

# Model Curriculum for UG Degree Course in Automobile

2020



ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

[www.aicte-india.org](http://www.aicte-india.org)





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**Model Curriculum for**  
**UG Degree Course**  
**in**  
**Automobile Engineering**

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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 Automobile Engineering. 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 160 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 Dr. S. Neelakrishnan, Dr. G. Devaradjane, Dr. Aravind Bhardwaj and Dr. S. S. Thispe. 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 160 credits.

**(Prof. Anil D. Sahasrabudhe)**

Chairman

All India Council for Technical Education



## PREFACE

Taking cognisance of growing concern about quality of technical education in India, AICTE in its 49<sup>th</sup> 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 Mechatronics Engineering. 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 Mechatronics 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.

I gratefully acknowledge the time and efforts of the members of the working group namely Dr. S. Neelakrishnan Head of Automobile Engineering, PSG College of Technology, Coimbatore; Dr. G. Devaradjane Head of Department of Automobile Engineering, Madras Institute of Technology, Chennai; Dr. Aravind Bhardwaj of Chief Technology Officer, Mahindra & Mahindra Ltd., Chennai and Dr. S. S. Thispe Deputy Director, Automotive Research Association of India (ARAI), Pune.

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. Neeraj Saxena, Adviser-II; Dr. Pradeep C. Bhaskar, Assistant Director (P&AP); Mr. Dharmesh Kumar Dewangan, Young Professional (P&AP); Mr. Rakesh Kumar Pandit Young Professional (P&AP); and other office staff of AICTE.

**(Prof. Dileep N. Malkhede)**

Advisor – I

Policy and Academic Planning Bureau  
All India Council for Technical Education





## **Committee for Model Curriculum of Automobile Engineering**

Dr. G. Devaradjane	Head, Department of Automobile Engineering, Madras Institute of Technology, Chennai
Dr. S. Neelakrishnan,	Head of Automobile Engineering, PSG College of Technology, Coimbatore
Dr. Aravind Bhardwaj	Chief Technology Officer, Mahindra & Mahindra Ltd., Chennai
Dr. S. S. Thispe	Deputy Director, Automotive Research Association of India (ARAI), Pune



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# **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 160 credits, the total number of credits proposed for the four-year B. Tech in Automobile Engineering is 160.

**C. Structure of Automobile Engineering program:** The structure of Automobile Engineering program 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	9
2.	Basic Science Courses	23
3.	Engineering Science Courses	23
4.	Program Core Courses (Branch specific)	62
5.	Program Elective Courses (Branch specific)	18
6.	Open Elective Courses (from Humanities and Technical Emerging Subjects)	9
7.	Project work, Seminar and Internship in Industry or elsewhere	16
8.	Audit Courses [Environmental Sciences, Indian Constitution]	(non-credit)
	<b>TOTAL</b>	<b>160*</b>

*\*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: 3

(ii) Credits: 9

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	HS102	English	2	0	2	II	3
2	HS201	Effective Technical Communication	3	0	0	III	3
3	HS301	Entrepreneurship and Startups	3	0	0	V	3
<b>Total Credits</b>							<b>9</b>

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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
<b>Total Credits</b>							<b>23</b>

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### ENGINEERING SCIENCE COURSES [ES]

(i) Number of Engineering Sciences Courses: 6

(ii) Credits: 23

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	Manufacturing Technology	3	0	0	III	3
6	ES203	Engineering Mechanics	3	1	0	III	4
<b>Total Credits</b>							<b>23</b>

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### PROGRAM CORE COURSES [PC]

(i) Number of Program Core Courses: 22 (including lab courses)

(ii) Credits: 62

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	PC201	Thermodynamics and Thermal Engineering	3	1	0	III	4
2	PC203	Automotive Powertrain	3	0	0	III	3
3	PC205	Mechanical Sciences Laboratory	0	0	4	III	2
4	PC202	Strength of Materials	3	0	0	IV	3
5	PC204	Automotive Chassis	4	0	0	IV	4
6	PC206	Fluid Mechanics	3	0	0	IV	3
7	PC208	Mechanics of Machines	3	1	0	IV	4
8	PC210	Vehicle	0	0	4	IV	2

		Components Laboratory					
9	PC212	Machine Drawing	0	0	4	IV	2
10	PC301	Engineering Design	3	0	0	V	3
11	PC303	Automotive Electrical and Electronics System	3	0	0	V	3
12	PC305	Automotive Transmission	3	0	0	V	3
13	PC307	Automotive Electrical and Electronics System	0	0	4	V	2
14	PC309	Vehicle Testing Laboratory	0	0	4	V	2
15	PC302	Design of Vehicle Components	3	0	0	VI	3
16	PC304	Vehicle Dynamics	3	0	0	VI	3
17	PC306	Electric and Hybrid Vehicles	3	0	0	VI	3
18	PC308	Vehicle Servicing Laboratory	0	0	4	VI	2
19	PC401	Automotive Pollution and Control	3	0	0	VII	3
20	PC403	Finite Element Techniques	3	0	0	VII	3
21	PC405	Vehicle Body Engineering	3	0	0	VII	3
22	PC407	Engine Testing and Emission Measurement Laboratory	0	0	4	VII	2
<b>Total Credits</b>							<b>62</b>

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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	PE301	Professional Elective I	3	0	0	V	3
2	PE302	Professional Elective II	3	0	0	VI	3

3	PE304	Professional Elective III	3	0	0	VI	3
4	PE401	Professional Elective IV	3	0	0	VII	3
5	PE403	Professional Elective V	3	0	0	VII	3
6	PE402	Professional Elective VI	3	0	0	VIII	3
<b>Total Credits</b>							<b>18</b>

For detailed syllabus of Professional Elective Course, Refer Appendix II.

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### OPEN ELECTIVE COURSES [OE]

(i) Number of Open Elective Courses: 3

(ii) Credits: 9

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	OE202	Open Elective I (Emerging Areas)	3	0	0	IV	3
2	OE302	Open Elective II (Humanities and Social Science)	3	0	0	VI	3
3	OE401	Open Elective III (Emerging Areas)	3	0	0	VII	3
<b>Total Credits</b>							<b>9</b>

For detailed syllabus of Open Elective Course, Refer Appendix I.

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### PROJECT WORK, SEMINAR AND INTERNSHIP IN INDUSTRY OR ELSEWHERE

S. No.	Course Code	Course Title	L	T	P	Semester	Credits
1	EEC201	Summer Internship I	-	-	-	III	2
2	EEC301	Summer Internship II	-	-	-	V	2
3	EEC302	Innovation Practices	0	0	2	VI	1
3	EEC401	Project Work I/Summer Internship III	-	-	-	VII	4
4	EEC402	Project Work II	0	0	14	VIII	7
<b>Total Credits</b>							<b>16</b>

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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	AU202	Environmental Science	3	0	0	IV	0
2	AU301	Indian Constitution	3	0	0	V	0
<b>Total Credits</b>							<b>0</b>

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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>). For more, Refer **Appendix III**.

Induction program (mandatory)	Three-week duration
Induction program for students to be offered right at the start of the first year.	<ul style="list-style-type: none"><li>• Physical activity</li><li>• Creative Arts</li><li>• Universal Human Values</li><li>• Literary</li><li>• Proficiency Modules</li><li>• Lectures by Eminent People</li><li>• Visits to local Areas</li><li>• Familiarization to Dept./Branch &amp; Innovations</li></ul>

### E. Mandatory Visits/ Workshop/Expert Lectures:

- It is mandatory to arrange one industrial visit every semester for the students of each branch.
- It is mandatory to conduct a One-week workshop during the winter break after fifth semester on professional/ industry/ entrepreneurial orientation.
- 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:

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

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# **SEMESTER WISE STRUCTURE**





### SEMESTER I

S. No.	Course Code	Course Title	L	T	P	Credit
<b>3-WEEKS COMPULSORY INDUCTION PROGRAM</b>						
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
<b>TOTAL</b>			<b>10</b>	<b>3</b>	<b>9</b>	<b>17.5</b>

### 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	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
<b>TOTAL</b>			<b>12</b>	<b>2</b>	<b>13</b>	<b>20.5</b>

### SEMESTER III

S. No.	Course Code	Course Title	Weekly Contact Hours	L	T	P	C
<b>THEORY</b>							
1	BS201	Mathematics III	4	3	1	0	4
2	HS201	Effective Technical Communication	3	3	0	0	3
3	ES201	Manufacturing Technology	3	3	0	0	3
4	PC201	Thermodynamics and Thermal Engineering	4	3	1	0	4
5	ES203	Engineering Mechanics	4	3	1	0	4
6	PC203	Automotive Powertrain	3	3	0	0	3
<b>PRACTICAL</b>							
7	PC205	Mechanical Sciences Laboratory	4	0	0	4	2
8	EEC201	Summer Internship I	-	-	-	-	2
<b>TOTAL</b>			<b>29</b>	<b>18</b>	<b>3</b>	<b>8</b>	<b>25</b>

### SEMESTER IV

S. No.	Course Code	Course Title	Weekly Contact Hours	L	T	P	C
<b>THEORY</b>							
1	OE202	Open Elective I (Emerging Areas)	3	3	0	0	3
2	AU202	Environmental Science	3 <sup>^</sup>	3	0	0	0
3	PC202	Strength of Materials	3	3	0	0	3
4	PC204	Automotive Chassis	4	4	0	0	4
5	PC206	Fluid Mechanics	3	3	0	0	3
6	PC208	Mechanics of Machines	4	3	1	0	4
<b>PRACTICAL</b>							
7	PC210	Vehicle Components Laboratory	4	0	0	4	2
8	PC212	Machine Drawing	4	0	0	4	2
<b>TOTAL</b>			<b>25+3<sup>^</sup></b>	<b>19</b>	<b>1</b>	<b>8</b>	<b>21</b>

### SEMESTER V

S. No.	Course Code	Course Title	Weekly Contact Hours	L	T	P	C
<b>THEORY</b>							
1	HS301	Entrepreneurship and Startups	3	3	0	0	3
2	AU301	Indian Constitution	3 <sup>^</sup>	3	0	0	0
3	PC301	Engineering Design	3	3	0	0	3
4	PC303	Automotive Electrical and Electronics System	3	3	0	0	3
5	PC305	Automotive Transmission	3	3	0	0	3
6	PE301	Professional Elective I	3	3	0	0	3
<b>PRACTICAL</b>							
7	PC307	Automotive Electrical and Electronics Laboratory	4	0	0	4	2
8	PC309	Vehicle Testing Laboratory	4	0	0	4	2
9	EEC301	Summer Internship II	-	-	-	-	2
<b>TOTAL</b>			<b>23+3<sup>^</sup></b>	<b>18</b>	<b>0</b>	<b>8</b>	<b>21</b>

<sup>^</sup> represent "Audit Course".

### SEMESTER VI

S. No.	Course Code	Course Title	Weekly Contact Hours	L	T	P	C
<b>THEORY</b>							
1	OE302	Open Elective II (Humanities and Social Science)	3	3	0	0	3
2	PC302	Design of Vehicle Components	3	3	0	0	3
3	PC304	Vehicle Dynamics	3	3	0	0	3
4	PC306	Electric and Hybrid Vehicles	3	3	0	0	3
5	PE302	Professional Elective II	3	3	0	0	3
6	PE304	Professional Elective III	3	3	0	0	3
<b>PRACTICAL</b>							
7	EEC302	Innovation Practices	2	0	0	2	1
8	PC308	Vehicle Servicing Laboratory	4	0	0	4	2
<b>TOTAL</b>			<b>24</b>	<b>18</b>	<b>0</b>	<b>6</b>	<b>21</b>

### SEMESTER VII

S. No.	Course Code	Course Title	Weekly Contact Hours	L	T	P	C
<b>THEORY</b>							
1	OE401	Open Elective III (Emerging Areas)	3	3	0	0	3
2	PC401	Automotive Pollution and Control	3	3	0	0	3
3	PC403	Finite Element Techniques	3	3	0	0	3
4	PE401	Professional Elective IV	3	3	0	0	3
5	PE403	Professional Elective V	3	3	0	0	3
6	PC405	Vehicle Body Engineering	3	3	0	0	3
<b>PRACTICAL</b>							
7	PC407	Engine Testing and Emission Measurement Laboratory	4	0	0	4	2
8	EEC401	Project Work I / Summer Internship III	-	-	-	-	4
<b>TOTAL</b>			<b>22</b>	<b>18</b>	<b>0</b>	<b>4</b>	<b>24</b>

## SEMESTER VIII

<b>S. No.</b>	<b>Course Code</b>	<b>Course Title</b>	<b>Weekly Contact Hours</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>THEORY</b>							
1	PE402	Professional Elective VI	3	3	0	0	3
<b>PRACTICAL</b>							
2	EEC402	Project Work II	-	0	0	14	7
<b>TOTAL</b>			<b>3</b>	<b>3</b>	<b>0</b>	<b>14</b>	<b>10</b>

# **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 <b>(Any One)</b>	:	<b>Anyone from the below options</b> <ol style="list-style-type: none"> <li>i. Introduction to Electromagnetic Theory</li> <li>ii. Introduction to Mechanics</li> <li>iii. Quantum Mechanics for Engineers</li> <li>iv. Oscillation, Waves and Optics</li> </ol>

**Course Objectives:** To enhance the fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology.

<b>Introduction to Electromagnetic Theory</b>
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 braking 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; displacement 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 Poynting 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 braking;
- 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. W. Saslow, Electricity, magnetism and light
- iv. R.L. Yadava, Electromagnetic Fields & Waves

### **Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
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1	INTRODUCTION ELECTROMAGNETIC THEORY	TO	PROF. MANOJ HARBOLA	IIT KANPUR
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**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

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

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<b>Introduction to Mechanics</b>
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;  $F = -\text{Grad } V$ , 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, 2<sup>nd</sup> ed. — MK Harbola
2. Engineering Mechanics - 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:**

<b>S. No.</b>	<b>NPTEL Course Name</b>	<b>Instructor</b>	<b>Host Institute</b>
1	ENGINEERING MECHANICS	PROF. MANOJ HARBOLA	IIT KANPUR
2	ENGINEERING MECHANICS	PROF. K. RAMESH	IIT M

### EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

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

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### 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. D. J. Griffiths, Quantum mechanics
3. Richard Robinett, Quantum Mechanics
4. Daniel McQuarrie, Quantum 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.	<a href="http://mpv-au.vlabs.ac.in/modern-physics/Photo%20Electric%20Effect/">http://mpv-au.vlabs.ac.in/modern-physics/Photo Electric Effect/</a>

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<b>Oscillations, waves and optics</b>
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, CO<sub>2</sub>), solid-state lasers (ruby, Neodymium), dye lasers; Properties of laser beams: monochromaticity, 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:**

<b>S. No.</b>	<b>NPTEL Course Name</b>	<b>Instructor</b>	<b>Host Institute</b>
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).	<a href="http://ov-au.vlabs.ac.in/optics/Diffraction%20Grating/">http://ov-au.vlabs.ac.in/optics/Diffraction Grating/</a>
2	Minimum deviation from a prism.	<a href="http://ov-au.vlabs.ac.in/optics/Spectrometer%20i%20d%20Curve/">http://ov-au.vlabs.ac.in/optics/Spectrometer i d Curve/</a>

**Course Outcomes:**

After completion of this course, the students will be able:

1. To acquire a core knowledge in physics, including the major premises of classical mechanics, quantum mechanics, electromagnetic theory, electronics, optics, Oscillation, Waves and Optics.
2. To design and conduct an experiment (or series of experiments) demonstrating their understanding of the scientific method and processes. Not only that they are expected to have an understanding of the analytical methods required to interpret and analyze results and draw conclusions as supported by their data.
3. To Develop problem solving methods that will include mathematical as well as numerical computations and solutions.
4. To Build connections between mathematical development and conceptual understanding.

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Course Code	:	BS103
Course Title	:	Mathematics- I
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	BS

**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 1: 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 2: 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 3: 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 4: 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. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Reena Garg, Engineering Mathematics – I, Khanna Publishing House, 2019.
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 text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
8. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.
9. Reena Garg, Advanced Engineering Mathematics, Khanna Publishing House.

### **Alternative NPTEL/SWAYAM Course:**

<b>S. No.</b>	<b>NPTEL Course Name</b>	<b>Instructor</b>	<b>Host Institute</b>
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.
- The fallouts of Rolle's Theorem that is fundamental to application of analysis to Engineering problems.
- 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.
- 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/REFERENC BOOKS:**

1. Ritu Sahdev, Basic Electrical Engineering, Khanna Publishing House.
2. Nagrath I.J. and D. P. Kothari (2001), Basic Electrical Engineering, Tata McGraw Hill.
3. Hayt and Kimberly, Engineering Circuit Analysis, Tata McGraw Hill.
4. Kulshreshtha D.C. (2009), Basic Electrical Engineering, Tata McGraw Hill.
5. Rajendra Prasad (2009), Fundamentals of Electrical Engineering, Prentice Hall, India Hughes, E. 2005).

**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. A.P. Gautam, Pradeep Jain, Ankita Maheshwari, Engineering Graphics & Design, Delhi
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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## **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 be 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:

#### Module 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 multicenter 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.

#### Module 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.

#### Module 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 H<sub>3</sub>, H<sub>2</sub>F and HCN and trajectories on these surfaces.

#### Module IV: Use of free energy in chemical equilibria (6 lectures)

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.

### **Module 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.

### **Module 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.

### **Module 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 demonstrate 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. University chemistry, by B. H. Mahan
2. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane
3. Fundamentals of Molecular Spectroscopy, by C. N. Banwell
4. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan

5. Physical Chemistry, by P. W. Atkins
6. Organic Chemistry: Structure and Function by K. P. C. Vollhardt and N. E. Schore, 5th Edition <http://bcs.whfreeman.com/vollhardtschore5e/default.asp>

**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.	<a href="http://pcv-au.vlabs.ac.in/physical-chemis-try/Determination_of_Viscosity_of_Organic_Solvents/">http://pcv-au.vlabs.ac.in/physical-chemis-try/Determination_of_Viscosity_of_Organic_Solvents/</a>
2	Ion exchange column for removal of hardness of water.	<a href="http://icv-au.vlabs.ac.in/inorganic-chemis-try/Water_Analysis_Determination_of_Chemical_Parameters/">http://icv-au.vlabs.ac.in/inorganic-chemis-try/Water_Analysis_Determination_of_Chemical_Parameters/</a>
3	Determination of chloride content of water.	<a href="http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determination-of-chloride-nitk/simulation.html">http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determination-of-chloride-nitk/simulation.html</a>
4	Colligative properties using freezing point depression.	<a href="http://pcv-au.vlabs.ac.in/physical-chemistry/Cryoscopy/">http://pcv-au.vlabs.ac.in/physical-chemistry/Cryoscopy/</a>
5	Determination of the rate constant of a reaction.	<a href="http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/">http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/</a>
6	Determination of cell constant and conductance of solutions.	<a href="http://icv-au.vlabs.ac.in/inorganic-chemis-try/Water_Analysis_Determination_of_Physical_Parameters/">http://icv-au.vlabs.ac.in/inorganic-chemis-try/Water_Analysis_Determination_of_Physical_Parameters/</a>
7	Potentiometry - determination of redox potentials and emfs.	<a href="http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/">http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/</a>
8	Saponification/acid value of an oil.	<a href="http://biotech01.vlabs.ac.in/bio-chemis-try/Estimation_of_Saponification_Value_of_Fats_or_Oils/">http://biotech01.vlabs.ac.in/bio-chemis-try/Estimation_of_Saponification_Value_of_Fats_or_Oils/</a>

9	Lattice structures and packing of spheres.	<a href="https://vlab.amrita.edu/?sub=1&amp;brc h=282&amp;sim=370&amp;cnt=1">https://vlab.amrita.edu/?sub=1&amp;brc h=282&amp;sim=370&amp;cnt=1</a>
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### 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.

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Course Code	:	BS104
Course Title	:	Mathematics- II
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.

## **Course Content:**

### **Module I: Multivariable Calculus (Integration)**

Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.

### **Module II: First order ordinary differential equations**

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for  $p$ , equations solvable for  $y$ , equations solvable for  $x$  and Clairaut's type.

### **Module III: Ordinary differential equations of higher orders**

Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

### **Module IV: Complex Variable – Differentiation**

Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

### **Module V: Complex Variable – Integration**

Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

## **TEXT BOOKS/REFERNCES:**

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.
4. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
5. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
6. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
7. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., McGraw Hill, 2004.

8. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
9. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.
10. Reena Garg, Advanced Engineering Mathematics, Khanna Publishing House.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	DIFFERENTIAL EQUATIONS FOR ENGINEERS	PROF. SRINIVASA MANAM	IITM
2	ENGINEERING MATHEMATICS II	PROF. JITENDRA KUMAR	IIT KHARAGPUR

**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:

- The mathematical tools needed in evaluating multiple integrals and their usage.
- The effective mathematical tools for the solutions of differential equations that model physical processes.
- 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:**

**Module I:** 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.

**Module II:** Arithmetic expressions and precedence.

**Module III:** Conditional Branching and Loops. Writing and evaluation of conditionals and consequent branching. Iteration and loops.

