technical education in the country. This 3-week mandatory Student Induction Program (SIP) based on Universal Human Values (UHV) is one of these key measures.

The SIP is intended to prepare newly admitted undergraduate students for the new stage in their life by facilitating a smooth transition from their home and school environment into the college and university environment.

The present form of the Student Induction Program (SIP) has taken inspiration from and gratefully acknowledges the many efforts in this direction. In particular the Foundation Program at IIT Gandhinagar1 (July 2011) and the course in Universal Human Values and Professional Ethics2 (IIIT Hyderabad, 2005; AKTU Lucknow, 2009 and PTU Jalandhar, 2011; overall about 35 universities); and also, the mentorship, internship and apprenticeship programs3 of several institutions. The SIP amalgamates all the three into an integrated whole, which leads to its high effectiveness in terms of building a healthy lifestyle, creativity, bonding and character. It develops sensitivity towards self and one's relationships, builds awareness about others and society beyond the individual, and also in bonding with their own batch-mates and senior students as well as faculty members.

The purpose of this document along with accompanying details are to help institutions / colleges in understanding the spirit of the Induction Program and implementing it.

It is in line with the thoughts expressed in the NEP 2020:

"*Education is fundamental for achieving* ***full human potential****, developing an* ***equitable and just society****, and promoting* ***National development***".

[1] IIT Gandhinagar places great emphasis on not only educating successful engineers of the future, but also creating well-rounded personalities, who contribute to society, are respectful of and can adapt to their surroundings, and prove themselves to be great thinkers and problem solvers in all avenues of life. In 2011, in line with this vision, It took the bold step to introduce a five week Foundation Program for incoming 1st year UG students. It involved activities such as games, art, etc.; also science and other creative workshops as well as lectures by eminent resource persons. To enable undivided attention on this, normal classes were scheduled only after this program was over.

[2] The foundation course was started in 2005 at IIIT Hyderabad. In 2009, UP Technical University (now AKTU) introduced it in all academic programs across their 550 colleges. From there on, it has been included in the curriculum of many universities, particularly in technical universities, in quite a natural manner, filling a long-felt need. After AKTU, it was IKG-Punjab Technical University in 2011, then Royal University of Bhutan in 2012 and so on. By 2020, more than 40 universities in India and both universities of Bhutan have been offering this foundation course. Since 2017, it has been a compulsory credit course in AICTE's model curriculum for all UG courses. Faculty from all departments are involved in conducting the course. The content is universal, rational, verifiable and leading to harmony. The mode is a self-exploration (and not sermonising or lecturing). Faculty are to be prepared beforehand. The results have been quite encouraging.

[3] Many institutes setup mentor-mentee network under which 1st year students are divided into small groups, each assigned to a senior student as a Student Buddy, and to a faculty member as a Faculty Mentor. Thus, a new student has their guidance through regular interactions. They can discuss their aims and aspirations as well as concerns whether social, psychological, financial, academic, or otherwise.

"The purpose of the education system is to develop good human beings capable of rational thought and action, possessing compassion and empathy, courage and resilience, scientific temper and creative imagination, with sound ethical moorings and values".

"It aims at producing engaged, productive, and contributing citizens for building an equitable, inclusive, and plural society as envisaged by our Constitution".

"Education must build character, enable learners to be ethical, rational, compassionate, and caring, while at the same time prepare them for gainful, fulfilling employment".

"The curriculum must include basic arts, crafts, humanities, games, sports and fitness, languages, literature, culture, and values, in addition to science and mathematics, to develop all aspects and capabilities of learners; and make education more well-rounded, useful, and fulfilling to the learner".

So, when new students join an institution, they are to be welcomed and oriented to the institute, its vision, people, purpose, culture and values, policies, programs, rules and regulations etc. through a well-planned 3-week interaction before regular classes start.

Education aims at developing the students to their full potential, so that they are able to participate meaningfully not only in their profession, but also in their family, society and their natural environment. That requires the development of their values as well as skills.