**Module IV:** Arrays, Arrays (1-D, 2-D), Character arrays and Strings

**Module V:** 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)

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

**Module VII:** 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.

**Module VIII:** Structures, Defining structures and Array of Structures

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

**Module 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. R.S. Salaria, Problem Solving & Programming in C,
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill.
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.	<a href="http://ps-iiith.vlabs.ac.in/exp7/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab">http://ps-iiith.vlabs.ac.in/exp7/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab</a>
2	Iterative problems e.g., sum of series.	<a href="http://ps-iiith.vlabs.ac.in/exp4/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab">http://ps-iiith.vlabs.ac.in/exp4/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab</a>
3	1D Array manipulation.	<a href="http://cse02-iiith.vlabs.ac.in/exp4/index.html">http://cse02-iiith.vlabs.ac.in/exp4/index.html</a>
4	Matrix problems, String operations.	<a href="http://ps-iiith.vlabs.ac.in/exp5/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab">http://ps-iiith.vlabs.ac.in/exp5/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab</a>
5	Simple functions.	<a href="http://cse02-iiith.vlabs.ac.in/exp2/index.html">http://cse02-iiith.vlabs.ac.in/exp2/index.html</a>
6	Programming for solving Numerical methods problems.	<a href="http://ps-iiith.vlabs.ac.in/exp1/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab">http://ps-iiith.vlabs.ac.in/exp1/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab</a>
7	Recursive functions.	<a href="http://ps-iiith.vlabs.ac.in/exp6/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab">http://ps-iiith.vlabs.ac.in/exp6/Introduction.html?do-main=Computer%20Science&amp;lab=Problem%20Solving%20Lab</a>



**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 root 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. Effective Communication Skills, Kulbhushan Kumar, Khanna Publishing House.
5. Study Writing. Liz Hamp-Lyons and Ben Heasley. Cambridge University Press. 2006.

6. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
7. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press.

**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:**

1. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods.
2. CNC machining, Additive manufacturing.
3. Fitting operations & power tools.
4. Electrical & Electronics.
5. Carpentry.
6. Plastic moulding, glass cutting.
7. Metal casting.
8. 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 moulding & 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. 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.
2. Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.
3. Gowri P. Hariharan and A. Suresh Babu," Manufacturing Technology – I" Pearson Education, 2008.
4. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.
5. 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).	<a href="http://mm-coep.vlabs.ac.in/LaserSpotWelding/Theory.html?domain=Mechanical%20Engineering&amp;lab=Welcome%20to%20Micromachining%20laboratory">http://mm-coep.vlabs.ac.in/LaserSpotWelding/Theory.html?domain=Mechanical%20Engineering&amp;lab=Welcome%20to%20Micromachining%20laboratory</a>
2	Casting	<a href="http://fab-coep.vlabs.ac.in/exp7/Theory.html?domain=Mechanical%20Engineering&amp;lab=Welcome%20to%20FAB%20laboratory">http://fab-coep.vlabs.ac.in/exp7/Theory.html?domain=Mechanical%20Engineering&amp;lab=Welcome%20to%20FAB%20laboratory</a>

**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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## **SEMESTER – III**





## SEMESTER III

Course Code	:	BS201
Course Title	:	Mathematics - III
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	BS

### Course Objective(s):

1. To understand and formulate linear and non-linear based engineering problems with applied linear and non-linear equations.
2. To study and understand the problem solving using ODE, PDE for automobile engineering problems solving applications.

### Course Content:

- **Module I: ERRORS:** Approximations and round-off errors - truncation errors.
- **Module II: Linear Algebraic Equations:** Direct methods - Naïve Gauss elimination method, Gauss-Jordan method, Crout's method, Iterative methods - Gauss-Jacobi method, Gauss-Seidel method, eigenvalues and eigenvectors - power method, Jacobi method.
- **Module III: Nonlinear Equations:** False- position method, Newton-Raphson method, Bairstow's method, Graeffe's root squaring method.
- **Module IV: Interpolation and Curve Fitting:** Newton's forward and backward interpolating polynomials, Newton's divided-difference interpolating polynomials, Lagrange interpolating polynomials, coefficients of an interpolating polynomial, Chebyshev interpolation Curve fitting - least- squares regression
- **Module V: Differentiation and Integration:** Numerical differentiation - equally spaced and unequally spaced data, numerical integration, Newton-Cotes formulae, Trapezoidal rule, Simpson's 1/3 rule.
- **Module VI: Ordinary Differential Equations:** Taylor-series method, Euler method, Heun's method, 4th order Runge-Kutta method, multi-step method - Milne method.
- **Module VII: Partial Differential Equations:** Finite difference: Elliptic equations - Laplace equation, Poisson equation - Liebmann method, parabolic equations - heat conduction equation - Crank Nicolson's method, hyperbolic equations - vibrating string.
- **Module VIII: Statistics:** Regression analysis - correlation and regression, Design of experiments - completely randomized design, randomized block design, Latin square design, Uncertainty Analysis.

### Text Books:

1. Steven C Chapra and Raymond P Canale, Numerical Methods for Engineers, McGraw Hill Education, New Delhi, 2012.
2. Curtis F Gerald and Patrick O Wheatly, Applied Numerical Analysis, Pearson Education, New Delhi, 2013.
3. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, Wiley India, Delhi, 2012.
4. Salaria, R.S., Computer Oriented Numerical Methods, Khanna Publishing House, Delhi.

**References:**

1. Rizwan Butt, Introduction to Numerical Analysis Using MATLAB, Infinity Science Press, Hingham, 2008.
2. Richard L Burden and Douglas J Faires, Numerical Analysis, Thomas Learning, New York, 2005.
3. Amparo Gil, Javier Segura, Nico M. Temme, Numerical Methods for Special Functions, SIAM publishers, USA, 2007.
4. Hugh W. Coleman, W. Glenn Steele, Jr., Experimentation and Uncertainty Analysis for .Engineers, John Wiley and Sons, New York 1999

**Course Outcome(s):**

The student after undergoing this course will be able to:

1. Solve problems in engineering domain related to Linear Algebra using suitable techniques.
2. Analyze and solve engineering problems using non-linear methods
3. Analyze and solve engineering problems using interpolation and curve fitting techniques.
4. Solve engineering problems using ODE and PDE for automobile engineering applications problems.

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

**Course Objective: -**

The goal of this course is to prepare engineering students with the individual and collaborative technical writing, presentation, and research skills necessary to be effective technical communicators in academic and professional environments.

**Course Content:**

**Module I:** 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 II:** 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 III:** 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 IV:** 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 V:** 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. Diane Hacker, Pocket Style Manual, Bedford Publication, New York, 2003. (ISBN 0312406843).
3. Shiv Khera, You Can Win, Macmillan Books, New York, 2003.
4. Raman Sharma, Technical Communications, Oxford Publication, London, 2004.
5. Dale Jungk, Applied Writing for Technicians, McGraw Hill, New York, 2004. (ISBN: 07828357-4)
6. Sharma, R. and Mohan, K. Business Correspondence and Report Writing, TMH New Delhi 2002.
7. Xebec, Presentation Book, TMH New Delhi, 2000. (ISBN 0402213).
8. Kulbhushan Kumar, Effective Communication Skills, Khanna Publishing House.

#### **Alternative NPTEL/SWAYAM Course:**

<b>S. No.</b>	<b>NPTEL Course Name</b>	<b>Instructor</b>	<b>Host Institute</b>
1	INTRODUCTION TO PROFESSIONAL SCIENTIFIC COMMUNICATION	PROF. S. GANESH	IIT KANPUR

#### **Course Outcomes:**

1. To Participate actively in writing activities (individually and in collaboration) that model effective scientific and technical communication in the workplace.
2. To Practice the unique qualities of professional writing style, including sentence conciseness, readability, clarity, accuracy, honesty, avoiding wordiness or ambiguity, previewing, using direct order organization, objectivity, unbiased analysing, summarizing, coherence and transitional devices.

3. To Recognize, explain, and use the rhetorical strategies and the formal elements of these specific genres of technical communication: technical abstracts, data based research reports, instructional manuals, technical descriptions, web pages, wikis, and correspondence.
4. To Collect, analyze document and report research clearly, concisely, logically, and ethically; & to understand the standards for legitimate interpretations of research data within scientific and technical communities.

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Course Code	:	ES201
Course Title	:	Manufacturing Technology
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	ES

### Course Objective(s):

1. To provide to the students the different methods of metal casting and metal melting furnaces.
2. To expose to the students, the different techniques of joining processes for metals and non-metals.
3. To provide to the students an understanding and appreciation of the metal cutting, forming processes and injection moulding.
4. To provide a proper insight about the importance of lubrication, wear problems and proper understanding of machining processes.
5. To provide the students with a proper understanding and importance of powder metallurgy and processing of plastics.

### Course Content:

- **Module I: Casting:** Steps involved in making a casting – Advantage of casting and its applications. Patterns and Pattern making – Types of patterns – Materials used for patterns, core and core making, casting design considerations. Casting processes - Sand, centrifugal, die, investment, lost foam, gravity, squeeze, shell. Methods of Melting: Crucible melting and cupola operation.
- **Module II: Welding:** Classification of welding processes. Principles of Oxy-acetylene gas welding. A.C metal-arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, soldering and brazing.
- **Module III: Forming and Shaping of Plastics:** Stamping, forming and other cold working processes: Blanking and piercing – Bending and forming – Rolling, Drawing and its types – wire drawing and Tube drawing – coining – Hot and cold spinning – Types of presses and press tools. Basic extrusion processes and its characteristics. Forging processes - Principles of forging, tools and dies - Types of forging – Open, closed, drop forging, roll forging. Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding.
- **Module IV: Machining:** General principles (with schematic diagrams only) of working and commonly performed operations in the following machines: Lathe, Shaper, Planer, Horizontal milling Machine-Universal drilling machine, cylindrical

grinding machine, Capstan and Turret lathe. Basics of CNC machines. General principles and applications of the following processes: Abrasive jet machining, Ultrasonic machining, electric discharge machining, electro chemical machining, Plasma arc machining, electron beam machining and laser beam machining.

- **Module V: Powder Metallurgy:** Production of metal powders, mixing and blending, compacting, sintering and secondary operations. Application of Powder Metallurgy in Automobile fields.

**Text Books:**

1. Schey A John, “Introduction to Manufacturing Processes”, Tata McGraw Hill, Noida, 2012.
2. Kalpakjian Serope, Schmid R. Steven, “Manufacturing Engineering and Technology”, Prentice Hall, 2009.

**References:**

1. Heine, Loper and Rosenthal, “Principles of Metal Casting”, Tata McGraw Hill Publishing Co, Ltd; New Delhi, 2011.
2. Banga T.R; and Agrawal R.L, “Foundry Engineering”, Khanna Publishers, New Delhi, 2007.
3. Parmar R.S, “Plastics & Plastics Technology”, Khanna Publishing House.
4. Rao P.N, “Manufacturing Technology, (Volume I)”, Tata McGraw Hill Education Private Limited, Noida, 2008.
5. James G. Bralla, “Handbook of Manufacturing Processes”, Industrial Press, New York, 2007.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Fundamentals of manufacturing processes	Dr. D. K. Dwivedi	IIT Roorkee

**Course Outcome(s):**

1. Identify the different casting methods and summarize which is the best suited for the industry.
2. Interpret the best joining techniques, and select an appropriate technique according to a specific requirement.
3. Infer the meaning and importance of tribology of forming operations, and how it affects the performance of a component during its service life.
4. Describe the machining process and to appreciate the effect of process parameters on the surface integrity aspects, categorize how they occur, and how to examine & interpret Injection moulding problems.
5. Design a powder metallurgy component using the best blending ratio and produce the best powders and compare with the conventional method of machining complex and hard materials.

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Course Code	:	PC201
Course Title	:	Thermodynamics and Thermal Engineering
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	PC

### Course Objective(s):

1. Understanding of the first law of thermodynamics and various forms of work that can occur.
2. An ability to evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations.
3. An understanding of the use of the Gibbs and Helmholtz free energies as equilibrium criteria, and the statement of the equilibrium condition for closed and open systems.

### Course Content:

- **Module I: Basic Thermodynamics:** Systems – Zeroth law – First law – Steady flow energy equation – Heat and work transfer in flow and non-flow processes – Second law – Kelvin-Planck statement – Clausius statement – Concept of Entropy Clausius inequality – Entropy change in non-flow processes – Properties of gases and vapours – Introduction to thermoelectricity.
- **Module II: Air Standard Cycle and Compressors:** Otto – Diesel – Dual combustion and Brayton cycles – Air standard efficiency – Mean effective pressure – Reciprocating compressors.
- **Module III: Steam and Jet Propulsion:** Properties of steam – Rankine cycle – Steam Nozzles – Simple jet propulsion system – Thrust rocket motor – Specific impulse.
- **Module IV: Refrigeration and Air-Conditioning:** Principles of psychometry and refrigeration – Vapour compression – Vapour absorption types – Coefficient of performance – Properties of refrigerants – Basic Principle and types of Air conditioning.
- **Module V: Heat Transfer:** Conduction in parallel – Radial and composite wall – Basics of Convective heat transfer – Fundamentals of Radiative heat transfer – Flow through heat exchangers.

### Text Books:

1. Nag. P.K., “Basic and applied thermodynamics”, Tata McGraw-Hill, 2007.
2. S. Domkundwar, C.P. Kothandaraman, Anand Domkundwar “A Course in Thermal Engineering, Dhanpat Rai & Co., 2013

### References:

1. Holman.J.P., “Thermodynamics”, McGraw-Hill, 2007
2. Arora C.P, “Thermodynamics”, Tata McGraw-Hill, 2003.
3. Radhakrishnan E., “Fundamentals of Engineering Thermodynamics”, Prentice-Hall India, 2005.

### Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	ENGINEERING THERMODYNAMICS	PROF. D. P. MISHRA	IITK

**Course Outcome(s):**

1. Understand concept of temperature measurements, work and its interaction, heat and its interaction, different types of thermodynamics systems.
2. Understand concept of reversibility and irreversibility, entropy and available energy.
3. Evaluate efficiency of heat efficiency of heat engine and coefficient of performance of heat pump & refrigerator.
4. Evaluate the properties of pure substance and efficiency of vapor power cycles using pure substance.
5. Understand the concept of moist air and its effect on air-conditioning.

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Course Code	:	ES203
Course Title	:	Engineering Mechanics
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	ES

**Course Objective(s):**

1. Learn the basic principles of engineering mechanics concepts to analyze the rigid bodies in static equilibrium conditions and friction.
2. Exposed to various structures and able to identify appropriate structure for the given problem
3. Understand the importance of centroids, centre of gravity (mass) and moment of inertia
4. Learn the kinematics and kinetics acting on bodies.
5. Understand the concept of work energy and impulse.

**Course Content:**

**Module I: STATICS:** Resultant of concurrent forces - Force on a particle - resultant of concurrent forces - resolution of force - equilibrium of a particle - free body diagram - force in space - equilibrium of a particle in space – transmissibility - moment of a force - resolution of a force into a force and a couple - reactions at supports - equilibrium of a two and three force bodies - Simple trusses - method of joints.

**Module II: FRICTION:** Laws of dry friction - angles of friction - coefficient of static and kinetic friction - wedge friction – rolling resistance - belt friction.

**Module III: CENTROID, CENTRE OF GRAVITY AND MOMENT OF INERTIA:** Centroids of areas - composite areas - center of gravity- determination of moment of inertia - polar moment of inertia - radius of gyration - mass moment of inertia of simple solids.

**Module IV: KINEMATICS AND KINETICS:** Equation of motion - rectilinear and rotary motion - Energy- potential energy- kinetic energy- conservation of energy- work done by a force - work energy method.

**Module V: IMPULSE AND MOMENTUM:** Impulse - Momentum principle - Direct central impact - oblique central impact - impact of a moving car on the spring board.

**Text Books:**

1. Bedi D.S., Engineering Mechanics, Khanna Publishing House.
2. Beer F P and Johnson E R. Vector Mechanics for Engineers, Statics and Dynamics New Delhi: Tata McGraw Hill Publishing Co. Ltd., 2010.
3. Rajasekaran S and Sankarasubramanian G. Engineering Mechanics-Statics and Dynamics New Delhi: Vikas Publishing House Pvt. Ltd., 2006.

**References:**

1. Bansal R K. Engineering Mechanics New Delhi: Laxmi Publications Pvt. Ltd., 2006.
2. Bhavikatti S S. Engineering Mechanics New Delhi: New Age International Pvt. Ltd., 2003.
4. Young D H and Timashenko S. Engineering Mechanics Tata Mcgraw-Hill, 2006.
5. Jivan Khachane,Ruchi Shrivastava. Engineering Mechanics: Statics and Dynamics ANE Books, 2006.

**Alternative NPTEL/SWAYAM Course:**

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

**Course Outcome(s):**

1. Analyze and solve forces in static problems
2. Solve applications related to friction.
3. Determine centroids and moment of inertia.
4. Solve problems associated with kinematics and kinetics.
5. Solve problems associated with impulse and momentum.

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Course Code	:	PC203
Course Title	:	Automotive Powertrain
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To study and understand the components, systems and architectures of automotive power-plant systems.
2. To study and evaluate the powertrain components in a modern day vehicle systems



### Course Content:

- **Engine:** Classification - SI and CI engine operation - two stroke and four stroke engines - construction - working principle. Theoretical and actual indicator diagrams - calculation of power - efficiency. Valve and port timing diagram - stages of combustion in SI and CI engine - abnormal combustion - combustion chamber.
- **Fuels, Lubrication and Cooling System:** Properties of I.C. engine fuels - fuel injection system- CRDI - MPFI - lubrication system- principle - lubricating system for petrol and diesel engines - oil pump. Cooling system - water cooled engine - air cooled engine.
- **Clutch and Gear Box:** Clutches - types - construction - working principle - torque calculation. Gear box - Types - construction - function and design characteristics - gear ratio calculations. Speed and torque characteristics of power transmission system. Gear shifting mechanisms. Hybrid Transmission- CVT- DCT, AMT and Automatic Transmission.
- **Final Drive and Modern Transmission:** Propeller shaft - functional and design characteristics - universal joints - slip joint. Rear end torque and driving force. Rear axle types. Differential and final drive - purpose - principle - construction.\_
- **Wheels and Tyres:** Types of wheels and tyres - specification - materials.

### Text Books:

1. Babu A.K., Automobile Mechanics, Khanna Publishing House.
2. William H Crouse & Anglin D L "Automotive Mechanics", Tata McGraw Hill Publishing Company., 2006

### References:

1. Robert Bosch "Automotive Handbook", 2011.
2. Kirpal Singh "Automobile Engineering", Vol 1 & 2., 2011.
3. Ganesan V "Internal Combustion Engines", Tata McGraw Hill, 2003.
4. Babu, A.K., "Automotive Engines", Khanna Publishing House.

### Course Outcome(s):

1. Explain the construction of SI and CI engine.
2. Identify the diesel and petrol engine fuel feed system components and its construction and working.
3. Identify the construction and operation of vehicle transmission systems.
4. Understand the need and working of drive-lines components
5. Elaborate the construction and working of tires and its requirements for automotive applications.

**Note:** Course content may be changed in near future based on deployment of Electric Vehicles / EV Policy.

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Course Code	:	PC205
Course Title	:	Mechanical Sciences Laboratory
Number of Credits	:	2 (L: 0, T: 0,P: 4)
Course Category	:	PC

**Course Objective(s):**

1. To introduce the student to the fundamental theories and the industrial applications of thermodynamics, heat transfer.
2. To familiarize the student with measuring crank angles and drawing timing diagrams.
3. To accustom the student to obtain the characteristics of the IC engine.
4. To familiarize the student with the usage of computers in obtaining the characteristics of the IC engine
5. To develop skills on handling Pneumatic and Hydraulic devices.
6. To build up handiness in performing load tests and performance tests.

**Course Content:****Thermal Engineering Laboratory**

1. Experimental study on valve timing diagram in 4-stroke engine and 2-stroke cut model.
2. Performance test on constant speed 4-stroke diesel engine.
3. Variable speed test on multi-cylinder diesel engine.
4. Heat balance test on 4-stroke diesel engine.
5. IC engine performance evaluation using PC interface.

**Fluid Mechanics Laboratory**

1. Calibration and comparison of instruments for measuring flow through pipes-orifice, venturi meter, water meter and rotameter.
2. Model study in wind tunnel.
3. Performance test on pumps.
4. Load test on reaction turbine.
5. Performance test on axial flow fan.

**Text Books / References:** Lab manual as per above experiments to be prepared by the institution.

**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

S. No.	Experiment Name	Experiment Link(s)	Name of Experiment on website
1	Calibration and comparison of instruments for measuring flow through pipes-orifice, venturi meter, water meter and rotameter.	<a href="http://eerc03-iiith.vlabs.ac.in/exp6/Introduction.html">http://eerc03-iiith.vlabs.ac.in/exp6/Introduction.html</a>	Orifices
2	Calibration and comparison of instruments for measuring flow	<a href="http://eerc03-iiith.vlabs.ac.in/exp5/Introduction.ht">http://eerc03-iiith.vlabs.ac.in/exp5/Introduction.ht</a>	Venturi Meter

	through pipes-orifice, venturi meter, water meter and rotameter.	ml	
3	Performance test on pumps.	<a href="https://fmc-nitk.vlabs.ac.in/fluid-machinery-lab/exp/centrifugal-pump/index.html">https://fmc-nitk.vlabs.ac.in/fluid-machinery-lab/exp/centrifugal-pump/index.html</a>	Performance Characteristics of Centrifugal Pump
4	Load test on reaction turbine.	<a href="https://fmc-nitk.vlabs.ac.in/fluid-machinery/exp/francis-turbine/">https://fmc-nitk.vlabs.ac.in/fluid-machinery/exp/francis-turbine/</a>	Performance Characteristics of Francis Turbine

**Course Outcome(s):**

1. Draw valve timing diagram in 4-stroke engine and 2-stroke cut model.
2. Evaluate the performance for a variable speed test on multi-cylinder diesel engine.
3. Balance heat in an engine and evaluate the performance with and without PC interface.
4. Calibrate flow measuring instruments such as orifice, venturi meter, water meter and rotameter.
5. Perform model study in wind tunnel and load test on reaction turbine.
6. Evaluate the performance pumps and axial flow fan.

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Course Code	:	EEC201
Course Title	:	Summer Internship I
Number of Credits	:	2
Course Category	:	EEC

**Note:** Internship of 3 to 4 Weeks to be performed by student in the summer break between Semester II and III. Internship can be done in an industry, Start-up, Social Internship, Work from Home Internship etc.

For more guidance regarding internship, refer AICTE Internship Policy and AICTE Internship Portal ([www.internship.aicte-india.org](http://www.internship.aicte-india.org)).

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## **SEMESTER – IV**



## SEMESTER IV

Course Code	:	OE202
Course Title	:	Open Elective I (Emerging Areas)
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Note:** A Student can opt for any one subject out of nine available subjects under “Section I – Emerging Areas” of **Appendix I** on Open Electives.

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Course Code	:	AU202
Course Title	:	Environmental Science
Number of Credits	:	0 (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:

#### Module I: Ecosystem

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

#### Module II: Air and, Noise Pollution

1. Definition of pollution and pollutant, Natural and manmade sources of air pollution (Refrigerants, I.C., Boiler).
2. Air Pollutants: Types, Particulate Pollutants: Effects and control (Bag filter, Cyclone separator, Electrostatic Precipitator).
3. Gaseous Pollution Control: Absorber, Catalytic Converter, Effects of air pollution due to Refrigerants, I.C., Boiler.

4. Noise pollution: sources of pollution, measurement of pollution level, Effects of Noise pollution, Noise pollution (Regulation and Control) Rules, 2000.

### **Module III: Water and Soil Pollution**

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

### **Module IV: Renewable sources of Energy**

1. 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.
2. Biomass: Overview of biomass as energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilization and storage of biogas.
3. Wind energy: Current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy.
4. 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.

### **Module V: Solid Waste Management, ISO 14000 & Environmental Management**

1. Solid waste generation- Sources and characteristics of: Municipal solid waste, E-waste, biomedical waste.
2. Metallic wastes and Non-Metallic wastes (lubricants, plastics, rubber) from industries. Collection and disposal: MSW (3R, principles, energy recovery, sanitary landfill), Hazardous waste.
3. Air quality act 2004, air pollution control act 1981 and water pollution and control act 1996. Structure and role of Central and state pollution control board.
4. Concept of Carbon Credit, Carbon Footprint.
5. Environmental management in fabrication industry.
6. 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](http://www.eco-prayer.org)
2. [www.teriin.org](http://www.teriin.org)
3. [www.cpcp.nic.in](http://www.cpcp.nic.in)
4. [www.cpcp.gov.in](http://www.cpcp.gov.in)
5. [www.indiaenvironmentportal.org.in](http://www.indiaenvironmentportal.org.in)
6. [www.whatis.techtarget.com](http://www.whatis.techtarget.com)
7. [www.sustainabledevelopment.un.org](http://www.sustainabledevelopment.un.org)
8. [www.conserve-energy-future.com](http://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 or 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	:	Strength of Materials
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To know the behavior of material at various loading conditions in compression and tension.
2. Understand and analyze shear force and bending moment in various loading conditions.
3. To know the phenomenon of bending of different sections and its analysis and recognize principle stresses.
4. To understand various column sections and geometrical analysis.
5. Concepts of strain energy, torsion and numerical analysis.

**Course Content:**

**Module I: Stresses and Strains:** Stress and strain due to axial force – Strain energy due to axial force – sudden load and impact load. Poisson's ratio– volumetric strain– shear stress–shear strain. Thin cylindrical and spherical shells under internal pressure. Thermal stresses. Principal stresses and planes – Mohr's circle for plane stress and plane strain. Strain gauges and rosettes.

**Module II: Bending Moment and Shear Force in Beams:** Shear force and bending moment diagrams for cantilever, simply supported and overhanging beams under concentrated loads, uniformly distributed loads, uniformly varying loads, concentrated moments – maximum bending moment and point of contra flexure.

**Module III: Flexure & Torsion in Beams:** Theory of simple bending and assumptions – flexure equation. Theory of torsion and assumptions – torsion equation – power transmitted by a shaft.

**Module IV: Deflection of Determinate Beams:** Governing differential equation – Macaulay's method – moment area method – application to simple problems (cantilever beams and simply supported beams only).

**Module V: Columns and Struts:** Columns – behaviour of axially loaded short and long column members – buckling load – Euler’s theory – different end conditions – Rankine’s formula.

**Text Books:**

1. Bedi D.S., “Strength of Materials”, Khanna Publishing House, 2017.
2. Jindal U C, “Strength of Materials”, Asian Books Pvt Ltd, New Delhi, 2007.
3. Rajput.R K, “Strength of Materials”, S.Chand& Co Ltd, New Delhi, 1996.

**References:**

1. Egor P Popov, “Engineering Mechanics of Solids”, Prentice Hall of India, New Delhi, 1997
2. Subramanian R, “Strength of Materials”, Oxford University Press, Oxford Higher Education Series, Oxford, 2007
3. Hibbeler R.C, “Mechanics of Materials”, Pearson Education, New Jersey, 2007
4. Bansal R.K, “Strength of Materials”, Lakshmi Publications(P)Ltd, New Delhi,2010
5. Ferdinand P Been, Russell Johnson,J.R. and John J Dewole, “Mechanics of Materials”, Tata Mcgraw Hill Publishing Co Ltd, New Delhi, 2006

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	STRENGTH OF MATERIALS	PROF. SRIMAN KUMAR BHATTACHARYYA	IIT KGP

**Course Outcome(s):**

1. Explain stress, strain, establish relationship between them and apply concepts of stress, strain to solve numerical problems.
2. Compute Shear Force and Bending Moment for determinate beams and draw Shear Force and draw Bending Moment Diagrams for various loading conditions.
3. Determine various stresses and draw stress diagrams using the knowledge of bending and shear concepts.
4. Explain theory of column failure with different support conditions, and develop numerical ability to solve numerical problems.
5. Solve numerical problems by applying knowledge of strain energy, torsion and thin cylinders and spherical shells.

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Course Code	:	PC204
Course Title	:	Automotive Chassis
Number of Credits	:	4 (L: 4, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To know the architectural requirements of different chassis structures

2. Understand the components and linkages related to steering mechanisms
3. To know the phenomenon of suspension and wheels and tyres requirements in a modern day vehicle
4. To understand the components and systems function in a vehicle brake system.

### **Course Content:**

**Module I: Introduction:** Requirements - Types of Chassis layout, different cross section and applications- Loads acting on vehicle frame, Constructional details and materials for frames, mounting bracket. Monocoque body construction- material and manufacturing- Recent trends.

**Module II: Steering Systems:** Types of Front Axles and Stub Axles, Front Wheel Geometry, Castor, Camber, King Pin Inclination and Toe-in, Condition for True Rolling. Motion of Wheels during Steering, Ackerman's and Davis Steering Mechanisms, Steering Error Curve, Steering Linkages, Different Types of Steering gear boxes, Hydraulic. Electric power steering and electrohydraulic power steering, steering damper – basic steering system kinematics.

**Module III: Tyres and Wheels:** Tyre requirements – interchangeability- types – radial ply -cross ply- tyre specification – tubed and tubeless tyres- wheels for cars and CVs- rolling resistance-lateral force and friction coefficients- self aligning torque and caster offset –wheel travel and elastokinematics.

**Module IV: Suspension System:** Need for Suspension System, Types of Suspension Springs, Constructional details and characteristics of Single Leaf, Multi-Leaf, Coil, Torsion bar, Rubber, Pneumatic and Hydro – elastic Suspension Spring Systems, Independent Suspension System, Shock Absorbers, Types and Constructional details, Design of Leaf and Coil Springs.

**Module V: Brake Systems:** Need for Brake systems, Stopping Distance, Time and Braking Efficiency, Effect of Weight Transfer during Braking, Classification of brakes, Braking Torque, Drum Brake and Disc Brake Theory, Types and Construction of Hydraulic Braking System, Mechanical Braking System, Pneumatic Braking System, Power-Assisted Braking System, Servo Brakes, Retarders – Antilock Braking Systems(ABS), Traction control and yaw control braking –Exhaust and Transmission braking systems

### **Text Books:**

1. Reimpbell, Stoll, and Betzler, "The Automotive Chassis" Butterworth and Heinmann 2009
2. R.K. Rajput, "A Text-Book of Automobile Engineering", Laxmi Publications Private Limited, 2007

**References:**

1. Heldt P.M., "Automotive Chassis" Chilton Co., New York.
2. Newton Steeds and Garrett, "The Motor Vehicle" Butterworth, London, 2005.
3. Heinz Hazler, "Modern Vehicle Technology", Butterworth, London, 2005.
4. Babu A.K., "Automobile Mechanics" Khanna Publishing House, New Delhi.

**Course Outcome(s):**

1. Understand the basic knowledge about various vehicle frames, front axles and steering systems.
2. Understand the construction and working principle of steering mechanisms.
3. Explain the constructional feature of wheels and tyres.
4. Explain suspension systems.
5. Understand the constructions and operations of brake systems

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Course Code	:	PC206
Course Title	:	Fluid Mechanics
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To introduce and explain fundamentals of Fluid Mechanics, which is used in the applications of Aerodynamics, Hydraulics, Marine Engineering, Gas dynamics etc.
2. To give fundamental knowledge of fluid, its properties and behavior under various conditions of internal and external flows.
3. To develop understanding about hydrostatic law, principle of buoyancy and stability of a floating body and application of mass, momentum and energy equation in fluid flow.
4. To imbibe basic laws and equations used for analysis of static and dynamic fluids.
5. To inculcate the importance of fluid flow measurement and its applications in Industries.
6. To determine the losses in a flow system, flow through pipes, boundary layer flow and flow past immersed bodies.

**Course Content:**

**Module I: Fluid Properties:** Pressure and temperature measurement, specific gravity and weight, viscosity, capillarity and surface tension, compressibility, vapour pressure and gas laws, Conservation of laws - mass, momentum and energy, continuum hypothesis - Newton's viscosity law-Newtonian vs Non-Newtonian Fluids – Analysis and problem solving.

**Module II: Fluid Statics:** Pressure in fluids at rest-hydrostatic force on submerged surfaces, Buoyancy and stability, Stream function and vortices, potential function, types

of flow and significance, Dimensional analysis, significant dimensionless groups, flow similarity and model studies, Problem solving of hydrostatics and model analysis.

**Module III: Fluid Dynamics:** Motion of a fluid particle – Fluid deformation – Differential analysis of fluid motion – Continuity and Navier Stokes equation, Euler and Bernoulli's Equation and their applications, introduction to computational fluid dynamics - necessity, limitations and applications.

**Module IV: Flow through Pipes and Flow Measurement Devices:** Boundary layer theory, Hagen-Poiseuille and Darcy's equations for friction and pressure drop, Helmholtz's Theorems, Flow through pipes - Major and minor losses through pipes, Measurement of discharge - Venturi and Orifice Meter, Flow Nozzle, Pitot Tubes, Multi-Hole Probe and anemometer.

**Module V: Fluid Machinery:** Specific Speed-Theory of turbo Machines-Hydraulic efficiency- Velocity components at the entry and exit of the Rotor-Velocity triangle for single stage radial flow and axial flow machines- Centrifugal pumps, turbines, reciprocating pumps and Rotary pumps- Working and performance analysis.

#### **Text Books:**

1. Yunus A Cengel and John M Cimballa, "Fluid Mechanics - Fundamentals and Application", Tata McGraw Hill Publishing Company, New Delhi, 2006.
2. Munson, Young, Okiishi and Huebsch, "Introduction to Fluid Mechanics", 5th Edition, John Willey and Sons, 2011.
3. Sadhu Singh, Fluid Mechanics, Khanna Publishing House, 2019.

#### **References:**

1. Streeter Wylie and Bedford, "Fluid Mechanics", McGraw- Hill Publishing Company Limited, New York, 1998.
2. Irwing H Shames, "Mechanics of Fluids", Third Edition, McGraw Hill Inc., New York, 1992.
3. Kumar K L, "Engineering Fluid Mechanics", Eurasia Publications Limited, New Delhi, 1990.
4. John D Anderson, "Computational Fluid Dynamics – The Basics with Applications", McGraw Hill, New Delhi, 1995.
5. King R P, "Introduction to Practical Fluid Flow (With CD)", Butterworth, 2002.
6. Bansal, R.K., Fluid Mechanics and Hydraulics Machines, Laxmi Publications (P) Ltd., New Delhi.
7. Robert W Fox & Alan T McDonald, 'Introduction to fluid Mechanics', John Wiley and Sons, 1995.
8. Kumar D S, "Fluid Mechanics and Fluid Power Engineering ", Kataria S K and Sons, New Delhi, 1997.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	FLUID MECHANICS	PROF. SUBASHISA DUTTA	IITG

**Course Outcome(s):**

1. Apply mathematical knowledge to predict the properties and characteristics of a fluid.
2. Analyse the performance of pumps and turbines.
3. Understand the mathematical techniques of practical flow problems.
4. Understand the energy exchange process in fluid machines.
5. Understand the boundary layer theory.

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Course Code	:	PC208
Course Title	:	Mechanics of Machines
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To impart the knowledge of various mechanisms, their inversions & their applications and make students to do displacement, velocity & acceleration analysis for these mechanisms.
2. To provide the basics knowledge on cams & followers, gears, gear trains, governors and gyroscopic couple.
3. To make students to do analysis for various cam& follower mechanisms, gears& gear trains.

**Course Content:**

**Module I: Mechanisms:** Terminology and definitions, degree of freedom, mobility. Grashoff's law. Mechanical advantage. Transmission angle. Description of common mechanisms, introduction to four bar spatial mechanisms. Kinematic inversions – Four bar chain, slider crank chain, applications of mechanisms.

**Module II: Kinematics:** Displacement, velocity and acceleration analysis in simple mechanisms, graphical method, velocity and acceleration polygons. Kinematic analysis by algebraic method, vector approach, Chace equation, computer applications in the kinematics analysis of simple mechanisms.

**Module III: Force Analysis of Mechanism:** Static force analysis- Free Body diagram, conditions of equilibrium, two, three and four force members, effect of friction. Dynamic force analysis of slider crank mechanism. Study of effect of friction.

**Module IV: Gears:** Spur gear terminology and definitions. Fundamental law of toothed gearing and tooth forms. Interchangeable gears, gear tooth action-Interference and undercutting. Helical, bevel, worm, rack and pinion gears (basics only). Gear trains, epicyclic gear trains, differentials, automotive transmission gear trains.

**Module V: Balancing:** Balancing of revolving, reciprocating masses in single plane and several planes-Primary and secondary forces and couples, balancing of multicylinder inline engine. Balancing of V type of engines, direct and reverse crank technique. Balancing machines – Field balancing, single and two planes.

**Module VI: Vibration:** Basic features of vibratory Systems-Elements, degrees of freedom, single degree of freedom system. Undamped free vibration, equation of motion, natural frequency. Damped free vibration, equation of motion, logarithmic decrement, critical speed of shaft. Torsional vibration of two and three rotor systems, geared systems.

**Text Books:**

1. John J. Uicker, Gordon R. Pennock & Late Joseph E. Shigley, "Theory of Machines and Mechanisms", SI Edition, International Version, 2009
2. Rattan S S, "Theory of Machines", Tata McGraw -Hill Publishers, New Delhi, 2009.

**References:**

1. Thomas Beven, "The Theory of Machines", CBS Publishers and Distributors, New Delhi, 2005.
2. Rao J.S and Dukkipati R.V, "Mechanism and Machine Theory", New Age International Publishers, New Delhi, 2006.
3. Sharma C.S, Kamlesh Purohit, "Theory of Mechanisms and Machines", PHI, New Delhi, 2006.
4. Sadhu Singh, "Theory of Machines", Pearson Education, New Delhi, 2009.
5. Gupta B.V.R, "Theory of Machines", I.K International publishing house Pvt Ltd, New Delhi, 2011.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Kinematics of Mechanisms and Machines	Prof. A. Dasgupta	IIT Kharagpur

**Course Outcome(s):**

1. Determine various mechanisms, their inversions and Identify their applications.
2. Analyze various mechanisms and measure displacement, velocity and acceleration for these mechanisms.
3. Construct the layout for cam profiles for various followers and Analyze them for their jump speed.



4. Distinguish various gears & gear trains and able to Analyze these gear trains for relative velocity and torque.
5. Describe governors & their various type and able to Determine their controlling forces.
6. Define the gyroscopic couple and their effect in ship, car, motorcycle & aero planes and able to Determine gyroscopic stabilization.

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Course Code	:	PC210
Course Title	:	Vehicle Components Laboratory
Number of Credits	:	2 (L: 0, T: 0, P: 4)
Course Category	:	PC

**Course Objective(s):**

1. To identify and explode the engine, drive-train components of atypical vehicle.
2. To dismantle and assemble the subsystems of a vehicle component to check its operational sequences.

**Course Content: List of Experiments**

1. Inspection and servicing of different types of clutches.
2. Inspection and servicing of different types of gear boxes.
3. Measurement of backlash and run out of differential unit.
4. Servicing of transaxle assembly.
5. Servicing of different types of rear axle assembly.
6. Servicing of steering gear boxes and verification of Ackerman steering geometry.
7. Tuning of electric horn system and wind screen wiper system.
8. Brake system troubleshooting and servicing.
9. Electrical system diagnostics.
10. Wheel balancing and wheel alignment.

**Text Books/References:** Lab manual as per the given experiments to be prepared by the institution.

**Course Outcome(s):**

1. Service the types of clutches, gear boxes and calculation of torque carrying capacity and gear ratio.
2. Identify the types of wear of the differential unit
3. Service the transaxle and rear axle assembly, brake system, identify the faults and service the same
4. Service the steering gear boxes, and measure the turning circle radius and check wheel balancing and set wheel alignment parameters of a given vehicle.
5. Tune the electric horn system and service wind screen wiper system and diagnose the faults of Electrical system of a vehicle.

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Course Code	:	PC212
Course Title	:	Machine Drawing
Number of Credits	:	2 (L: 0, T: 0, P: 4)
Course Category	:	PC

### Course Objective(s):

1. To make the students understand and interpret drawings of machine components so as to prepare assembly drawings either manually and using standard CAD packages.
2. To familiarize the students with Indian Standards on drawing practices and standard components.

### Course Content:

**Module I: Introduction:** Introduction to machine drawing. Review of orthographic and isometric projections, Importance of sectional views. Computer-aided drafting.

**Module II: Conventions:** Code of practice for engineering drawing-conventional representation of details- drilled and tapped holes, countersunk and counter bored holes, internal and external threads, undercuts, grooves, chamfers, fillet radii and keyways. Conventions to represent standard components-bolts, nuts, washers, screws, cotters, pins, circlips, bearings, gears, springs and flanges.

**Module III: Assembly Concepts:** Methods and concepts of assemblies-assembly requirements, Bill of materials. Methods of assembly-bolts, nuts, studs, screws and pins. Methods of arresting motion of a member in an assembly. Assembly and dismantling exercise of a typical assembly with emphasis on assembly sequence and appropriate fits. Assembling and dismantling practice in assemblies like pneumatic cylinder, machine vice.

**Module IV: Fits and Tolerances:** Limits, fits and tolerances-need, types, representation of tolerances on drawing, calculation of minimum and maximum clearances and allowances. Geometric tolerance-uses, types of form and position tolerances, symbols, method of indicating geometric tolerances on part drawings. Surface finish symbols-methods of indicating the surface roughness. Blue print reading exercises. Making blue print drawings of production drawing.

**Module V: Assembly Drawing Practice:** Making free hand sketches of typical subassemblies-flange coupling, stuffing box, journal bearings, rolling element bearings, keyed joints, cotter joints, C clamp. Free hand sketching of I.C Engine subassemblies like piston and connecting rod, gear box.

**Module VI: Assembly Using Solid Modelling:** Modelling and assembly using a CAD software-extracting views and sections. Drawing of assemblies-plummer block, machine vice, stop valve, screw jack, tail stock, cylindrical gear box, simple drilling. Creation of bill of materials, calculation of mass and section properties, interference check between solids.

**Text Books:**

1. Gopalakrishna K R, "Machine Drawing", Subhas Stores, Bangalore, 2013.
2. Narayana K L, Kannaiah P, Venkata Reddy K, "Machine Drawing" New Age International, New Delhi, 2012.

**References:**

1. John K C, "Machine Drawing", PHI Learning, Delhi, 2009.
2. BIS,"SP:46-2003 "Engineering Drawing Practice for Schools and Colleges", New Delhi, 2003.
3. Faculty of Mechanical Engineering, PSG College of Technology, "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2012.
4. ASME Y 14.5M-1994, "Dimensioning and Tolerancing", ASME, New York, 1995.

**Course Outcome(s):**

1. Identify assembly drawing of simple engineering products from part drawing.
2. Discuss, understand and visualize the individual parts that constitute an engineering assembly
3. Apply production drawing incorporating details of tolerances, type of fits, machining details, materials, standards and conventional
4. Analyze and demonstrate working of simple engineering assemblies with specific understanding of the role of individual parts in satisfying the functional requirement.
5. Build, edit and parameterize the capability of reading blue print drawing from industry.

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# **SEMESTER – V**



## SEMESTER V

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

### Course Objective:

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

### Course Content:

#### Unit 1: Introduction to Entrepreneurship and Start - Ups

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

#### Unit 2: Business Ideas and their implementation

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

#### Unit 3: Idea to Start-up

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

#### Unit 4: Management

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

#### Unit 5: Financing and Protection of Ideas

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

#### Unit 6: 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

S. No.	Title of Book	Author	Publication
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 to demonstrate knowledge of the following topics:

1. Understanding the dynamic role of entrepreneurship and small businesses
2. Organizing and Managing a Small Business
3. Financial Planning and Control
4. Forms of Ownership for Small Business
5. Strategic Marketing Planning
6. New Product or Service Development
7. 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 Objective:** - The course is designed to impart knowledge to Understand the emergence and evolution of Indian Constitution and to Understand and analyse the three organs of the state in the contemporary scenario.

### 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

- Role and Functioning
- Chief Election Commissioner
- 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:

- <https://www.constitution.org/cons/india/const.html>
- <http://www.legislative.gov.in/constitution-of-india>
- <https://www.sci.gov.in/constitution>
- <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 analyze federalism in the Indian context.
- 4 To Analyze Panchayati Raj institutions as a medium of decentralization
- 5 To Understand and Evaluate the Indian Political scenario amidst the emerging challenges.