Engineering colleges were established to train graduates in their respective branch/ department of study, be ready for the job market, but also have a holistic outlook towards life and have a desire and competence to work for national needs and beyond. The graduating student must have the knowledge and skills in the area of his study. However, s(he) must also have a broad understanding of society and relationships. Besides the above, several meta-skills and underlying values are needed. Character needs to be nurtured as an essential quality by which s(he) would understand and fulfil his/her responsibility as an engineer, a family member, a citizen etc.

The same applies to all other branches of study – be it professional, vocational or any other area of academic. The graduating student must be a good human being and have the skills in their area of study.

Each family, institution, region, community etc. have evolved their way of life, their cultures over a period of time. The new students are going from one culture to another. Today, a major issue is that one culture tends to be opposed to other cultures. This is because their basic assumptions, and therefore thoughts, are different. Even though there are commonalities at the core value level, the conflict is at the level of expression and details.

With this situation, it is imperative to

- Articulate the essence or core aspects of human culture and civilization, i.e. understand universal human values like trust and respect, love and compassion
- Appreciate the various expressions, different approaches taken in different regions

Our effort is in the context of the whole humanity. However, when it comes to exemplifying these essential concepts, we will have to take to local or national expressions.

In SIP, we want to provide an exposure to essence in the context of the whole humanity first. Then we can take a representative cross-section of all cultures as expressions of this essence. A yardstick to evaluate these various options is provided to guide the student towards a humanistic culture founded on the truth and universal human values like love and compassion.

For example: We want to live with fulfilment as a society. This part is common, universal. *To exemplify this, we may expose students to traditional Indian culture and philosophy as well as contemporary western culture and thought.*

The intent is:

- Connecting the basic principles through specific examples
- To see and appreciate various cultures, to see the commonality amongst them, in the light of clarity about human culture and civilisation.
- To evaluate any specific example, system or culture, with a view to fill the gaps, rather than to criticise or reject it. Further, we can also be mutually enriching for other cultures.

Student Induction Program (SIP)

With this background, the SIP has been formulated with specific goals to help students to:

- Become familiar with the ethos and culture of the institution (based on institutional culture and practices)
- Set a healthy daily routine, create bonding in batch as well as between faculty members and students
- Get an exposure to a holistic vision of life, develop awareness, sensitivity and understanding of the
  Self---family---Society---Nation---International---Entire Nature
- Facilitate them in creating new bonds with peers and seniors who accompany them through their college life and beyond
- Overcome weaknesses in some essential professional skills – only for those who need it (e.g. Mathematics, Language proficiency modules)

The SIP consists of different activities which includes meeting new students, socializing with teachers and other people in the university. Secondly associating with the Local area or city, knowing different departments, associating with the department heads, local stores and necessary shops for the survival at new place. Basically, getting information about the rules and regulations of the university which includes do's and don'ts. Other activities which may involve students in several creative, cultural and co- curricular activities through which they can explore themselves and get idea about their intrinsic desires and interests which may help them in the long run. In order to make it worth, at the initial level of joining of student various seminars, lectures by eminent personalities, sessions by the appointed mentor for the student is being done to make them more familiar with the university environment. It has been seen that student after schooling when moves towards further studies for either under graduation or post-graduation has got so many confusions and false knowledge about the college and the curriculum. They should know the basic idea about the fruits and prospects of the particular course and the university or institute in

which they are entering. To have faith about their choices and to know that after completion, they will be well equipped with the values and skills which may aid to their future goals and let them work for their personal motives, society and the Nation's development.

The various modules or core areas recommended for the 3-week SIP are:

SIP Module 1: Universal Human Values I (UHV I) **22 hours**

The purpose is to help develop a holistic perspective about life. A self-reflective methodology of teaching is adopted. It opens the space for the student to explore his/her role (value) in all aspects of living – as an individual, as a member of a family, as a part of the society and as a unit in nature. Through this process of self-exploration, students are able to discover the values intrinsic in them. The session-wise topics are given below:

Session No.	Topic Title	Aspirations and Issues	Basic Realities (underlying harmony)
1	Welcome and Introductions	Getting to know each other	Self-exploration
2 and 3	Aspirations and Concerns	Individual academic, career… Expectations of family, peers, society, nation… Fixing one's goals	Basic human aspirations Need for a holistic perspective Role of UHV
4 and 5	Self-Management	Self-confidence, peer pressure, time management, anger, stress… Personality development, self-improvement…	Harmony in the human being
6 and 7	Health	Health issues, healthy diet, healthy lifestyle Hostel life	Harmony of the Self and Body Mental and physical health
8, 9, 10 and 11	Relationships	Home sickness, gratitude towards parents, teachers and others Ragging and interaction Competition and cooperation Peer pressure	Harmony in relationship Feelings of trust, respect… gratitude, glory, love
12	Society	Participation in society	Harmony in the society
13	Natural Environment	Participation in nature	Harmony in nature/existence
14	Sum Up	Review role of	Information

		education Need for a holistic perspective	about UHV-II course, mentor and buddy
15	Self-evaluation and Closure	Sharing and feedback	

SIP Module 2: Physical Health and Related Activities 51 hours

This module is intended to help understand the basic principles to remain healthy and fit and practice them through a healthy routine which includes exercise, games etc.

SIP Module 3: Familiarization of Department/ Branch and Innovation 06 hours

This module is for introducing and relating the student to the institution/department/branch; how it plays a role in the development of the society, the state, region, nation and the world at large and how students can participate in it.

SIP Module 4: Visit to a Local Area 10 hours

To relate to the social environment of the educational institution as well as the area in which it is situated through interaction with the people, place, history, politics…

SIP Module 5: Lectures by Eminent People 06 hours

Listening to the life and times of eminent people from various fields like academics, industry etc. about careers, art, self-management and so on enriches the student's perspective and provides a holistic learning experience.

SIP Module 6: Proficiency Modules 06 hours

This module is to help fill the gaps in basic competency required for further inputs to be absorbed. It includes effort to make student proficient in interpersonal communication and expression as well as awareness about linguistic and thereafter NLP.

SIP Module 7: Literature / Literary Activities 30 hours

Through the exposure of local, national and international literature, this module is aimed at helping the student learn about traditional as well as contemporary values and thought.

SIP Module 8: Creative Practices 49 hours

This module is to help develop the clarity of humanistic culture and its creative, joyful expression through practice of art forms like dance, drama, music, painting, pottery, sculpture etc.

SIP Module 9: Extra Curricular Activities 06 hours

This is a category under which things that are not placed in any of the above may be placed. Some clubs and hobby group may be made for each of the above categories, so that students may pursue them even after SIP.

The recommended hours to be allocated are given above. Depending on the available faculty, staff, infrastructure, playgrounds, class timings, hostellers and day scholars etc., the timetable for these activities may be drawn up. Of course, colleges may conduct an inaugural function at the beginning of the SIP; and they may also conduct a celebratory closing ceremony at the end of the SIP.

In particular, during the lockdown phase, appropriate care may be taken and some or all activities may be planned in distance-learning or on-line mode.

Sample 3-week Activity List

Week 1	Inaugural Function Regular SIP Activities (See Hours Plan)
Week 2	Regular SIP Activities (See Hours Plan)
Week 3	Regular SIP Activities (See Hours Plan) Valedictory and Closing Ceremony (Celebration)

Implementation

Every institution/college is expected to conduct the 3-week SIP under the guidance of the Director/Principal or Dean Students or a senior faculty member. For this, the institution is expected to make an SIP Cell / team, which will be responsible for planning, and then implementation of the SIP.

A UHV Cell is expected to be set up at each college and university. At the college, it will be managed by the UHV Convener / Coordinator under the chairpersonship of the director/principal. Faculty members and some students will be the members. They will coordinate the UHV activities like UHV-I during SIP, UHV-II, the faculty mentoring program and student buddy program throughout the student's association with the institute/college. The UHV Cell will work to incorporate human values in every aspect of education at the institute/college. Preparing UHV Faculty (Mentors) is one of its important activities.

Follow up

The SIP is only the beginning of the interaction with newly joined students.

An important part of the SIP is to associate one faculty mentor to every small groups of about 20 students; and also associate one senior student buddy to an even smaller groups of about 5 students for the guidance required for holistic development of the newly joined student throughout his/her time in the institution/college.