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Course Code	:	PC301
Course Title	:	Engineering Design
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To construct the fundamental knowledge needed for perform Engineering Design
2. To provide the basic skills about various Engineering Design Concepts
3. To make outline of Engineering Design Procedure
4. To provide better Engineering Design solutions for the Engineering Problem

**Course Content:**

**Module I: Introduction:** Concepts of design, preferred numbers – basic and derived series – concurrent engineering – static stress equation in axial, bending and torsional loading – criteria for failure – Strength under static and dynamic conditions– factor of safety.

**Module II: Design Against Static and Fluctuating Load:** Static loading - Combination of normal stresses - combination of normal and shear stresses - principal stresses - theories of failure – maximum shear stress, maximum principal stress, maximum strain energy, maximum distortion energy. Fluctuating load- Mechanism of fatigue failure, fatigue limit and fatigue strength, S-N curves, Soderberg, Goodman and Gerber equations - stress raisers - stress concentration factor, notch sensitivity factor, factors affecting fatigue limit, equivalent stress, combined variable stress.

**Module III: Design of Shafts Couplings and Bearings:** Forces on shafts due to gears, belts and chains, estimation of shaft size based on strength and critical speed. Couplings, types – flexible and rigid, design of key. Bearings – Static and dynamic load capacity, cubic mean load, variable load, probability of survival, selection of bearings - (deep groove, angular contact ball bearings and taper roller bearings).

**Module IV: Springs:** Helical springs, stresses and deflection in round wires, concentric springs - accounting for variable stresses. Design of leaf springs - stress and deflection equations.

**Module V: Riveted / Bolted and Welded Joints:** Strength equations, efficiency, design of riveted joints. Thread forms, initial stress, stresses due to external loads, elastic analysis of bolted joints for pressure vessel flanges. Welded joints - types, weld symbols, strength of welds, centrally loaded unsymmetrical sections, axially loaded and eccentrically loaded joints.

**Module VI: Selection of Transmission Belts and Chains:** Transmission belts – V belts - narrow multiple V belts – timing belts – V ribbed belts. Belts for given power and velocity ratio. Selection of roller chain for power and speed ratio.

**Text Books:**

1. Bandari V B, "Design of Machine Elements ", Tata McGraw Hill, 2010.
2. Shigley and Mische, "Mechanical Engineering Design", McGraw Hill, 2010.

**References:**

1. Faculty of Mechanical Engineering, PSG College of Technology, "Design Data Book", DPV Printers, Coimbatore, 2012.
2. Maitra G M, "Handbook of Gear design", Tata McGraw Hill, New Delhi, 2004.
3. Gope P. C, "Machine Design: Fundamentals and applications", PHI learning, 2012.
4. Robert L Mott, "Machine elements in Mechanical Design", Macmillan Publishing Co, 2003.
5. Sadhu Singh, Machine Design, Khanna Publishing House, Delhi
6. Sadhu Singh, Machine Design Data Book, Khanna Publishing House, Delhi

**Course Outcome(s):**

1. Describe the concepts of design, design process and design department functions. State the implication of various forces in durability of engineering component, such that, Justify the influence of those stresses in Design safest level
2. Associate the types of stresses induced while operating of an Engineering component in static and dynamic conditions. Discover the safe stress limit and dynamic stress concentration factor, compute the maximum stress limit of an Engineering component working under both static and dynamic loading condition.
3. Evaluate the working stresses of an engineering component such as coupling, bearing, springs, riveted/ bolted and welded joints
4. Estimate the working stresses and design safe stress of an engineering component such as coupling, bearing, springs, riveted/ bolted and welded joints. Also choose appropriate suitable materials for those components based on materials strength.
5. Describe about various ranges of power and velocity ratios available belts and chain. Choose the suitable transmission elements such as chain and belts according to that design requirement. Also derive the specification of the transmission elements.

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Course Code	:	PC303
Course Title	:	Automotive Electrical and Electronics System
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To educate students on construction, working and testing of lead acid battery
2. To educate the students on construction and working of different types of ignition system
3. To give knowledge on construction, working of types of starter motors and Alternator and selection of starter motor.
4. To introduce basics and advancement in automobile lighting system
5. To familiarize students with electrical accessories and selection of cables, fuses and multiplexing.

**Course Content:**

**Module I: Batteries:** Lead acid, Lithium-ion and alkaline batteries, construction and working, battery rating, battery charging methods, testing and maintenance.

**Module II: Ignition System:** Introduction -Construction and working of magneto coil and battery coil ignition systems, spark plug types, spark advance mechanisms, electronic ignition systems -Transistorized ignition system, solid state ignition systems, capacitor discharge ignition system and distributor less ignition system.

**Module III: Starting/Charging System:** Principle, construction and working of starter motor, working of different starter drive units. Alternators –Principle, construction and working –Regulators, Introduction to Start / Stop system, integrated starter generator (ISA/ISG).

**Module IV: Lighting System:** Details of head light and side light, LED lighting system, head light dazzling and preventive methods. Automatic headlight-daytime running lamps-adaptive brake lights-instrument panel lighting.

**Module V: Accessories and Wiring:** Fuses, cables, connectors and selection, multiplexing and de-Multiplexing-Automotive Wiring-Insulated and earth return system, Wiring Diagrams, symbols and standards. Horn, wiper system – power window and mirrors, sun roof, defrosters.

**Text Books:**

1. Babu A.K., “Automotive Electricals & Electronics”, Khanna Publishing House.
2. Barry Hollembeak, “Automotive Electricity and Electronics” Cengage Learning, Clifton Park, USA 2007.
3. Kholi P L, “Automotive Electrical Equipment”, Tata McGraw Hill Co., Ltd., New Delhi, 2001.

**References:**

1. Joseph Bell, “Diesel Engineering: Electricity and Electronics”, Cengage Learning, New Delhi, 2007.
2. Robert Bosch, “Automotive Hand Book” SAE, 2018.

3. "Automotive Electrics Automotive Electronics", Robert Bosch GmbH, 2004.
4. Tom Denton, "Automobile Electrical and Electronics systems", Routledge Taylor & Francis Group London & New York, 2002.

**Course Outcome(s):**

1. Explain the construction and testing of lead acid battery, charging of batteries and selection of battery for a vehicle.
2. Identify the type of ignition system and advance and retarding of spark timing.
3. Identify the type of starter motor and charging system. Selection of starter motor and alternator for a vehicle.
4. Select the cables and lighting system for a vehicle.
5. Identify the accessories, select cables and multiplexing.

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Course Code	:	PC305
Course Title	:	Automotive Transmission
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To educate students on types of clutches and calculation of its torque carrying capacity
2. To give knowledge on types of gear boxes, transfer case and auxiliary gear box with gear ratio calculation.
3. To educate the students on drive line parts like propeller shaft, joints axles, wheels and tyre.
4. To familiarize students with final drive and types of differential unit
5. To discuss the types of wheels and tyres and selection.

**Course Content:**

**Module I: Clutch:** role - positive and gradually engaged types - types of clutches, single plate clutch, coil spring type and diaphragm spring type, multiple plate clutch, centrifugal clutch, calculation of torque transmission, over running clutch.

**Module II: Gear Box:** Need for a gearbox, types of gear boxes, sliding mesh, constant mesh and synchromesh gear boxes, calculation of gear ratios, epicyclical gearboxes, overdrives, transfer case - auxiliary gearbox, gear shifting mechanisms.

**Module III: Automatic Transmission:** Need for fluid coupling and torque converters, Borg Warner type, control mechanisms, limitations. Transmission Electronics, Automatic Manual Transmission.

**Module IV: Drive Line:** Chain drive, propeller shaft drive, torque reaction and drive thrust, Hotchkiss drive, Torque tube drive, universal joints, trunnion type, ring type, flexible disc type, constant velocity joint type, swinging arm drives.

**Module V: Axle:** live and dead axles, front axle and its types, stub axle and its types, rear axle and its types, fully floating, semi- floating and three quarter floating axles, two

speed axles, twin axles, swing axles.

**Module VI: Final Drive and Differential:** need for final drive and differential, types of final drives, single reduction and double reduction final drives, differential and its types, conventional and non-slip differentials, differential lock, Inter axle differential transaxle types.

**Module VII: Wheels and Tyres:** basic construction of wheel, hub and tyres, tyre requirements, interchangeability, passenger car and commercial vehicle requirements, bias ply and radial ply tyres, tubeless tyres, wheel balancing, tyre inflation, tyre wear and tyre rotation, quick change wheels, special wheels, run flat tyre.

**Text Books:**

1. Garrett TK, Newton K. and Steeds W. "Motor Vehicle", Butter Worths& Co. Publishers Ltd., New Delhi, 2011.
2. Heinz Heisler, "Advanced Vehicle Technology". Butterworth Heinemann Publishers, 2002.

**References:**

1. Crouse WH, "Automotive Chassis and Body," McG raw Hill Book Co., 1976.
2. Crouse WH, "Automotive Transmissions and Power Trains", McGraw Hill Book Co., 1976.
3. Fenton J, "Hand book of Automotive Power Trains and Chassis Design", Progressive publisher,1998.
4. Martin W Stockel and Martin T Stockel, "Auto Mechanics Fundamentals ", The Good Heart and Wilcox Co. Inc., 1982.

**Course Outcome(s):**

1. Explain the construction and working of types of clutches and calculation of torque carrying capacity.
2. Explain the construction and working of types of gearboxes and calculation of gear ratio.
3. Identify the type of joints and axle.
4. Identify the type of differential unit and calculation of final drive ratio.
5. Explain the types of wheels and tyres and selection.

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Course Code	:	PE301
Course Title	:	Professional Elective I
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

**Important Note:** For Professional Elective Courses (Professional Elective I to VI), a student has to opt four courses from any one of the three streams as defined in **Appendix II** namely 'Design Engineering', 'Thermal Engineering' and 'Industrial & Manufacturing Engineering'. The remaining two courses may be taken from any of the other streams (Design, Thermal, Manufacturing) or from "Miscellaneous".

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Course Code	:	PC307
Course Title	:	Automotive Electrical and Electronics Laboratory
Number of Credits	:	2 (L: 0, T: 0, P: 4)
Course Category	:	PC

**Course Objective(s):**

1. To provide hands on experience on the use of automotive application development and simulation using IDE tool.
2. To make them understand on development of design and constructions of various logic as per the end uses.

**Course Content: List of Experiments**

1. Diagnosing and troubleshooting of starting and charging systems.
2. Scanning and calibrating Sparking ignition systems of SI Engines.
3. Identifying and rectifying fault codes in Engine management systems.
4. Headlight Alignment for dazzling effects.
5. Diagnosing and troubleshooting issues in vehicle fuse box.
6. Interfacing thermocouple and calibrating with microcontroller unit.
7. Multiplexing two microcontrollers for actuation.
8. Stepper motor interfacing for electronic throttle control.
9. IoT based interfacing systems for automotive actuators.
10. Analysis and study of CAN communication protocol for instrument cluster display systems.

**Text Books/References:** Lab manual as per above experiments to be prepared by the institution.

**Course Outcome(s):**

1. Find the relationships between design development and Justify the various logical design based on end use.
2. Construct a suitable design and models and Explore final design based on the applications.
3. Recognize the manufacturing techniques and Implement them for suitable final applications.
4. Implement process plan for the given component.
5. Build, edit and parameterize the capability of reading look up table.

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Course Code	:	PC309
Course Title	:	Vehicle Testing Laboratory
Number of Credits	:	2 (L: 0, T: 0, P: 4)
Course Category	:	PC

**Course Objective(s):**

1. To enable the student to determine the centre of gravity, drawbar pull, stopping distance of a vehicle
2. To estimate the natural frequency and rolling resistance
3. To enable the student to determine the steady state characteristics and steering gear ratio.

### Course Content: List of Experiments

1. Determination of centre of gravity (X-axis)
2. Determination of centre of gravity (Y-axis).
3. Determination of centre of gravity (Z-axis)
4. Determination of steady state characteristics of vehicle
5. Determination of drawbar pulls.
6. Determination of maximum drawbar pull at different surfaces and coefficient of adhesion.
7. Determination of stopping distance
8. Estimation of natural frequency for automotive components
9. Determination of Steering gear ratio
10. Estimation of rolling resistance.

**Text Books/References:** Lab manual as per above experiments to be prepared by the institution.

### Course Outcome(s):

1. Locate the centre of gravity for the given axis.
2. Analyse the steady state characteristics to find whether the vehicle is under steer, over steer or neutral steer.
3. Determine the draw pull for different surfaces and stopping distance.
4. Estimate the natural frequency and rolling resistance.
5. Calculate the steering gear ratio.

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Course Code	:	EEC301
Course Title	:	Summer Internship II
Number of Credits	:	2
Course Category	:	EEC

**Note:** Internship of 3 to 4 Weeks to be performed by student in the summer break between Semester IV and V. Internship can be done in an industry, Start-up, Social Internship, Work from Home Internship etc.

For more guidance regarding internship, refer AICTE Internship Policy and AICTE Internship Portal ([www.internship.aicte-india.org](http://www.internship.aicte-india.org)).

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## **SEMESTER – VI**



## SEMESTER VI

Course Code	:	OE302
Course Title	:	Open Elective II (Humanities and Social Science)
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Note:** A Student can opt for any one subject out of available subjects under “Section II – Humanities and Social Science” of **Appendix I** on Open Electives.

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Course Code	:	PC302
Course Title	:	Design of Vehicle Components
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

### Course Objective(s):

To make the student to understand the principle of designing of vehicle components like engine cylinder, piston, connecting rod valve actuating mechanism, and clutch and gear box.

### Course Content:

**Module I: Design of Engine Components:** Selection of engine based on vehicle performance characteristics - Analysis of forces – Design procedure for cylinder, piston, - piston rings and piston pin. Design procedure for connecting rod and crank shaft. Design of inlet and outlet valves, Design of valve springs, rocker arm, tappet, Cam, camshaft, Design procedure for flywheel.

**Module II: Design of Clutch, Gear Box, Drive Line and Rear Axle:** Design of single and multi-plate clutches. Design of Spur gear, helical and bevel gears - Selection of gear ratios - Design of gear box. Design of propeller shaft and final drive - Design of rear axle - selection of tyres.

**Module III: Design of Frame, Suspension, Front Axle and Steering:** Force analysis and Design procedure for frame - Design of Suspension system – leaf spring - coil spring and torsion spring. Force analysis. Design procedure for front axle. - Determination of steering torque - design of linkages, steering gear box.

**Module IV: Design of Braking System:** Force analysis, design of drum and disc brakes - design of actuating mechanisms –mechanical, hydraulic and pneumatic.

**Module V: Design of Vehicle Body and Vehicle Interior against Ergonomics and Safety:** criteria for vehicle body design, sheet metal representation - Unit load method for structural deflection - Car body idealization, and bus body idealization for analysis - adhesives and sealants. Car interior ergonomics, ergonomics system design - seating dimensions dash board instruments - commercial vehicle cabin ergonomics and goods vehicle layout - Crash tests, forces in rollover, head on impact.

**Text Books:**

1. Khurmi R S, Gupta J K "A Text Book of Machine Design", Eurasia Publishing house., New Delhi, 2010.
2. Lichty "IC Engines", Kogakusha Co. Limited, Tokyo, 1986.
3. Heinz Heisler "Advanced Vehicle Technology", SAE International, 2002.
4. John Fenton "Handbook of Automotive Body and Systems Design", John Wiley & Sons, 2013.

**References:**

1. Thomas D Gillespie "Fundamentals of Vehicle Dynamics", SAE., US, 1992.
2. Giles J G "Engine Design", Illiff Books Ltd., London, 1968.
3. Heldt.P.M "Automotive Chassis", Chilton Co., New York, 1992.
4. Giles.K.G "Steering, Suspension and tyres", Illiffe Books Ltd., London, 1988.
5. JnuszPawlowski "Vehicle Body Engineering", Business Books Limited, 1989.

**Course Outcome(s):**

1. Analyse various forces coming on the vehicle and deduce the power of the engine.
2. Analyse various forces coming on the piston and connecting rod and design the components.
3. Analyse various forces coming on the crank shaft and flywheel and design the components.
4. Analyse various forces coming on the valve and valve actuating mechanisms and design the components.
5. Analyse various forces coming on the Clutch and Gear box and design the components.

**Note:** Course content may be changed in near future based on deployment of Electric Vehicles / EV Policy.

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Course Code	:	PC304
Course Title	:	Vehicle Dynamics
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To understand the fundamentals of Vehicle dynamics and systems.
2. To evaluate the influence vehicle subsystems on the vehicle behavior.

**Course Content:**

**Module I: Introduction:** Earth and vehicle coordinate system. Longitudinal, lateral and vertical vehicle dynamics. Dynamic axle loads. Road loads - Aerodynamic forces and moments, viscosity effects, separation and its control; aerodynamic lift and its control, ground effect, styling for minimum drag. Rolling resistance, grade loads.

**Module II: Performance Mode:** Acceleration - Free body diagram of accelerating vehicle, maximum transferable tractive force, gradability, Deceleration - free body diagram of decelerating vehicle, maximum decelerating rates, stopping distance, maximum braking force. Vehicle performance.

**Module III: Ride Mode:** Degrees of freedom-single, two and multi degrees of freedom system, free, forced and damped vibration, model of an automobile, magnification factor, transmissibility, vibration absorbers, pitch and bounce motion, oscillation centers, active and semi active suspension, orthogonality of mode shapes, modal analysis. MATLAB based Quarter car modelling and simulation.

**Module IV: Springing System:** Requirements, sprung mass and un-sprung mass, wheel hop, shimmy, wheel wobble, choice of suspension spring rate, calculation of effective spring rate. Tyres - mechanics, stability of vehicle on slope, on curve and banked road. Pacejaka's tire model using MATLAB.

**Module V: Handling Mode:** Vehicle control-low speed cornering and static Steering-Ackerman steering geometry, steady-state cornering -steering factors, vehicle control parameters (under steer, neutral steer and over steer), roll steer, compliance steer, ride steer, slip angle steer, steady state handling-lateral acceleration gain, characteristic speed, yaw velocity gain, critical speed, effect of braking on vehicle handling\_ MATLAB based Assignment.

**Text Books:**

1. Thomas D Gillespie, "Fundamentals of Vehicle Dynamics", SAE USA 1992.
2. Rao S.S "Mechanical Vibrations", Pearson Education Publication, 2009.

**References:**

1. Babu A.K., "Automobile Mechanics", Khanna Publishers, New Delhi.
2. Cole D.E., "Elementary Vehicle Dynamics", Ann Arbor, Michigan, USA, 1972.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Vehicle Dynamics	Dr. R. Krishnakumar	IIT Madras

**Course Outcome(s):**

1. Understand the fundamentals of Vehicle dynamics and describe various terminologies.
2. Explain various performance mode characteristics of the vehicle.
3. Analyse ride mode oscillations and compare their characteristics.
4. Evaluate the suspension and stability systems concepts and design the same according to requirements.
5. Analyse the cornering characteristics of the vehicle and evaluate yaw stability.

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Course Code	:	PC306
Course Title	:	Electric and Hybrid Vehicles
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To study the characteristics behaviour of engine, electric motor, controller and energy storage devices for vehicle propulsion systems
2. To study and analyze the renewable energy systems to develop zero emission vehicles.

**Course Content:**

**Module I: Electric Vehicles:** Architecture of an electric vehicle, essentials and performance of electric vehicles –Traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, advantage and limitations.

**Module II: Hybrid Vehicles:** Hybrid electric drivetrains -Concepts, architecture, design, control strategies, merits and demerits.

**Module III: Electric Propulsion Systems:** DC motor drives, induction motor drives, permanent magnet motor drives and switched reluctance motor drives.

**Module IV: Energy Storage Devices:** Electrochemical batteries –Reactions, thermodynamic voltage, lead-acid batteries, nickel based batteries, lithium based batteries, flywheel and ultra-capacitors, Battery management systems, range calculation.

**Module V: Fuel Cell and Solar Powered Vehicles:** Fuel cell thermodynamics, operating principle, fuel cell technologies, fuel reforming, hydrogen production and storage, open circuit voltage flow rate testing and evaluation. Photovoltaic cell, maximum power point tracking, solar powered accessories, hybrid solar vehicles. Fuel Cell testing and evaluation.

**Text Books:**

1. Mehrdad Ehsani, YiminGao, Sebastien E. Gay and Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2009.
2. Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011.

**References:**

1. Seref Soylu “Electric Vehicles -The Benefits and Barriers”, InTech Publishers, Croatia, 2011.
2. AuliceScibioh M. and Viswanathan B., “Fuel Cells –Principles and Applications”, University Press, India, 2006.
3. Barbir F., “PEM Fuel Cells: Theory and Practice” Elsevier, Burlington, 2005.
4. James Larminie and John Lory, “Electric Vehicle Technology-Explained”, John Wiley & Sons Ltd., 2003.
5. Babu A.K., “Electric & Hybrid Vehicles”, Khanna Publishing House, Delhi.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Electric Vehicles - Part 1	Prof. Amit Jain	IIT Delhi

**Course Outcome(s):**

1. Analyse the challenges of electric vehicle over conventional IC engine powered vehicles.
2. Apply the degree of hybridization and alternate powertrain architectures for a conventional system.
3. Evaluate the characteristics and maximum power demand of electric and hybrid drive propulsion system.
4. Analyse the performance and characteristics of battery and electronics converters for the vehicle propulsion systems.
5. Analyse the performance and characteristics of fuel cell for the vehicle Propulsion system.

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Course Code	:	PE302
Course Title	:	Professional Elective II
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

**Important Note:** For Professional Elective Courses (Professional Elective I to VI), a student has to opt four courses from any one of the three streams as defined in **Appendix II** namely 'Design Engineering', 'Thermal Engineering' and 'Industrial & Manufacturing Engineering'. The remaining two courses may be taken from any of the other streams (Design, Thermal, Manufacturing) or from "Miscellaneous".

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Course Code	:	PE304
Course Title	:	Professional Elective III
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

**Important Note:** For Professional Elective Courses (Professional Elective I to VI), a student has to opt four courses from any one of the three streams as defined in **Appendix II** namely 'Design Engineering', 'Thermal Engineering' and 'Industrial & Manufacturing Engineering'. The remaining two courses may be taken from any of the other streams (Design, Thermal, Manufacturing) or from "Miscellaneous".

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Course Code	:	EEC302
Course Title	:	Innovation Practices
Number of Credits	:	1 (L: 0, T: 0, P: 2)
Course Category	:	EEC

**Course Objective(s):**

1. Learn difference between problem and issue, create the correct problem statement and its objectives.
2. Conduct benchmarking analysis based on literature and propose alternative solutions.
3. Learn various costs involved in product development, perform cost estimates and project schedules.
4. Learn the systematic procedure to design and develop a product.
5. Learn the importance of testing and system integration.
6. Interpret and communicate the solution of the problem in organized manner.

**Course Content: The “Innovation Practices” laboratory involves the following:**

1. Preparing a project brief proposal including
  - Problem identification.
  - A statement of system / process specification proposed to be developed (Block diagram / concept tree).
  - List of possible solutions including alternative and constraints.
  - Cost benefits analysis.
  - Time Line of activities.
2. A report highlighting the design finalization (based on functional requirements & standards (if any)).
3. A presentation including the following:
  - Implementation Phase (Hardware / Software / both).
  - Testing & Validation of the developed system.
  - Learning in the Project.
4. Consolidated report preparation.

**Course Outcome(s):**

1. Identify, create problem statement and define objectives
2. Understand the importance of literature survey and perform benchmarking analysis to identify alternative solutions.
3. Learn to apply cost analysis and create project schedules.
4. Design and develop the system based on functional requirements.
5. Execute various types of tests and integrate the system (implementation plan).
6. Interpret and create a report of the project in organized manner.

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Course Code	:	PC308
Course Title	:	Vehicle Servicing Laboratory
Number of Credits	:	2 (L: 0, T: 0, P: 4)
Course Category	:	PC

**Course Objective(s):**

1. Identify the problems with their causes and remedies by dismantling the given clutch assembly and gear box assembly.
2. Students will be able to measure backlash and run out of differential unit and assess the fault.



3. Students are able to service the transaxle and rear axle assembly, brake system, identify the faults and service the same.
4. Students will be able to Service the steering gear boxes, and measure the turning circle radius and check wheel balancing and set wheel alignment parameters of a given vehicle.
5. To align the head lamp of the given vehicle.

**Course Content:**

1. Inspection and servicing of different types of clutches.
2. Inspection and servicing of different types of gear boxes.
3. Measurement of backlash and run out of differential unit.
4. Servicing of transaxle and transfer case assembly.
5. Servicing of different types of rear axle assembly.
6. Servicing of steering gear boxes and verification of Ackerman steering geometry.
7. Servicing and Troubleshooting of Brake system and Brake bleeding on a vehicle.
8. Head light beam alignment
9. Electrical system diagnostics.
10. Wheel balancing and wheel alignment.

**Text Books/References:** Lab manual as per above experiments to be prepared by the institution.

**Course Outcome(s):**

1. Service the types of clutches, gear boxes and calculation of torque carrying capacity and gear ratio.
2. Identify the types of wear of the differential unit
3. Service the transaxle and rear axle assembly, brake system, identify the faults and service the same
4. Service the steering gear boxes, and measure the turning circle radius and check wheel balancing and set wheel alignment parameters of a given vehicle.
5. Align the head lamp of the given vehicle.

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## **SEMESTER – VII**



## SEMESTER VII

Course Code	:	OE401
Course Title	:	Open Elective III (Emerging Areas)
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Note:** A Student can opt for any one subject out of available subjects under “Section I – Emerging Areas” of **Appendix I** on Open Electives provided he/she has not taken that particular subject under OE202 in Semester IV.

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Course Code	:	PC401
Course Title	:	Automotive Pollution and Control
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

### Course Objective(s):

1. To describe emissions from SI and CI engines, measure and control the same.
2. To identify sources of noise and vibration, measure and control the same.

### Course Content:

**Module I: Emissions from SI and CI Engines:** Emission formation in SI and CI engines – factors influencing emission, effect of pollution on environment and human health. Emission norms - Euro & Bharat norms, effect of fuel properties and additives, emissions from alternate fuels.

**Module II: Emission Testing:** Emission test cycles, constant volume sampling method, non-dispersive infrared (NDIR) analyzer, flame ionization detectors (FID), chemiluminescence analyzer, smoke meters, gas chromatograph.

**Module III: Emission Control Techniques:** Air fuel ratio (A/F) control, crank case emission control, fuel evaporation & control, EGR, SCR, catalytic converters, Particulate traps, LNT, DOC. Effect of engine combustion modification and control technologies.

**Module IV: Noise and Noise Control:** Introduction to sound, noise measurements, control of air borne and structure borne noise- use of absorber, criteria for the selection of materials. Engine noise and control, Brake noise and control, tyre noise and control, gear noise and control, clutch noise and control, resonators, reactive and absorptive silencers, anechoic chamber.

**Module V: Vibration Measurement and Control:** Introduction, elements of vibration, source of vibration, types of vibration, measurement of vibration- FFT analyzer, quarter car model analysis. Methods of vibration control – passive, active, semi active control, vibration isolation, engine and drive train vibrations.

**Text Books:**

1. Pundir B P, "Engine Emissions: Fundamentals and Advances in Control", Alpha Science International Ltd, 2017.
2. Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles, Matthew Harrison, Butterworth-Heinemann, Burlington, 2011.
3. XuWang , "Vehicle Noise and Vibration Refinement", Woodhead Publishing; 1st edition, 2010.

**References:**

1. James D. Halderman, "Automotive Fuel and Emissions Control Systems", 4<sup>th</sup> Edition, Prentice Hall, Pearson Education, 2016.
2. Gang Sheng, "Vehicle Noise, vibration and Sound quality", SAE International 2012.
3. Rajesh Rajamani, "Vehicle Dynamics and Control", 2nd edition, Springer, 2012.
4. Singiresu.S. Rao, "Mechanical Vibrations", 5th edition, Prentice Hall, 2010.
5. Babu, A.K., Automotive Engines, Khanna Publishing House.

**Course Outcome(s):**

1. Identify the sources of vehicle emission, emission norms, properties of various types of fuel and additives in control of emission.
2. Apply the emission standard test methods and procedure in accordance to driving conditions for different vehicles.
3. Evaluate different pre-combustion and post combustion methods involving in emission control.
4. Understand the sources of vehicle noise in vehicle refinement along with control measures.
5. Understand the sources of vehicle vibration in vehicle refinement along with control measures.

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Course Code	:	PC403
Course Title	:	Finite Element Techniques
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To construct the fundamental knowledge in failure analysis of engineering components.
2. To provide the basic skills about failure analysis.
3. To make outline of computer aided design and analysis.
4. To provide better engineering design solutions for the engineering problems.

**Course Content:**

**Module I: Introduction to FEM:** Engineering design analysis --meaning and purpose, Steady state, propagation and transient problems. - Basic concepts of FEM - Advantages and limitations of FEM. Test for convergence. Element choice. - Commercial finite element packages organization - advantages and limitations. Matrix approach -

Handling of simultaneous equations - Gaussian elimination method and Choleski method. - Solving Eigen value problems Jacobi method. Numerical integration.

**Module II: One Dimensional Analysis:** Coordinates and shape functions– Assembly of stiffness matrix - load vector – Finite element equations - 1D spar and spring elements. Dynamic analysis - Consistent and lumped mass matrices. Formulation of element mass matrices. Equations of motion for dynamic problems. Free vibration problem formulation.

**Module III: Two Dimensional Analysis:** Coordinates and shape functions – Stiffness matrix- beam elements, 2Dtriangular and quadrilateral elements, - Isoparametric elements. Treatment of boundary condition.

**Module IV: Heat Transfer and Fluid Flow Analysis:** Basic equations of heat transfer and fluid flow problems – Finite element formulation. One dimensional heat transfers and fluid flow problems.

**Module V: Design of Automotive Structures:** Force distribution on different parts of automotive structure, design of the parts, static, dynamic and thermal analysis of the parts using finite element method. - Material redistribution to minimize stresses and deflection. Optimisation of location of ribs to maximize rigidity.

**Text Books:**

1. Logan D L "A First Course in the Finite Element Method", Ceneage Learning India Pvt Ltd., 2007.
2. Ch, rupatla T R "Introduction to Finite Elements in Engineering", Prentice Hall India., 2011.

**References:**

1. John D.A "Computational Fluid Dynamics – The Basics with Applications", International Edition, 2012.
2. Rao S.S "The Finite Element Method in Engineering", Elsevier, 2017.
3. Reddy J.N "An Introduction to Finite Element Method", McGraw Hill International, 2017.
4. Seshu P "A Text book on Finite Element Analysis", Prentice Hall of India., 2013.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Basics of Finite Element Analysis-I	Prof. Nachiketa Tiwari	IIT KANPUR

**Course Outcome(s):**

1. Describe the failure of an engineering component. Define the basic constraints in the mechanical system.

2. Associate mathematical applications in the FEA. Describe about various steps in the basics of FEA modeling.
3. Evaluate the various design parameters by FEA in static analysis
4. Evaluate the various design parameters by FEA in static analysis. Estimate design parameters in fluid and heat transfer problems.
5. Describe about various applications of FEA in engineering solutions.

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Course Code	:	PE401
Course Title	:	Professional Elective IV
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

**Important Note:** For Professional Elective Courses (Professional Elective I to VI), a student has to opt four courses from any one of the three streams as defined in **Appendix II** namely 'Design Engineering', 'Thermal Engineering' and 'Industrial & Manufacturing Engineering'. The remaining two courses may be taken from any of the other streams (Design, Thermal, Manufacturing) or from "Miscellaneous".

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Course Code	:	PE403
Course Title	:	Professional Elective V
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

**Important Note:** For Professional Elective Courses (Professional Elective I to VI), a student has to opt four courses from any one of the three streams as defined in **Appendix II** namely 'Design Engineering', 'Thermal Engineering' and 'Industrial & Manufacturing Engineering'. The remaining two courses may be taken from any of the other streams (Design, Thermal, Manufacturing) or from "Miscellaneous".

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Course Code	:	PC405
Course Title	:	Vehicle Body Engineering
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PC

**Course Objective(s):**

1. To understand different types of chassis.
2. To gain knowledge about different types of steering geometry and types of front axle.
3. To educate the students regarding the ergonomics of an automobile.

**Course Content:**

**Module I: Ergonomics:** Introduction, seating dimensions, interior ergonomics, ergonomics system design, seat comfort, suspension seats, split frame seating, back pain



reducers, dash board instruments, electronic displays, commercial vehicle cabin ergonomics, mechanical package layout, goods vehicle layout.

**Module II: Car Body Details:** Types: saloon, convertibles, limousine, estate car, racing and sports car. Visibility - Regulations, driver's visibility, tests for visibility, methods of improving visibility and space in cars. Car body construction - Design criteria and initial tests.

**Module III: Truck and Speciality Passenger Vehicles:** Commercial vehicle body technology, trends, special goods vehicle, special haulage vehicles cab body. Buses and coaches PSV (Passenger Specialty Vehicle) structural design, low floor and articulated buses, three wheelers and light weight trailers.

**Module IV: Vehicle Body Analysis:** Introduction, criteria for vehicle body design, sheet metal representation, curved panels, equation for flexure, torsion, twist and differential bending, beam idealization and flexural axis, instability of thin walled structures. Unit load method and structural deflection, torsional stiffness car body idealization, symmetric bending and torsional loading, closed integral car structure, bus body idealization for analysis, bus body in torsion.

**Module V: Design, Safety and Fatigue Aspects:** Design for press working, design for spot welding, adhesives and sealants, goods vehicle structure design, chassis frame configuration, structural properties of chassis frame members. Crash tests, forces in roll over, head on impact, plastic collapse and analysis, fatigue and vibration, structural vibration.

**Text Books:**

1. John Fenton, "Handbook of Automotive Body and Systems Design", John Wiley & Sons, 2013.
2. John Fenton, "Handbook of Automotive Construction and Design Analysis", John Wiley & Sons, 2014.

**References:**

1. Jnusz Pawlowski, "Vehicle Body Engineering", Business books limited, 1989.
2. Julian Happian Smith, "Introduction to Modern Vehicle Design", Butterworth Publisher, 2001.
3. Ian Andrew Norman, "Heavy Duty Vehicle systems", third edition, Delmar- Thomson Learning Ltd.

**Course Outcome(s):**

1. Understand the fundamentals of various automotive body construction details
2. Identify different aspects of car body and bus body, types, commercial vehicle.
3. Describe the materials used in body building, tools used, body repairs
4. Analyse vehicle body for different load conditions
5. Design for safety and fatigue aspects.

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Course Code	:	PC407
Course Title	:	Engine Testing and Emission Measurement Laboratory
Number of Credits	:	2 (L: 0, T: 0, P: 4)
Course Category	:	PC

**Course Objective(s):**

1. To teach the procedure involved to dismantle and assemble various engine components.
2. To develop the knowledge for students about cooling system and lubricating systems.

**Course Content: List of Experiments**

1. Dismantling and assembly of engines and measurement of engine parts.
2. Radiator pressure test and Thermostat valve test.
3. Compression test, vacuum test and Valve clearance adjustment on petrol / diesel engine.
4. Injection system testing and servicing (i) Multi point fuel injector (ii) diesel injector.
5. Ignition system trouble shooting and servicing and testing and troubleshooting of alternator, starter motor and Battery.
6. Performance test on SI and CI engines.
7. Performance test on VCR engine.
8. Diagnostic of engine using engine tester.
9. Exhaust gas emission measurement on diesel and petrol engine.
10. Heat Balance test and Morse test.

**Text Books/References:**

Lab manual as per above experiments to be prepared by the institution.

**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

S. No.	Experiment Name	Experiment Link(s)	Name of Experiment on web-site
1	Performance test on SI and CI engines	<a href="http://vlabs.iitkgp.ernet.in/rtvlas/exp3/index.html">http://vlabs.iitkgp.ernet.in/rtvlas/exp3/index.html</a>	Load Test on a SI Engine

**Course Outcome(s):**

1. Distinguish and test various types of engine and engine components.
2. Dismantle & assemble sub-assemblies.

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Course Code	:	EEC401
Course Title	:	Project Work I / Summer Internship III
Number of Credits	:	4
Course Category	:	EEC

### PROJECT WORK I

**Guidance for Project Work I:** Project Work I can be done either during the Summer Break between Semester VI and Semester VII or during the Semester VII. It will be evaluated as part of Semester VII. It may either be a complete project related to field of Automobile Engineering or it may be an initiation (Phase I) of Project Work II present in Semester VIII, provided the “Project Work II” is expected to extend beyond the duration of 6 months.

**Objective:**

To synthesize and apply the knowledge gained over the engineering programme to solve real world problems.

**Course Content:**

1. Identification of a real life problem in thrust areas.
2. Developing a mathematical model for solving the above problem.
3. Finalization of system requirements and specification.
4. Proposing different solutions for the problems based on literature survey.
5. Future trends in providing alternate solutions.
6. Consolidated report preparation of the above.

**Course Outcome(s):** The student(s) should be able to demonstrate:

1. Fulfill team roles assigned.
2. Communicate effectively.
3. Solve engineering problems involving current issues using modern tools.
4. Demonstrate the ability to apply the knowledge gained in the programme.
5. Recognize the global, economic and environmental issues associated with the project undertaken and the implications to the society.

### SUMMER INTERNSHIP III

**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 Automobile Engineering.

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](http://www.internship.aicte-india.org)).

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## **SEMESTER – VIII**



## SEMESTER VIII

Course Code	:	PE402
Course Title	:	Professional Elective VI
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE402

**Important Note:** For Professional Elective Courses (Professional Elective I to VI), a student has to opt four courses from any one of the three streams as defined in **Appendix II** namely 'Design Engineering', 'Thermal Engineering' and 'Industrial & Manufacturing Engineering'. The remaining two courses may be taken from any of the other streams (Design, Thermal, Manufacturing) or from "Miscellaneous".

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Course Code	:	EEC402
Course Title	:	Project Work II
Number of Credits	:	7 (L: 0, T: 0, P: 14)
Course Category	:	EEC402

**Course Objective(s):** To synthesize and apply the knowledge gained over the engineering programme to solve real world problems.

**Course Content:** The project work involves the following:

1. Preparing a project brief proposal including
  - Problem identification
  - A statement of system / process specification proposed to be developed (Block diagram / concept tree)
  - List of possible solutions including alternative and constraints
  - Cost benefit analysis
  - Time Line of activities
2. A report highlighting the design finalization (based on functional requirements & standards (if any)).
3. A presentation including the following:
  - Implementation Phase (Hardware / Software / both)
  - Testing & Validation of the developed system
  - Learning in the Project
4. Consolidated project report preparation.

**Course Outcome(s):** The student(s) should be able to demonstrate:

1. Fulfill team roles assigned.
2. Communicate effectively.
3. Solve engineering problems involving current issues using modern tools.
4. Demonstrate the ability to apply the knowledge gained in the programme.
5. Recognize the global, economic and environmental issues associated with the project undertaken and the implications to the society.

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# Appendix – I

## Open Electives

**(SECTION I – Emerging Areas: Open Elective I & Open Elective III)**

**(SECTION II – Humanities & Social Science: Open Elective II)**



## ‘Open Elective I’ & ‘Open Elective III’ on Emerging Areas

S. No.	Available to be taken as	Subject
1	Open Elective I or Open Elective III	3D Printing & Design
2	Open Elective I or Open Elective III	Internet of Things
3	Open Elective I or Open Elective III	Artificial Intelligence
4	Open Elective I or Open Elective III	Quantum Computing
5	Open Elective I or Open Elective III	Cyber Security
6	Open Elective I or Open Elective III	Robotics
7	Open Elective I or Open Elective III	Virtual Reality
8	Open Elective I or Open Elective III	Data Sciences
9	Open Elective I or Open Elective III	Block Chain

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### SECTION I – Emerging Areas

Course Code	:	OEXXX
Course Title	:	3D Printing & Design
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:** The course is designed to impart knowledge and skills related to 3D printing technologies, selection of material and equipment and develop a product using this technique in Industry 4.0 environment.

#### **Course Content:**

##### **Module I: 3D Printing (Additive Manufacturing)**

Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes, Applications.

##### **Module II: CAD for Additive Manufacturing**

CAD Data formats, Data translation, Data loss, STL format.

##### **Module III: Additive Manufacturing Techniques**

3.1 Stereo- Lithography, LOM, FDM, SLS, SLM, Binder Jet technology.

3.2 Process, Process parameter, Process Selection for various applications.

3.3 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defence, Automotive, Construction, Food Processing, Machine Tools.

##### **Module IV: Materials**

4.1 Polymers, Metals, Non-Metals, Ceramics

4.2 Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties.

4.3 Support Materials

## **Module V: Additive Manufacturing Equipment**

- 5.1 Process Equipment- Design and process parameters
- 5.2 Governing Bonding Mechanism
- 5.3 Common faults and troubleshooting
- 5.4 Process Design

## **Module VI: Post Processing: Requirement and Techniques**

## **Module VII: Product Quality**

- 7.1 Inspection and testing
- 7.2 Defects and their causes

### **Practicals**

1. 3D Modelling of a single component.
2. Assembly of CAD modelled Components.
3. Exercise on CAD Data Exchange.
4. Generation of .stl files.
5. Identification of a product for Additive Manufacturing and its AM process plan.
6. Printing of identified product on an available AM machine.
7. Post processing of additively manufactured product.
8. Inspection and defect analysis of the additively manufactured product.
9. Comparison of Additively manufactured product with conventional manufactured counterpart.

### **Text Books/References:**

1. Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
2. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
3. Sabrie Soloman "3D Printing and Design", Khanna Publishing House, Delhi.
4. CK Chua, Kah Fai Leong, "3D Printing and Rapid Prototyping- Principles and Applications", World Scientific, 2017.
5. J.D. Majumdar and I. Manna, "Laser-Assisted Fabrication of Materials", Springer Series in Material Science, 2013.
6. L. Lu, J. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Kulwer Academic Press, 2001.
7. Zhiqiang Fan and Frank Liou, "Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy", InTech, 2012.

### **Alternative NPTEL/SWAYAM Course:**

<b>S. No.</b>	<b>NPTEL Course Name</b>	<b>Instructor</b>	<b>Host Institute</b>
1	Rapid Manufacturing	Dr. Amandeep Singh, Prof. J. Ramkumar	IIT Kanpur

**Course Outcomes:** After completion of this course, the students will be able to:

- Develop CAD models for 3D printing.

- Import and Export CAD data and generate '.stl' file.
- Select a specific material for the given application.
- Select a 3D printing process for an application.
- Produce a product using 3D Printing or Additive Manufacturing (AM).

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Course Code	:	OEXXX
Course Title	:	Internet of Things
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:** The objective of this course is to impart necessary and practical knowledge of components of Internet of Things and develop skills required to build real-life IoT based projects.

**Course Content:**

**Module I: Introduction to IoT**

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.

**Module II: Elements of IoT**

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces.

Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

**Module III: IoT Application Development**

Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

**Module IV: IoT Case Studies**

IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation.

**Practicals:**

1. Familiarization with Arduino/Raspberry Pi and perform necessary software installation.
2. To interface LED/Buzzer with Arduino/Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds.

3. To interface Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
4. To interface DHT11 sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings.
5. To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON motor when push button is pressed.
6. To interface OLED with Arduino/Raspberry Pi and write a program to print temperature and humidity readings on it.
7. To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth.
8. To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when '1'/'0' is received from smartphone using Bluetooth.
9. Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud.
10. Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud.
11. To install MySQL database on Raspberry Pi and perform basic SQL queries.
12. Write a program on Arduino/Raspberry Pi to publish temperature data to MQTT broker.
13. Write a program on Arduino/Raspberry Pi to subscribe to MQTT broker for temperature data and print it.
14. Write a program to create TCP server on Arduino/Raspberry Pi and respond with humidity data to TCP client when requested.
15. Write a program to create UDP server on Arduino/Raspberry Pi and respond with humidity data to UDP client when requested.