These activities are to be continued in the ongoing academic program along with other cultural activities through various student clubs which are largely be managed by students with the help of one or more faculty mentors. One of the main responsibilities of the faculty mentors would be helping the clubs to review their activities in alignment with human values.

Assessing the Implementation and Impact

The institution / college is expected to take feedback and prepare appropriate reports for assessing the impact and for further improvement of SIP. The basic feedback forms are included with the SIP Teaching Materials.

The SIP and its further follow up is expected to positively impact common graduate attributes like:
Holistic vision of life
Socially responsible behaviour
Environmentally responsible work
Ethical human conduct
Having Competence and Capabilities for Maintaining Health and Hygiene
Appreciation and aspiration for excellence (merit) and gratitude for all

AICTE will conduct periodic assessment to ascertain the implementation efforts and impact of the SIP and related activities.

Faculty Development

To ensure the implementation of SIP, and in particular to prepare the faculty, the National Coordination Committee for Student Induction (NCC-IP) has been formed. It offers various faculty development programs (FDPs) with the support from AICTE HQ and Regional Offices.

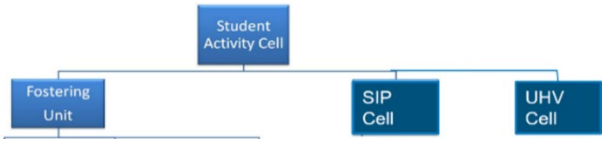
UHV Faculty (Mentors): Every institution is expected to prepare UHV Faculty in the ratio of 1:20 (1 faculty per 20 newly admitted students). Faculty from every teaching department are to be prepared. The basic preparation is participation in an 8-day FDP-SI (UHV).

Faculty for other Modules: Institutions/colleges generally have faculty, coaches, student clubs, alumni for these areas. FDP and comprehensive material will also be made available.

Student Activity Cell (SAC) – SIP Cell, UHV Cell and Fostering Unit

Student Activity Cell will have three cells or units:

- Fostering Unit – for coordinating various student clubs and activities in alignment with human values and IKS through various student clubs
- SIP Cell – for coordinating the annual SIP
- UHV Cell – for coordinating regular UHV activities, including UHV-I during SIP and UHV-II during future semesters, faculty mentoring and student buddy programs etc.



Each cell / unit will have some axis. E.g. the Fostering Unit will have 3 axis:

- UHV Axis – for UHV inputs and activities after the SIP
- Health Axis – for health oriented inputs and activities after SIP
- Career Axis – for career related inputs

Each axis will have one or more dimensions. E.g. the UHV Axis will have two dimensions:

- UHV Dimension
- Social Work Dimension

- Details of the clubs will be based on local conditions.

- Director or Principal or Dean of Student affairs will be the Chairman of Student Activity Cell

- SIP Cell (or Induction Unit) will be managed by faculty members with the help of student volunteers. 5 to 7 faculty members will be the members. The SIP Cell will be responsible for planning, organization, coordination and reporting of the annual Student Induction Program with the help of other faculty members and student volunteers

- UHV Cell will be managed by the UHV Convener / Coordinator under the chairpersonship of the director/principal. Faculty members and some students will be the members. They will coordinate the UHV activities like UHV-I during SIP, UHV-II 3rd/4th semester, faculty mentoring program and student buddy program throughout the student's association with the institute/college. UHV Cell will work to incorporate human values in every aspect of education at the institute/college. Preparing UHV Faculty (Mentors) is one of its activities

- Fostering unit will largely be managed by students with the help of one fostering unit faculty mentor. Student will be coordinators for axis, dimensions and clubs. Fostering unit will take support from induction unit as and when required. It will be responsible for coordinating various student clubs and activities in alignment with human values and Indian Knowledge System

SIP Teaching Material and More Details

The SIP Handbook as well as detailed guides and material for each of the modules is available on the AICTE website (http://www.fdp-si.aicte-india.org/download.php).

Details and Reference Documents:

- G012 SIP Handbook v2
- Teaching Material for UHV-I v2.1
- Teaching Material for SIP modules 2 to 9 v1
- G008 Facilitator (Mentor) Manual Version 2.1
- G911 UHV Cell, Nodal and Resource Centres
- G009 RP Development Process v2

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