**Text Books/References:**

1. Jeeva Jose, "Internet of Things", Khanna Publishing House, Delhi
2. Vijay Madiseti, Arshdeep Bahga, Internet of Things, "A Hands on Approach", University Press
3. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs
4. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
5. Adrian McEwen, "Designing the Internet of Things", Wiley
6. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill
7. Cuno Pfister, "Getting Started with the Internet of Things", O Reilly Media

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction to internet of things	Prof. Sudip Misra	IIT Kharagpur

**Course Outcomes:** After the completion of this course, the students will be able to:

- Understand internet of Things and its hardware and software components.
- Interface I/O devices, sensors & communication Modules.
- Remotely monitor data and control devices.
- Develop real life IoT based projects.

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Course Code	:	OEXXX
Course Title	:	Artificial Intelligence
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objectives:** Artificial Intelligence is a major step forward in how computer system adapts, evolves and learns. It has widespread application in almost every industry and is considered to be a big technological shift, similar in scale to past events such as the industrial revolution, the computer age, and the smart phone revolution.

This course will give an opportunity to gain expertise in one of the most fascinating and fastest growing areas of Computer Science through classroom program that covers fascinating and compelling topics related to human intelligence and its applications in industry, defence, healthcare, agriculture and many other areas. This course will give the students a rigorous, advanced and professional graduate-level foundation in Artificial Intelligence.

**Course Contents:**

**Module I: Introduction**

Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search tree.

**Module II: Search Algorithms**

Random search, Search with closed and open list, Depth first and Breadth first search, Heuristic search, Best first search, A\* algorithm, Game Search.

**Module III: Probabilistic Reasoning**

Probability, conditional probability, Bayes Rule, Bayesian Networks- representation, construction and inference, temporal model, hidden Markov model.

#### **Module IV: Markov Decision process**

MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.

#### **Module V: Reinforcement Learning**

Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning- Q learning.

#### **Practicals:**

1. Write a programme to conduct uninformed and informed search.
2. Write a programme to conduct game search.
3. Write a programme to construct a Bayesian network from given data.
4. Write a programme to infer from the Bayesian network.
5. Write a programme to run value and policy iteration in a grid world.
6. Write a programme to do reinforcement learning in a grid world.
7. Mini Project work.

#### **Text Books/References:**

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3rd Edition, Prentice Hall
2. Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill
3. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi.
4. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, 2011
5. David Poole and Alan Mackworth, "Artificial Intelligence: Foundations for Computational Agents", Cambridge University Press 2010.

#### **Websites:**

1. <https://nptel.ac.in/courses/106105077>
2. <https://nptel.ac.in/courses/106106126>
3. <https://aima.cs.berkeley.edu>
4. [https://ai.berkeley.edu/project\\_overview.html](https://ai.berkeley.edu/project_overview.html) (for Practicals)

#### **Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Fundamentals Of Artificial Intelligence	Prof. Shyamanta M. Hazarika	IIT Guwahati

**Course Outcomes:** After undergoing this course, the students will be able to:

- Build intelligent agents for search and games.
- Solve AI problems through programming with Python.
- Build Learning optimization and inference algorithms for model learning.
- Design and develop programs for an agent to learn and act in a structured environment.

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Course Code	:	OEXXX
Course Title	:	Quantum Computing
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:** The objective of this course is to impart necessary knowledge to the learner so that he/she can develop and implement algorithm and write programs using these algorithms.

### **Course Content:**

#### **Module I: Introduction to Quantum Computing**

- 1.1 Motivation for studying Quantum Computing
- 1.2 Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.)
- 1.3 Origin of Quantum Computing
- 1.4 Overview of major concepts in Quantum Computing
  - Qubits and multi-qubits states, Bra-ket notation.
  - Bloch Sphere representation
  - Quantum Superposition
  - Quantum Entanglement

#### **Module II: Math Foundation for Quantum Computing**

Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigen values and Eigen vectors.

#### **Module III: Building Blocks for Quantum Program**

- 1.1 Architecture of a Quantum Computing platform
- 1.2 Details of q-bit system of information representation:
  - Bloch Sphere
  - Multi-qubits States
  - Quantum superposition of qubits (valid and invalid superposition)
  - Quantum Entanglement
  - Useful states from quantum algorithmic perspective e.g. Bell State
  - Operation on qubits: Measuring and transforming using gates.
  - Quantum Logic gates and Circuit: Pauli, Hadamard, phase shift, controlled gates, Ising, Deutsch, swap etc.
- 1.3 Programming model for a Quantum Computing Program
  - Steps performed on classical computer
  - Steps performed on Quantum Computer
  - Moving data between bits and qubits

#### **Module IV: Quantum Algorithms**

- 1.1 Basic techniques exploited by quantum algorithms.
  - Amplitude amplification

- Quantum Fourier Transform
  - Phase Kick-back
  - Quantum Phase estimation
  - Quantum Walks
- 1.2 Major Algorithms
- Shor’s Algorithm
  - Grover’s Algorithm
  - Deutsch’s Algorithm
  - Deutsch -Jozsa Algorithm
- 1.3 OSS Toolkits for implementing Quantum program
- IBM quantum experience
  - Microsoft Q
  - Rigetti PyQuil (QPU/QVM)

**Practicals:**

1. Building Quantum dice.
2. Building Quantum Random No. Generation.
3. Composing simple quantum circuits with q-gates and measuring the output into classical bits.
4. Implementation of Shor’s Algorithms.
5. Implementation of Grover’s Algorithm.
6. Implementation of Deutsch’s Algorithm.
7. Implementation of Deutsch-Jozsa’s Algorithm.
8. Mini Project such as implementing an API for efficient search using Grover’s Algorithms or Integer factorization using Shor’s Algorithm.

**Text Books/References:**

1. Michael A. Nielsen, “Quantum Computation and Quantum Information”, Cambridge University Press.
2. David McMahon, “Quantum Computing Explained”, Wiley
3. IBM Experience: <https://quantumexperience.ng.bluemix.net>
4. Microsoft Quantum Development Kit <https://www.microsoft.com/en-us/quantum/development-kit>
5. Forest SDK PyQuil: <https://pyquil.readthedocs.io/en/stable/>

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Quantum Information and Computing	Prof.Dipan Ghosh	IIT Bombay

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

- Explain the working of a Quantum Computing program, its architecture and program model.
- Develop quantum logic gate circuits.
- Develop quantum algorithm.
- Program quantum algorithm on major toolkits.

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Course Code	:	OEXXX
Course Title	:	Cyber Security
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:**

The course has been designed to give students an extensive overview of cyber security issues, tools and techniques that are critical in solving problems in cyber security domains. The course aims at providing students with concepts of computer security, cryptography, digital money, secure protocols, detection and other security techniques. The course will help students to gauge understanding in essential techniques in protecting Information Systems, IT infrastructure, analysing and monitoring potential threats and attacks, devising security architecture and implementing security solutions. The students will also have a wider perspective to information security from national security perspective from both technology and legal perspective.

**Course Content:**

**Module I: Cyber Security Concepts**

Essential Terminologies: CIA, Risks, Breaches, Threats, Attacks, Exploits. Information Gathering (Social Engineering, Foot Printing & Scanning).

Open Source/ Free/ Trial Tools: nmap, zenmap, Port Scanners, Network scanners.

**Module II: Cryptography and Cryptanalysis**

Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security, Security Protocols: - security at the Application Layer- PGP and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer-IPSec.

Open Source/ Free/ Trial Tools: Implementation of Cryptographic techniques, OpenSSL, Hash Values Calculations MD5, SHA1, SHA256, SHA 512, Steganography (Stools).

**Module III: Infrastructure and Network Security**

Introduction to System Security, Server Security, OS Security, Physical Security, Introduction to Networks, Network packet Sniffing, Network Design Simulation. DOS/DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Intrusion detection and Prevention Techniques, Host based Intrusion Prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation.

Open Source/ Free/ Trial Tools: DOS Attacks, DDOS attacks, Wireshark, Cain & abel, iptables/ Windows Firewall, snort, suricata, fail2ban.

**Module IV: Cyber Security Vulnerabilities& Safe Guards**

Internet Security, Cloud Computing & Security, Social Network sites security, Cyber

Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards- Overview, Access control, IT Audit, Authentication. Open Web Application Security Project (OWASP), Web Site Audit and Vulnerabilities assessment.

Open Source/ Free/ Trial Tools: WinAudit, Zap proxy (OWASP), burp suite, DVWA kit.

### **Module V: Malware**

Explanation of Malware, Types of Malware: Virus, Worms, Trojans, Rootkits, Robots, Adware's, Spywares, Ransom wares, Zombies etc., OS Hardening (Process Management, Memory Management, Task Management, Windows Registry/ services another configuration), Malware Analysis.

Open Source/ Free/ Trial Tools: Antivirus Protection, Anti Spywares, System tuning tools, Anti Phishing.

### **Module VI: Security in Evolving Technology**

Biometrics, Mobile Computing and Hardening on android and ios, IOT Security, Web server configuration and Security. Introduction, Basic security for HTTP Applications and Services, Basic Security for Web Services like SOAP, REST etc., Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges.

Open Source/ Free/ Trial Tools: adb for android, xcode for ios, Implementation of REST/ SOAP web services and Security implementations.

### **Module VII: Cyber Laws and Forensics**

Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013. Introduction to Cyber Forensics, Need of Cyber Forensics, Cyber Evidence, Documentation and Management of Crime Scene, Image Capturing and its importance, Partial Volume Image, Web Attack Investigations, Denial of Service Investigations, Internet Crime Investigations, Internet Forensics, Steps for Investigating Internet Crime, Email Crime Investigations.

Open Source/ Free/ Trial Tools: Case Studies related to Cyber Law, Common Forensic Tools like dd, md5sum, sha1sum, Ram dump analysis, USB device.

### **Practicals:**

1. Implementation to gather information from any PC's connected to the LAN using whois, port scanners, network scanning, Angry IP scanners etc.
2. Implementation of Symmetric and Asymmetric cryptography.
3. Implementation of Steganography.
4. Implementation of MITM- attack using wireshark/ network sniffers.
5. Implementation of Windows security using firewall and other tools.
6. Implementation to identify web vulnerabilities, using OWASP project.
7. Implementation of IT Audit, malware analysis and Vulnerability assessment and generate the report.

8. Implementation of OS hardening and RAM dump analysis to collect the Artifacts and other information's.
9. Implementation of Mobile Audit and generate the report of the existing Artiacts.
10. Implementation of Cyber Forensics tools for Disk Imaging, Data acquisition, Data ex- traction and Data Analysis and recovery.

**Text Books/References:**

1. William Stallings, "Cryptography and Network Security", Pearson Education/PHI, 2006.
2. V.K. Jain, "Cryptography and Network Security", Khanna Publishing House.
3. Gupta Sarika, "Information and Cyber Security", Khanna Publishing House, Delhi.
4. Atul Kahate, "Cryptography and Network Security", McGraw Hill.
5. V.K. Pachghare, "Cryptography and Information Security", PHI Learning
6. Nina Godbole, "Information System Security", Wiley
7. Bothra Harsh, "Hacking", Khanna Publishing House, Delhi.

**Web link:** <http://www.ignou.ac.in/upload/Announcement/programmedetails.pdf>

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction to Information Security I	Prof. V. Kamakoti	IIT MADRAS

**Course Outcomes:** After completion of this course, the students should be able to:

- Understand, appreciate, employ, design and implement appropriate security technologies and policies to protect computers and digital information.
- Identify & Evaluate Information Security threats and vulnerabilities in Information Systems and apply security measures to real time scenarios.
- Identify common trade-offs and compromises that are made in the design and development process of Information Systems.
- Demonstrate the use of standards and cyber laws to enhance information security in the development process and infrastructure protection.

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Course Code	:	OEXXX
Course Title	:	Robotics
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:**

The objective of this course is to impart knowledge about industrial robots for their control and design.

## **Course Content:**

### **Module I: Introduction to Robotics**

- Types and components of a robot, Classification of robots, closed-loop and open loop control systems.
- Kinematics systems; Definition of mechanisms and manipulators, Social issues and safety.

### **Module II: Robot Kinematics and Dynamics**

- Kinematic Modelling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics
- Dynamic Modelling: Equations of motion: Euler-Lagrange formulation

### **Module III: Sensors and Vision System**

- Sensor: Contact and Proximity, Position, Velocity, Force, Tactile etc.
- Introduction to Cameras, Camera calibration, Geometry of Image formation, Euclidean/Similarity/Affine/Projective transformations
- Vision applications in robotics.

### **Module IV: Robot Control**

- Basics of control: Transfer functions, Control laws: P, PD, PID.
- Non-linear and advanced controls.

### **Module V: Robot Actuation Systems**

Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators.

### **Module VI: Control Hardware and Interfacing**

Embedded systems: Architecture and integration with sensors, actuators, components, Programming for Robot Applications.

### **Practicals:**

1. Study components of a real robot and its DH parameters.
2. Forward kinematics and validate using a software (Robo Analyser or any other free software tool).
3. Inverse kinematics of the real robot and validation using any software.
4. Use of open source computer vision programming tool openCV.
5. Image Processing using openCV.
6. Image Processing for color/shape detection.
7. Positioning and orientation of robot arm.
8. Control experiment using available hardware or software.
9. Integration of assorted sensors (IR, Potentiometer, strain gages etc.), micro controllers and ROS (Robot Operating System) in a robotic system.
10. Project work

**Text Books/References:**

1. Saha, S.K., "Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.
2. Ghosal, A., "Robotics", Oxford, New Delhi, 2006.
3. Niku Saeed B., "Introduction to Robotics: Analysis, Systems, Applications", PHI, New Delhi.
4. Mittal R.K. and Nagrath I.J., "Robotics and Control", Tata McGraw Hill.
5. Mukherjee S., "Robotics and Automation", Khanna Publishing House, Delhi.
6. Craig, J.J., "Introduction to Robotics: Mechanics and Control", Pearson, New Delhi, 2009
7. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modelling and Control", John Wiley and Sons Inc, 2005
8. Steve Heath, "Embedded System Design", 2nd Edition, Newnes, Burlington, 2003
9. Merzouki R., Samantaray A.K., Phathak P.M. and Bouamama B. Ould, "Intelligent Mechatronic System: Modeling, Control and Diagnosis", Springer.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Robotics	Prof. Dilip Kumar Pratihar	IIT Kharagpur

**Course Outcomes:** After the completion of this course, the students will be able to

- Perform kinematic and dynamic analyses with simulation.
- Design control laws for a robot.
- Integrate mechanical and electrical hardware for a real prototype of robotic device.
- Select a robotic system for given application.

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Course Code	:	OEXXX
Course Title	:	Virtual Reality
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:** The objective of this course is to provide a detailed understanding of the concepts of Virtual Reality and its applications

**Course Content:****Module I: Introduction to Virtual Reality**

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark.

## **Module II: 3D Computer Graphics**

Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism-Stereographic image.

## **Module III: Geometric Modelling**

Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation.

Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection.

Generic VR system: Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems.

## **Module IV: Virtual Environment**

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system.

Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

## **Module V: VR Hardware and Software**

Human factors: Introduction, the eye, the ear, the somatic senses.

VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems.

VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML.

## **Module VI: VR Applications**

Introduction, Engineering, Entertainment, Science, Training.

The Future: Virtual environment, modes of interaction.

## **Practicals**

1. Developing architecture of a house using Virtual Reality.
2. Perform CRO based experiment using Virtual Reality.
3. Undertaking qualitative analysis in Chemistry using Virtual Reality.
4. Carry out assembly/disassembly of an engine using Virtual Reality.
5. Explore human anatomy using Virtual Reality.
6. Simulation of circulation of blood in heart.
7. Simulation of Fight/Vehicle/Space Station.
8. Building Electronic circuit using Virtual Reality, given basic electronic components.
9. Developing concept of Virtual class room with multiplayer.



**Text Books/References:**

1. John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2007.
2. Adams, "Visualizations of Virtual Reality", Tata McGraw Hill, 2000.
3. Grigore C. Burdea, Philippe Coiffet , "Virtual Reality Technology", Wiley Inter Science, 2 nd Edition, 2006.
4. William R. Sherman, Alan B. Craig, "Understanding Virtual Reality: Interface, Application and Design", Morgan Kaufmann, 2008.
5. www.vresources.org
6. www.vrac.iastate.edu
7. www.w3.org/MarkUp/VRM

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Virtual Reality	Prof Steven LaValle	IIT Madras

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

- Understand geometric modelling and Virtual environment.
- Study about Virtual Hardware and Software
- Develop Virtual Reality applications.

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Course Code	:	OEXXX
Course Title	:	Data Sciences
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:** The objective of this course is to impart necessary knowledge of the mathematical foundations needed for data science and develop programming skills required to build data science applications.

**Course Content:**

**Module I: Introduction to Data Science:** Concept of Data Science, Traits of Big data, Web Scraping, Analysis vs Reporting.

**Module II: Introduction to Programming Tools for Data Science:**

- 1.1 Toolkits using Python: Matplotlib, NumPy, Scikit-learn, NLTK
- 1.2 Visualizing Data: Bar Charts, Line Charts, Scatterplots
- 1.3 Working with data: Reading Files, Scraping the Web, Using APIs (Example: Using the Twitter APIs), Cleaning and Munging, Manipulating Data, Rescaling, Dimensionality Reduction.

### **Module III: Mathematical Foundations**

- 1.4 Linear Algebra: Vectors, Matrices.
- 1.5 Statistics: Describing a Single Set of Data, Correlation, Simpson's Paradox, Correlation and Causation.
- 1.6 Probability: Dependence and Independence, Conditional Probability, Bayes's Theorem, Random Variables, Continuous Distributions, The Normal Distribution, The Central Limit Theorem.
- 1.7 Hypothesis and Inference: Statistical Hypothesis Testing, Confidence Intervals, Phacking, Bayesian Inference.

### **Module IV: Machine Learning**

Overview of Machine learning concepts – Over fitting and train/test splits, Types of Machine learning – Supervised, Unsupervised, Reinforced learning, Introduction to Bayes Theorem, Linear Regression- model assumptions, regularization (lasso, ridge, elastic net), Classification and Regression algorithms- Naïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees, and random forest, Classification Errors, Analysis of Time Series- Linear Systems Analysis, Nonlinear Dynamics, Rule Induction, Neural Networks Learning And Generalization, Overview of Deep Learning.

### **Module V: Case Studies of Data Science Application**

Weather forecasting, Stock market prediction, Object recognition, Real Time Sentiment Analysis.

#### **Practicals:**

1. Write a programme in Python to predict the class of the flower based on available attributes.
2. Write a programme in Python to predict if a loan will get approved or not.
3. Write a programme in Python to predict the traffic on a new mode of transport.
4. Write a programme in Python to predict the class of user.
5. Write a programme in Python to identify the tweets which are hate tweets and which are not.
6. Write a programme in Python to predict the age of the actors.
7. Mini project to predict the time taken to solve a problem given the current status of the user.

#### **Text Books/References:**

1. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media
2. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems", 1st Edition, O'Reilly Media
3. Jain V.K., "Data Sciences", Khanna Publishing House, Delhi.
4. Jain V.K., "Big Data and Hadoop", Khanna Publishing House, Delhi.
5. Jeeva Jose, "Introduction to Machine Learning", Khanna Publishing House, Delhi.
6. Chopra Rajiv, "Machine Learning", Khanna Publishing House, Delhi.
7. Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press <http://www.deeplearningbook.org>
8. Jiawei Han and Jian Pei, "Data Mining Concepts and Techniques", Third Edition, Morgan Kaufmann Publishers.

### Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Data Science for Engineers	Prof. Shankar Narasimhan, Prof. Rangunathan Rengasamy	IIT MADRAS

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

- Demonstrate understanding of the mathematical foundations needed for data science.
- Collect, explore, clean, munge and manipulate data.
- Implement models such as k-nearest Neighbors, Naive Bayes, linear and logistic regression, decision trees, neural networks and clustering.
- Build data science applications using Python based toolkits.

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Course Code	:	OEXXX
Course Title	:	Block Chain
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:** The objective of this course is to provide conceptual understanding of how block chain technology can be used to innovate and improve business processes. The course covers the technological underpinning of block Chain operations in both theoretical and practical implementation of solutions using block Chain technology.

### Course Content:

#### Module I: Introduction

Introduction: Overview of Block chain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Permissioned Model of Block chain, Overview of Security aspects of Block Chain.

Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency.

#### Module II: Understanding Block chain with Crypto currency

Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay.

Working with Consensus in Bitcoin: Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of

Burn and Proof of Elapsed Time, The life of a Bitcoin Miner, Mining Difficulty, Mining Pool.

### **Module III: Understanding Block chain for Enterprises**

Permissioned Block chain: Permissioned model and use cases, Design issues for Permissioned block chains, Execute contracts, State machine replication, Overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak-Pease BFT Algorithm, BFT over Asynchronous systems.

Enterprise application of Block chain: Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Block chain, Block chain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Block chain.

### **Module IV: Block chain application development**

Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda.

#### **Practicals:**

1. Install and understand Docker container, Node.js, Java and Hyperledger Fabric, Ethereum and perform necessary software installation on local machine/create instance on Cloud to run.
  1. <https://github.com/hyperledger/>
  2. <https://docs.docker.com/get-started/>
  3. [https://console.bluemix.net/docs/containers/container\\_index.html#container\\_index](https://console.bluemix.net/docs/containers/container_index.html#container_index)
4. Create and deploy a block chain network using Hyperledger Fabric SDK for Java Set up and initialize the channel, install and instantiate chaincode, and perform invoke and query on your block chain network (<https://developer.ibm.com/patterns/create-and-deploy-block-chain-network-using-fabric-sdk-java/>)
2. Interact with a block chain network. Execute transactions and requests against a block chain network by creating an app to test the network and its rules (<https://developer.ibm.com/patterns/interacting-with-a-block-chain-network/>)
3. Deploy an asset-transfer app using block chain. Learn app development within a Hyperledger Fabric network (<https://developer.ibm.com/patterns/deploy-an-asset-transfer-app-using-block-chain/>)
4. Use block chain to track fitness club rewards Build a web app that uses Hyperledger Fabric to track and trace member rewards (<https://developer.ibm.com/patterns/fitness-club-rewards-points-iot-and-retail-integration/>)
5. Car auction network: A Hello World example with Hyperledger Fabric Node SDK and IBM Block chain Starter Plan. Use Hyperledger Fabric to invoke chaincode while storing results and data in the starter plan (<https://developer.ibm.com/patterns/car-auction-network-hyperledger-fabric-node-sdk-starter-plan/>)

6. Develop an IoT asset tracking app using Block chain. Use an IoT asset tracking device to improve a supply chain by using Block chain, IoT devices, and Node-RED ([https://developer.ibm.com/patterns/develop-an-iot-asset-tracking-app-using-block chain/](https://developer.ibm.com/patterns/develop-an-iot-asset-tracking-app-using-block-chain/))
7. Secure art using block chain digital certificates. Node.js-based auction application can help democratize the art market ([https://developer.ibm.com/patterns/securing-art-using-block chain-digital-certificates/](https://developer.ibm.com/patterns/securing-art-using-block-chain-digital-certificates/))
8. Mini projects such as:
  - (i) Block chain for telecom roaming, fraud, and overage management. See how communication service providers use block chain to enhance their value chains. [https://developer.ibm.com/patterns/block chain-for-telecom-roaming-fraud-and-overagemanagement/](https://developer.ibm.com/patterns/block-chain-for-telecom-roaming-fraud-and-overagemanagement/)
  - (ii) Use IoT dashboards to analyze data sent from a Block chain network. Build an IoT app and IoT dashboards with Watson IoT Platform and Node-RED to analyze IoT data sent from a Block chain network [https://developer.ibm.com/patterns/iot-dashboards-analyze-data-block chain-network/](https://developer.ibm.com/patterns/iot-dashboards-analyze-data-block-chain-network/)
  - (iii) Create an Android app with Block chain integration. Build a Block chain enabled health and fitness app with Android and Kubernetes [https://developer.ibm.com/patterns/create-an-android-app-with-block chain-integration/](https://developer.ibm.com/patterns/create-an-android-app-with-block-chain-integration/)
  - (iv) Create a global finance block chain application with IBM Block chain Platform Extension for VS Code. Develop a Node.js smart contract and web app for a Global Finance with block chain use case [https://developer.ibm.com/patterns/global-financing-use-case-for-block chain/](https://developer.ibm.com/patterns/global-financing-use-case-for-block-chain/)
  - (v) Develop a voting application using Hyperledger and Ethereum. Build a decentralized app that combines Ethereum's Web3 and Solidity smart contracts with Hyperledger's hosting Fabric and Chaincode EVM <https://developer.ibm.com/patterns/voting-app-hyperledger-ethereum/>
  - (vi) Create a block chain app for loyalty points with Hyperledger Fabric Ethereum Virtual Machine. Deploy Fabric locally with EVM and create a proxy for interacting with a smart contract through a Node.js web app <https://developer.ibm.com/patterns/loyalty-points-fabric-vm/>

### **Text Books/References:**

1. Melanie Swan, "Block Chain: Blueprint for a New Economy", O'Reilly, 2015
2. Josh Thompsons, "Block Chain: The Block Chain for Beginners- Guide to Block chain Technology and Leveraging Block Chain Programming"
3. Daniel Drescher, "Block Chain Basics", Apress; 1st edition, 2017
4. Anshul Kaushik, "Block Chain and Crypto Currencies", Khanna Publishing House, Delhi.
5. Imran Bashir, "Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained", Packt Publishing
6. Ritesh Modi, "Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Block Chain", Packt Publishing

7. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O’Dowd, Venkaraman Ramakrishna, “Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer”, Import, 2018

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction to Blockchain Technology and Applications	Prof. Sandeep Shukla	IIT KANPUR

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

- Understand block chain technology.
- Develop block chain based solutions and write smart contract using Hyperledger Fabric and Ethereum frameworks.
- Build and deploy block chain application for on premise and cloud based architecture.
- Integrate ideas from various domains and implement them using block chain technology in different perspectives.

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**SECTION II – Humanities & Social Science**

S. No.	Available to be taken as	Subject
1	Open Elective II (Take Any One)	Sports and Yoga
2		<b>Engineering Economics*</b>
3		Human Relations at Work
4		Values and Ethics
5		Intellectual Property Rights

*\*: Specially recommended for Automobile Engineering Students*

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

**Course Objectives:**

- 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 Content:**

#### **Module I: Introduction to Physical Education**

- Meaning & definition of Physical Education
- Aims & Objectives of Physical Education
- Changing trends in Physical Education

#### **Module II: 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.)

#### **Module III: 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

#### **Module IV: 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.)

#### **Module V: 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.

#### **Module VI: 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

#### **Module VII: 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

### **Module VIII: 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.
- Asthma: Procedure, Benefits & contraindications for Sukhasana, Chakrasana, Gomukhasana, Parvatasana, Bhujangasana, Paschimottasana, Matsyasana.

### **Module IX: 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.

### **Module X: 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.

### **Module XI: Doping**

- Meaning and Concept of Doping
- Prohibited Substances & Methods
- Side Effects of Prohibited Substances

### **Module XII: Sports Medicine**

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

### **Module XIII: Sports / Games**

Following sub topics 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.

**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

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

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Course Code	:	OEXXX
Course Title	:	Engineering Economics
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE
<b><i>This courses is strongly recommended for Automobile Engineering Students.</i></b>		

### **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 Content:**

- **Module I: Introduction:** Definition – Nature – Scope and Significance of Economics for Engineers.
- **Module II: 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.
- **Module III: Cost and Revenue:** Concepts – Classifications – Short run and long run cost curves – Revenue – Concepts – Measurement of Profit (Case Study).
- **Module IV: 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.
- **Module V: Market Failure:** Causes – Type of Goods – Rivalrous and Non-rivalrous goods – Excludable and Non-excludable goods – Solutions – Government Intervention.
- **Module VI: Money and Banking:** Money – Functions – Quantity theory of money – Banking – Commercial Banks – Functions – Central Bank (RBI) – Functions – Role of Banks in Economic Development.
- **Module VII: Foreign Exchange:** Balance of Payments – Exchange rate determination – Methods of foreign payments – International Institutions – IMF, IBRD.
- **Module VIII: 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 & Economics for Engineers, Khanna Publishing House, 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.

### Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Managerial Economics	Dr. Trupti Mishra	IIT Bombay

### Course Outcome(s):

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 bench marking.

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Course Code	:	OEXXX
Course Title	:	Human Relations at Work
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

### Course Objective(s):

1. The quality of the organization's employees, their attitude, behavior and satisfaction with their jobs, and their behavior towards ethics and values and a sense of fair treatment all impact the firm's productivity, level of customer service, reputation, and survival.
2. The students of human resources management must aware of basic aspects of human resource management to understand the functioning of human resource management in an organizational setting.

### Course Content:

**Module I: Organisation:** Definition, Nature, scope and significance, Approaches, Departmentation, Line and staff relationships, Delegation and Decentralization, Committee system, Determinants of effective organising, Staffing - nature and significance, Selection, Appraisal and Development of Managers.

**Module II: Motivation:** Financial and non-financial motivational techniques - Job satisfaction - Meaning - Factors - Theories - Measurement - Morale - Importance - Employee attitudes and behavior and their significance to employee productivity.

**Module III: Work Environment:** Good housekeeping practices - Design of work place - Fatigue - Causes and prevention and their importance - Leadership - Types and Theories of leadership.

**Module IV: Group Dynamics:** Cohesiveness - Co-operation - Completion - Conflict - Resolution - Sociometry - Group forms - Role position status.

**Module V: Organizational Culture and Climate:** Organizational effectiveness - Organizational Development. Counselling and guidance - Importance of Counsellor - Types of Counselling - Information needed for Counselling.

**Text Books:**

1. Blum ML - Industrial Psychology and its social foundation.
2. Diwedi - Human Relation and Organizational Behavior, MacMillan India.
3. Aswathappa - Organizational Behavior.
4. Sekaran - Organizational Behavior.

**References:**

1. Arnold - Work Psychology, MacMillan I Ltd.
2. Hippo - Organizational Behavior.
3. Heresy Bianchand - Introduction to organizational Behavior.
4. Hanell - Industrial Psychology.
5. Keith Davis - Human Relations at work.
6. Pestonjee Motivation & Job satisfaction, MacMillan I Ltd.

**Course Outcome(s):**

1. Understand the basic concepts, functions and processes of human resource management
2. Recognize the role, functions and functioning of human resource department of the organizations.
3. Design and formulate various HRM processes such as Recruitment, Selection, Training, Development, Performance appraisals and Reward Systems, Compensation Plans and Ethical Behaviour.
4. Develop ways in which human resources management might diagnose a business strategy and then facilitate the internal change necessary to accomplish the strategy
5. Evaluate the developing role of human resources in the global arena.

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Course Code	:	OEXXX
Course Title	:	Values and Ethics
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective(s):**

1. To increase ethical sensitivity.
2. To impart ethical knowledge.
3. To improve ethical judgment.

**Course Content:**

**Module I: Human Values:** Morals, values and Ethics – Integrity – Work ethic – Service learning – Civic virtue – Respect for others – Living peacefully – Caring – Sharing –

Honesty – Courage – Valuing time – Cooperation – Commitment – Empathy – Self-confidence – Character – Spirituality – Introduction to Yoga and meditation for professional excellence and stress management.

**Module II: Engineering Ethics:** Senses of ‘Engineering Ethics’ – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg’s theory – Gilligan’s theory – Consensus and Controversy – Models of professional roles - Theories about right action – Self-interest – Customs and Religion – Uses of Ethical Theories.

**Module III: Engineering as Social Experimentation:** Engineering as Experimentation – Engineers as responsible Experimenters – Codes of Ethics – A Balanced Outlook on Law.

**Module IV: Safety, Responsibilities and Rights:** Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis and Reducing Risk - Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) – Discrimination.

**Module V: Global Issues:** Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Moral Leadership – Code of Conduct – Corporate Social Responsibility.

**Text Books:**

1. Mike W. Martin and Roland Schinzinger, “Ethics in Engineering”, Tata McGraw Hill, New Delhi, 2003.
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, “Engineering Ethics”, Prentice Hall of India, New Delhi, 2004.
3. Premvir Kapoor, Professional Ethics & Human Values, Khanna Publishing House, Delhi, 2019.

**References:**

1. Charles B. Fleddermann, “Engineering Ethics”, Pearson Prentice Hall, New Jersey, 2004.
2. Charles E. Harris, Michael S. Pritchard and Michael J. Rabins, “Engineering Ethics – Concepts and Cases”, Cengage Learning, 2009
3. John R Boatright, “Ethics and the Conduct of Business”, Pearson Education, New Delhi, 2003
4. Edmund G Seebauer and Robert L Barry, “Fundamentals of Ethics for Scientists and Engineers”, Oxford University Press, Oxford, 2001
5. Laura P. Hartman and Joe Desjardins, “Business Ethics: Decision Making for Personal Integrity and Social Responsibility” McGraw Hill education, India Pvt. Ltd. New Delhi 2013.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Ethics in Engineering Practice	Dr. Susmita Mukhopadhyay	IIT Kharagpur

**Course Outcome(s):**

1. Recognize Ethical, social and environmental issues.
2. Recognize Engineer's rights and responsibilities act in morally desirable ways, towards moral commitment and responsible conduct.
3. Integrate academic learning with experimental learning in a profession.

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Course Code	:	OEXXX
Course Title	:	Intellectual Property Rights
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	OE

**Course Objective:**

To promote the dissemination of the knowledge in intellectual properties by affording protection to its creators and its applications relevant to various streams of Engineering and Technology.

**Course Content:**

**Module I: INTRODUCTION:** Nature of Intellectual Property: Patents, Designs, Trademarks and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development.

**Module II: INTERNATIONAL SCENARIO:** International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Module III: PATENT RIGHTS:** Scope of Patent Rights. Licensing and transfer of technology. Patent information and data bases. Geographical Indications.

**Module IV: NEW DEVELOPMENTS IN IPR:** Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR –patent corporation treaty (PCT)- patent laboratory treaty

**Module V: LEGAL PROCEDURE:** Registered and unregistered trademarks, design, concept, idea patenting

**TEXTBOOKS:**

1. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
2. Mayall, "Industrial Design" McGraw Hill, 2004.

**REFERENCES:**

1. Niebel, “ Product Design” Mc Graw Hill, 2002
2. Robert P. Merges, Menell, Mark A. Lemley, “ Intellectual Property “ New Technological Age , 2002
3. Ramappa T, “Intellectual Property Rights” Under WTO, T., S. Chand, 2003.
4. <http://www.ipindia.nic.in/>

**Alternative NPTEL/SWAYAM Course:**

<b>S. No.</b>	<b>NPTEL Course Name</b>	<b>Instructor</b>	<b>Host Institute</b>
1	Introduction on Intellectual Property to Engineers and Technologists	Prof. Tapas Kumar Bandyopadhyay	IIT Kharagpur

**Course Outcome:**

1. To give an understanding of Intellectual Property Rights, Patents.
2. To familiarise the students to what constitutes professional practice, introduction of various stakeholders and their respective roles; understanding the fundamental ethics governing the profession
3. To develop good ideas of the legal and practical aspects of their profession.

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# Appendix – II

## Professional Electives



## Professional Electives (I to VI)

<b>Course Codes</b>	PE301; PE302; PE304; PE401; PE402; PE403
<b>Credit distribution for any Professional Elective Course</b>	3 (L: 3, T: 0, P: 0)

**Important Note:** For Professional Elective Courses (Professional Elective I to VI), a student has to opt four courses from any one of the three streams as defined in **Appendix II** namely '**Design Engineering**', '**Thermal Engineering**' and '**Industrial & Manufacturing Engineering**'. The remaining two courses may be taken from any of the other streams (Design, Thermal, Manufacturing) or from "Miscellaneous".

### Stream Wise Course Distribution

Stream	Available Courses
Design Engineering	Automatic Transmission
	Automotive Electronics
	Automotive Product Life Cycle Management
	Vibration and Noise Engineering
	Automotive Styling
	Power Train Design (Electric and Hybrid)
Thermal Engineering	Automotive HVAC
	Modelling and Simulation of Internal Combustion Engines
	Advanced Theory of Internal Combustion Engines
	Computational Fluid Dynamics
	Theory of Fuels and Lubricants
	Combustion Thermodynamics and Heat Transfer
Industrial & Manufacturing Engineering	Advanced Materials for Green Vehicles
	Value Engineering
	Commercial Fleet Operation
	Quality Assurance and Reliability
	Process Planning and Cost Estimation
	Lean Methods for Automobile Engineers

### List of Miscellaneous Courses:

1. Sensor Fusion
2. Vehicle Communication Systems
3. Alternative Sources of Energy
4. Signals and Systems
5. Automotive Testing

6. Control Systems
7. Automotive Energy Sources
8. Autonomous and Connected Vehicles
9. Automotive Materials
10. Two and Three Wheeler Technology

# **Design Engineering**



## **Design Engineering**

Course Code	:	PEXXX
Course Title	:	Automatic Transmission
Number of Credits	:	3 (L: 3, T: 0, P:0)
Course Category	:	PE
Pre-requisites	:	Automotive Powertrain Automotive Transmission

**Course Objective(s):** To understand and apply the principles and working of components associated with various types of automatic transmission.

### **Course Content:**

**Module I: Concept:** Principles of automatic transmission - advantages - limitations - types - Mechanical - hydrodynamic -hydro mechanical - hydro static and electric.

**Module II: Mechanical:** Principle of centrifugal clutches - comparison between conventional and centrifugal clutches - centrifugal clutches used in two wheelers - over drives - Principle - operation - types - advantages and limitations.

**Module III: Hydrodynamic Drives:** Principle of fluid coupling - construction - operation and characteristics - fluid coupling with conventional gear boxes. Introduction to torque converters - comparison between fluid coupling and torque converters - performance characteristics - slip - principles of torque multiplication - types of torque converters.

**Module IV: Hydro-Mechanical Drives:** Major components - principle of planetary gear trains - actuating mechanism -controls system - Types -Manual - governor - throttle and hydraulic control systems. Principle of automatic gear shifting. Typical automatic transmissions.

**Module V: Hydrostatic Drives:** Principles of hydrostatic drives - different systems of hydrostatic drives - fixed displacement pump and fixed displacement motor - variable displacement pump and fixed displacement motor - fixed displacement pump and variable displacement motor - variable displacement pump and variable displacement motor - applications - plunger type pump and plunger type motor - advantages and limitations -typical hydrostatic drives.

**Module VI: Electric Drives:** Early Ward Leonard control system - Main features - generator - merits - reverse motion - modified Ward Leonard control system -Main features - modifications. Modern electric drives -Main features -performance characteristics - advantages and limitations.

**Text Books:**

1. Jack Erjavec "Automatic Transmissions", Delmar Publishers., 2005.
2. Heinz Heisler "Advanced Vehicle Technology", SAE., 2002.
3. Babu A.K. "Automotive Mechanics", Khanna Publishers, 2018.

**References:**

1. Theraja B.L "Fundamentals of Electrical Engineering and Electronics", S Chand & Company Ltd., 2009
2. Tucker H.F "Automatic Transmission", Van Nostrand Reinhold Company., 1980
3. Mathias F.B "Automatic Transmission", Prentice Hall., 1998
4. John J.P, Tyler G.H "Industrial Hydraulics", MGH Published., 1980

**Course Outcome(s):**

1. Understand the concept of automatic transmission
2. Understand the concept of hydro dynamic drive and list various types clutches.
3. Describe major components of hydro mechanical drives.
4. Compare various types of hydro static drives and list various components of hydro static drives.
5. Categorize various types of electric drives and identify the importance of modern electric drives.

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Course Code	:	PEXXX
Course Title	:	Automotive Electronics
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Automotive Electrical and Electronics System

**Course Objective(s):**

1. To obtain the knowledge of Automotive Electronics
2. To choose appropriate sensors for Automotive Application.

**Course Content:**

**Module I: Electronics in Automobile:** Introduction-Body and convenience electronics: vehicle power supply controllers and lighting modules, door control modules, Safety electronics: active safety systems: ABS, ASR, ESP passive safety systems: Restraint systems and their associated sensors in an automobile. Infotainment electronics: Dashboard/instrument cluster, car audio, telematics systems, navigation systems, multimedia systems.

**Module II: Electronic Engine Controls:** Concept of an electronic engine control system, electronic fuel injection -Throttle body fuel injection, multi-point fuel injection, gasoline direct injection, common rail direct injection, electronic ignition control, engine mapping, on-board diagnostics -L-Jetronic Fuel Injection Systems.



**Module III: Sensors and Actuators:** Classification of sensors, sensor for speed, throttle position, exhaust oxygen level, manifold pressure, crankshaft position, Accelerometer, NOx Sensor, Coolant temperature, exhaust temperature, air mass flow for engine application. Solenoids, stepper motors and relay.

**Module IV: Introduction to RTOS:** Comparison of conventional OS with RTOS. Tasks & task states (Pre-emptive & Non-pre-emptive, scheduler, interrupt –Interrupt latency and context switch latency) –Task, multi-tasking, task synchronization, inter-task communication, shared data problem and its prevention -Features of a typical embedded RTOS ( $\mu$ C/OS-II).

**Module V: Communication Protocols:** Introduction to control networking – Communication protocols in embedded systems –SPI, I2C, USB. Vehicle communication protocols –Introduction TO CAN, LIN, FLEXRAY, MOST, AUTO SAR.

**Text Books:**

1. Denton. T, “Automobile Electrical and Electronic Systems”, Elsevier Jordan Hill, Oxford, 2010.
2. Bosch Automotive Handbook, Bentley Publications, Massachusetts Avenue, London, 2010.
3. Babu A.K., “Automotive Electricals & Electronics”, Khanna Publishing House, Delhi.

**References:**

1. Knowles.D, “Automotive Electronic and Computer Controlled Ignition Systems”, Prentice Hall Publications, New Jersey, 2009
2. JoergSchaeuffele, Thomas Zurawka, “Automotive Software Engineering–Principles, Processes, Methods and Tools”, SAE. International Publication, 2005
3. Ronald K.J, “Automotive Electronics Handbook”, McGraw Hill Publications, Columbus, 2009
4. Nicholas Navit, “Automotive Embedded System Handbook”, CRC Press Publications, New Delhi, 2009.

**Course Outcome(s):**

1. Understand the concepts of Automotive system
2. Understand the safety and security system in a vehicle
3. Describe various Sensoric systems in the vehicle
4. Describe various communication systems.
5. Explain embedded system in a vehicle.

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Course Code	:	PEXXX
Course Title	:	Automotive Product Life Cycle Management
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Engineering Design

**Course Objective(s):**

1. To familiarize the new product design and development.
2. To expose the components of product lifecycle management.
3. To understand the product visualization using CAD.
4. To familiarize modules of PLM software
5. To analyze and evaluate the product lifecycle management to industry needs.

**Course Content:**

**Module I: Motivation and Introduction:** E-commerce, B to B, B to C forms of business, extended enterprise, concepts in PDM - product life cycle, business objects, work flows, versions, views, product structure, change processes, work list, information flow model in product development, engineering bill of materials and manufacturing bill of materials.

**Module II: Components of PLM Solutions:** Object oriented approach in product development solutions, phase gate process in product design - disparate databases and connectivity, use of EAI technology (middleware) - cases for preparation of combined BOM and other reports. Component supplier management and sourcing.

**Module III: Product Visualisation:** CAD neutral environment and visualization of products, standard software, use of visualization in several stages of lifecycle, reviews, mark-up - case studies.

**Module IV: Role of PLM in Industries:** Automotive sectors, ten step approach to PLM, benefits of PLM.

**Module V: Details of Module:** Details of modules in a PDM/PLM software, basics on customization and implementation of automotive PDM/PLM software.

**Text Books:**

1. Stark John, "Product Lifecycle Management (Volume 1)", Springer International Publishing, 2015.
2. Stark John, "Product Lifecycle Management (Volume 2)", Springer International Publishing, 2016.

**References:**

1. Wang Lihui and Andrew YCN, "Collaborative Design and Planning for Digital Manufacturing", Springer-Verlag London Limited, 2009.
2. Stark John, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
3. GrievesMichael, "Product Life Cycle Management", Tata McGraw Hill, 2006.

**Course Outcome(s):**

1. Understand the product lifecycle management in an automotive industry
2. Identify the suitable PLM components for OEMS's and Tier-I industry.
3. Visualize new product design and styling

4. Apply the suitable PLM modules in new product development.
5. Recognize the change management and develop a time compression technology.

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Course Code	:	PEXXX
Course Title	:	Vibration and Noise Engineering
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Mechanics of Machines

**Course Objective(s):**

1. To understand the sources of vehicle vibration the customer faces in vehicle refinement.
2. To analyze the different control methods in suppression of vehicle vibration.
3. To understand the sources of vehicle, noise the customer faces in vehicle refinement.
4. To analyzing the different control methods in noise attenuation.
5. To evaluate the tail pipe noise with silencer in noise attenuation.

**Course Content:**

**Module I: Basics of Vibration:** Introduction, classification of vibration: free and forced vibration, undamped and damped vibration, linear and nonlinear vibration, response of damped and undamped systems under harmonic force, analysis of single degree and two degree of freedom systems, torsional vibration, determination of natural frequencies.

**Module II: Vibration Control Techniques:** Vibration isolation, tuned absorbers, untuned viscous dampers, damping treatments, engine mounts and transmissibility, semi-active and active mounts - crank shaft damping, modal analysis.

**Module III: Basics of Noise and Sources:** Introduction, noise dose level, legislation, measurement and analysis of noise in engines, Noise characteristics, overall noise levels, assessment of combustion noise, assessment of mechanical noise, engine radiated noise, intake and exhaust noise, engine accessory contributed noise, transmission noise, aerodynamic noise, tyre noise, brake noise.

**Module IV: Noise Control:** Methods for control of engine noise, combustion noise, mechanical noise, predictive analysis, palliative treatments and enclosures, automotive noise control principles, sound in enclosures, sound energy absorption, sound transmission through barriers, Helmholtz resonators.

**Module V: Silencers and Active Noise Control:** Introduction- Requirements –reactive and absorptive type -simple expansion chamber and its TL calculation – double

chamber mufflers Extended-Tube Expansion Chamber(ETEC)- back pressure considerations- active noise control strategies.

**Text Books:**

1. Vehicle refinement Controlling Noise and vibration in road vehicles, Mathew Harrison, SAE International, Elsevier Butterworth-Heinemann, 2008.
2. Vehicle noise and vibration refinement Xu Wang, Woodhead Publishing Limited, 2010.

**References:**

1. Singiresu S. Rao - “Mechanical Vibrations” - Pearson Education, ISBN –81-297-0179-0 - 2004. 95
2. Rao V. Dukkipati and J.Srinivas, ”Text book of Mechanical Vibrations”, Prentice-Hall of India P Ltd,New Delhi, 2004.
3. Kewal Pujara “Vibrations and Noise for Engineers, Dhanpat Rai & Sons, 1992.

**Course Outcome(s):**

1. Understand the sources of vehicle vibration the customer faces in vehicle refinement.
2. Analyse the different control methods in suppression of vehicle vibration.
3. Understand the sources of vehicle noise the customer faces in vehicle refinement.
4. Analyse the different control methods in noise attenuation.
5. Evaluate the tail pipe noise with silencer in noise attenuation.

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Course Code	:	PEXXX
Course Title	:	Automotive Styling
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Engineering Design

**Course Objective(s):**

1. To gain knowledge on the basics of concept styling and design.
2. To understand the computer aided design for communication of ideas.
3. To familiarize the computer aided styling for new product styling.
4. To expose the existing global standards related to technical drawings.
5. An ability to illustrate the product for an industry standard.

**Course Content:**

**Module I: Vision:** Identifying opportunity, defining a vision, setting targets, opportunities in portfolio, research examples of personal, design manifesto and design movements, spreading the word and generating a mission statement, understanding the interplay between brand and design brief, creating a design brief.

**Module II: Ideate:** Explore various vehicle packages and technical solutions based on the needs of target customer and market opportunity, structure and a framework for

vehicle architecture, explore unique visual DNA for a vehicle based on objectives, begin to explore surface language, selecting key directions and identifying themes, understanding segmentation and competitive benchmarking.

**Module III: Develop:** Character development and processing imagery, establishing an architectural and visual foundation, design development in full-size, refining proposals and making a final selection, creating an initial design prototype, final theme selection.

**Module IV: Model:** Virtual 3D and the digital design process, digital sketch modelling, 3D data development, rapid validation mock-ups.

**Module V: Build and Launch:** Vetting an idea, engineering, processing, market research, early-stage vetting for designers, presenting to client’s management and key stakeholders, pitching to prospective users, selling new viewers on an idea, launching a vehicle.

**Text Books:**

1. Jordan Meadows, “Vehicle Design: Aesthetic Principles in Transportation Design”, Taylor & Francis Group, 2018.
2. Tony Lewin, Ryan Borroff, “How to Design Cars Like a Pro”, Motor Books International, 2010.
3. Alan Pipes, “Drawing for Designers”, Laurence King Publishing, 2007.

**References:**

1. Thom Taylor, “How to Draw Cars Like a Pro”, Motor Books International, 2006.
2. Stuart Macey, Geoff Wardle, Ralph Gilles, Freeman Thomas, Gordon Murray, “H-Point: The Fundamentals of Car Design & Packaging”, Design Studio Press, 2009.
3. Erik Olofsson, Klara Sjöln, “Design Sketching”, Keeos Design Books AB, 2005.

**Course Outcome(s):**

1. Express the innovative ideas in new concept and styling.
2. Identify the suitable computer aided design tools for communication of ideas.
3. Understand the computer aided styling for new product styling.
4. Apply the global standards in new product development.
5. Recognize the customer insight and develop an innovative product.

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Course Code	:	PEXXX
Course Title	:	Power Train Design (Electric and Hybrid)
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Automotive Powertrain Electric and Hybrid Vehicles

**Course Objective(s):**

1. To gain knowledge on the operational features of electric vehicle.
2. To understand and express the knowledge on advanced hybrid vehicles.
3. To familiarize the load scheduling on charging of xEVs
4. To expose the suitable modelling techniques.
5. An ability to illustrate the optimisation techniques for xEVs architectures

**Course Content:**

**Module I: Concept of Electrification:** Constituents of a conventional vehicle-Vehicle and propulsion load-drive cycles and drive terrain-constituents of a PHEV-vehicle model-EV powertrain component sizing-electrically peaking hybrid concept-gradability Requirement.

**Module II: Advanced HEV Architectures and Dynamics of HEV Powertrain:** Principle of Planetary Gears-Operating Principle of the Two-Mode Powertrain-Gear Shift Schedule-DCT-Based Hybrid Powertrain-Regenerative Braking Mode-Electric CVT Mode-Energy Recovery Mode.

**Module III: Plug-In Hybrid Electric Vehicles:** Plug-In Hybrid Electric Vehicles-Blended PHEVs-Equivalent Electric Range of Blended PHEVs-Utility Factor-Power Management of PHEVs-Component Sizing of EREVs.

**Module IV: Modeling and Simulation of Electric and Hybrid Vehicles:** Fundamentals of Vehicle System Modeling-Hybrid Powertrain Modeling-Modeling of Vehicle Dynamics-Bond Graph Modeling Techniques-Consideration of Numerical Integration Methods.

**Module V: HEV Component Sizing and Design Optimization:** Algorithm Description-Flow Chart-Operators and Selection Method-Particle Swarm Optimization-Model-in-the-Loop Design Optimization Process- Genetic Algorithm modelling.

**Text Books:**

1. Mi Chris and Masur Abul, "Hybrid Electric Vehicles", First edition, John Wiley, 2018.
2. Liu Wei, "Introduction to Hybrid Vehicle Systems Modelling and Control", Third edition, John Wiley, 2018.

**References:**

1. Hayes.G and Goodarzi, "Electric Powertrain- Energy systems, power electronics and drives" First Edition, John Wiley, Sussex UK 2018.
2. Emadi A, "Advanced Electric Drive Vehicles", First Edition Taylor & Francis Group, LLC, 2015.

**Course Outcome(s):**

1. Explain the sequence of operating modes of HEVs.
2. Analyze the regenerative braking energy concepts with suitable drivelines.
3. Analyze a suitable design and optimized sizing of xEVs Component.
4. Synthesize the EV architectural for various drive cycle needs.
5. Use suitable algorithm for modelling and optimized techniques.

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# **Thermal Engineering**





## **Thermal Engineering**

Course Code	:	PEXXX
Course Title	:	Automotive HVAC
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Thermodynamics and Thermal Engineering

### **Course Objective(s):**

1. To be acquainted with the different types of air conditioning systems and components.
2. To make the student responsive to cooling load calculations of psychrometric processes.
3. To impart the knowledge of refrigeration and refrigerants.
4. To inculcate the importance of ventilation and impart knowledge of testing the air control and handling systems.
5. To disseminate knowledge on air-conditioning in automobiles.

### **Course Content:**

**Module I: Refrigeration:** Introduction - Methods of refrigeration - Air Refrigeration System and its applications – Vapour compression refrigeration system - Vapour absorption refrigeration system - Applications of refrigeration & air conditioning - Automobile air conditioning -Air conditioning for passengers. isolated vehicles, transport Vehicles-Applications related with very low temperatures, Classification, properties and selection criteria - Commonly used refrigerants – Alternative refrigerants - Eco-friendly refrigerants - Applications of refrigerants - Refrigerants used in automobile air conditioning.

**Module II: Psychrometry:** Psychrometric properties, tables, charts - Psychrometric processes - Comfort charts – Factor affecting comfort - Effective temperature - Ventilation requirements.

**Module III: Air Conditioning Systems and Load Analysis:** Classification and layouts - Central unitary air conditioning systems - Components like compressors. evaporators, condensers, expansion devices, fan blowers, heating systems etc. Load Analysis: Outside & inside design consideration - Factors forming the load on refrigeration & air conditioning systems - Cooling & heating load calculations - Load calculations for automobiles - Effect of air conditioning load on engine performance.

**Module IV: Air Distribution Systems:** Distribution duct system. sizing. supply return ducts - Types of gnlis. diffusers, ventilation, air noise level - Layout of duct systems for automobiles and their impact on load calculations. Air Routine & Temperature Control: Objectives- evaporator care air flow - Through the dash re-circulating unit - Automatic temperature control - Controlling flow - Control of air handling systems.

**Module V: Air Conditioning Service and Control:** Air conditioner maintenance & service - servicing heater system - Removing & replacing components - Trouble shooting of air conditioning system -Compressor service, methods of dehydration. charging & testing. Air Conditioning Control: Common control such as thermostats- Humidistat-Control dampers - Pressure cutouts and relays.

**Text Books:**

1. Mark Schnubel, 'Automotive Heating and Air Conditioning', Today's Technician, 5<sup>th</sup> edition, 2013.

**References:**

1. C. P. Arora, "Refrigeration and Air conditioning" McGraw Hill Education (India) Private Limited, New Delhi.
2. William H. Crouse and Donald I. Anglin, "Automotive Air conditioning" McGraw Hill, 1983.
3. Paul Weiser, "Automotive Air Conditioning" - Reston Publishing Co., Inc., 1990.
4. MacDonald K.I., "Automotive Air Conditioning" Theodore Audel series, 1978.

**Course Outcome(s):**

1. Differentiate types of air conditioning systems and design the power and heat requirements components.
2. Calculate cooling load for an air-conditioning process of using psychometry.
3. Distinguish different types of refrigerants and select a specific refrigerant for an application.
4. Design a ventilation system and test the air control and handling systems
5. Distinguish between the different types of air-conditioning in automobiles and service them.

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Course Code	:	PEXXX
Course Title	:	Modeling and Simulation of Internal Combustion Engines
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Thermodynamics and Thermal Engineering

**Course Objective(s):**

1. To enable the student to model IC Engines.
2. To impart the knowledge of combustion in IC engines.
3. To enable the student to simulate IC Engines.

**Course Content:**

**Module I: Modelling of IC Engines:** Heat of reaction - Hrp and Urp calculations, adiabatic, constant volume combustion, constant pressure combustion, temperature drop due to fuel vaporization, adiabatic flame temperature, mean effective pressure, torque and thermal efficiency at full throttle, part throttle and supercharged conditions. Spray models, flow models and combustion models.

**Module II: Combustion in SI Engines:** Combustion in premixed flames - Stages of combustion, flame propagation, rate of pressure rise, cycle-to-cycle variation, abnormal combustion - Theories and effect of engine operating variables on combustion.

**Module III: Combustion in CI Engines:** Combustion in diffusion flames - Droplet and spray combustion theory, stages of combustion, delay period, peak pressure, heat release, gas temperature and diesel knock.

**Module IV: Simulation of IC Engines:** SI and CI engine simulation – Air standard cycle, fuel-air cycle, progressive combustion cycle and actual cycle simulation – Part throttle, full throttle and supercharged conditions.

**Module V: Simulation of New Engine Concepts:** Dual fuel engine, low heat rejection engine, lean burn engine, variable compression ratio engine, homogeneously charged compression ignition engine and controlled auto ignition engine.

**Text Books:**

1. Ganesan V, “Computer Simulation of Spark-Ignition Engine Processes “, Universities Press (I) Ltd, Hyderabad, 1996.
2. Ganesan V, “Computer Simulation of Compression-Ignition Engine Processes”, University Press (I) Ltd, Hyderabad, 2000.

**References:**

1. Ganesan V, “Internal Combustion Engines”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.
2. Heywood J.B, “Internal Combustion Engine Fundamentals” McGraw Hill Book Co., USA,1988.
3. Ramoss A.L, "Modeling of Internal Combustion Engines Processes", McGraw Hill Publishing Co.,1992.
4. Ashley Campbel, "Thermodynamic analysis of combustion engines", John Wiley & Sons, New York, 1986.
5. Babu, A.K., Automotive Engines, Khanna Publishing House, New Delhi.

**Course Outcome(s):**

1. Choose appropriate mathematical model for IC engine combustion under given conditions.
2. Review combustion in SI engines.
3. Review combustion in CI engines.
4. Analyse combustion in IC engines by simulation.
5. Evaluate the given combustion concept by simulation.

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Course Code	:	PEXXX
Course Title	:	Advanced Theory of Internal Combustion Engines
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Thermodynamics and Thermal Engineering

**Course Objective(s):**

1. To be acquainted with the different types of combustion processes and types of air motion that drive combustion.
2. To be aware of the differences between abnormal combustion and normal combustion.
3. To impart the knowledge of combustion theories, phenomenon, types and characteristics.
4. To offer the fundamental knowledge on combustion calculations.

5. To emancipate new developments in IC Engines.

### **Course Content:**

**Module I: Combustion Processes:** Combustion in premixed and diffusion flames, combustion process in IC engines, adiabatic flame temperature, effect of super charging and scavenging on combustion.

**Module II: Abnormal Combustion in SI Engines:** Stages of combustion, flame propagation, rate of pressure rise, cycle-to-cycle variation, abnormal combustion, theories of detonation, heat release.

**Module III: Combustion and Knock in CI Engines:** Droplet and spray combustion theory, stages of combustion, delay period, peak pressure, heat release, gas temperature, diesel knock.

**Module IV: Combustion of Fuels:** Combustion stoichiometry of petrol, diesel, alcohol and hydrogen fuels, chemical energy and heating values, chemical equilibrium and maximum temperature, flame velocity and area of flame front, fuel spray characteristics -, penetration and atomization.

**Module V: Advanced IC Engines:** Adiabatic and low heat rejection engines, homogeneously charged compression ignition engines - multi- fuel engines, stratified charged and lean burn engines.

### **Text Books:**

1. Heywood J B, "Internal Combustion Engine Fundamentals" McGraw Hill Book Co., USA, 1988.
2. Ganesan V. "Internal Combustion Engines", Tata Mc-graw Hill Publishing Co. Ltd., New Delhi 2008.

### **References:**

1. Lewis B, Pease.R.N. and Taylor.H.S., "Combustion Process High Speed Gas dynamics and Jet Propulsion Series", Princeton University Press, New Jersey, 1976.
2. Taylor E.F, "The Internal Combustion Engines", International Book Co., Pennsylvania, 1982.
3. Spalding D.B, "Some Fundamental of Combustion", Butterworth Science Publications, London, 1985.
4. Ganesan V, "Computer Simulation of Spark Ignition Engine Processes", Universities Press (India) Ltd, Hyderabad, 1996.

### **Course Outcome(s):**

1. Differentiate different types of combustion processes in an IC engine, determine the adiabatic flame temperature for a given fuel and comprehend effect of super charging and scavenging on combustion
2. Distinguish the stages of combustion, theories of detonation, heat release, determine flame propagation, rate of pressure rise, cycle-to-cycle variation and differentiate abnormal combustion and normal combustion.

3. Identify droplet and spray combustion theories, stages of combustion, diesel knock and arrive at delay period, peak pressure, heat release, gas temperature,
4. Determine the stoichiometry of petrol, diesel, alcohol and hydrogen fuels, chemical energy and heating values, chemical equilibrium and maximum temperature, flame velocity and area of flame front, characterise fuel spray -, penetration and atomization.
5. Enumerate various advances IC engines and apply them to improve the efficiency and reduce the emissions.

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Course Code	:	PEXXX
Course Title	:	Computational Fluid Dynamics
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Thermodynamics and Thermal Engineering Fluid Mechanics

**Course Objective(s):**

1. A foundation in the fundamentals of fluid mechanics, thermodynamics and fluid flow.
2. Methods and various techniques on CFD for various engineering applications includes heat transfer, fluid flow analysis, automobile and medical treatment.

**Course Content:**

**Module I: Introduction:** Application areas of CFD, Basic concepts of fluid flow - governing equations, conservation of mass, momentum and energy – Navier-stokes and energy equation for Newtonian fluid, Mathematical classification of flow - hyperbolic, parabolic, elliptic and mixed flow types.

**Module II: Discretisation:** Finite difference method - forward, backward and central difference schemes, Explicit and implicit methods: Numerical solution for heat transfer and fluid flow problems for steady state and transient conditions, Stability analysis and error estimation. Grid generation: Choice of grid, grid oriented velocity components, cartesian velocity components, staggered and collocated arrangements.

**Module III: CFD Techniques:** Lax - Wendroff technique - MacCormack’s technique, Relaxation technique. ADI technique, Pressure correction technique, SIMPLE algorithm. Fluid flow and convection problems: Upwind scheme, Stability criteria.

**Module IV: Turbulence Modeling:** Turbulence energy equation- one-equation model, the k- $\omega$  model, the k-  $\epsilon$  model.

**Module V: Case Studies:** Modeling and analysis of heat transfer, fluid flow and automobile components using CFD packages.

**Text Books:**

1. John D Anderson, "Computational Fluid Dynamics – The Basics with Applications", McGraw Hill, New York, 1995.
2. Muralidhar K and Sundararajan T, "Computational Fluid Flow and Heat Transfer", Narosa Publications, New Delhi, 2003.

**References:**

1. Chung T J, "Computational Fluid Dynamics", Cambridge University Press, London, 2002.
2. David C Wilcox, "Turbulence Modeling for CFD", DCW Industries, Inc., 1993.
3. Versteeg H K and Malalasekara W, "An Introduction to Computational Fluid Dynamics - The Finite Volume Method", Longman, 1995.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Computational Fluid Dynamics	Dr. K. M. Singh	IIT Roorkee

**Course Outcome(s):**

1. Understand the concepts of CFD, apply numerical methods for solving steady and transient heat conduction equation.
2. Use conservation laws in differential forms and apply them to determine velocities, pressures and acceleration in a moving fluid for convection heat transfer
3. Use CFD Techniques and analyse the problems based on fluid flow and heat transfer applications.
4. Solve problems using Turbulence modelling
5. Apply principles of fluid mechanics and CFD for numerical analysis of automotive applications.

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Course Code	:	PEXXX
Course Title	:	Theory of Fuels and Lubricants
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Thermodynamics and Thermal Engineering

**Course Objective(s):**

1. Find out the properties of fuels and lubricants.
2. Be familiar with the properties of fuels and lubricants.

**Course Content:**

**Module I: Manufacture of Fuels and Lubricants:** Structure of petroleum, refining process, fuels, thermal cracking, catalytic cracking, polymerization, alkylation, isomerisation, blending, products of refining process. Manufacture of lubricating oil base stocks, manufacture of finished automotive lubricants.

**Module II: Theory of Lubrication:** Engine friction: introduction, total engine friction, effect of engine variables on friction, hydrodynamic lubrication, elasto hydrodynamic lubrication, boundary lubrication, bearing lubrication, functions of the lubrication system, introduction to design of a lubricating system.

**Module III: Lubricants:** Specific requirements for automotive lubricants, oxidation deterioration and degradation of lubricants, additives and additive mechanism, synthetic lubricants, classification of lubricating oils, properties of lubricating oils, tests on lubricants. Grease, classification, properties, test used in grease.

**Module IV: Properties and Testing of Fuels:** Thermo-chemistry of fuels, properties and testing of fuels, relative density, calorific value, flash point, fire point, distillation, vapour pressure, spontaneous ignition temperature, viscosity, pour point, flammability, ignitability, diesel index, API gravity, aniline point, carbon residue, copper strip corrosion etc.

**Module V: Combustion & Fuel Rating:** SI Engines – flame propagation and mechanism of combustion, normal combustion, knocking, octane rating, fuel requirements. CI Engine, mechanism of combustion, diesel knock, cetane rating, fuel requirements. Additive – mechanism, requirements of an additive, petrol fuel additives and diesel fuel additives – specifications of fuels.

**Text Books:**

1. Ganesan.V., “Internal Combustion Engineering”, Tata McGraw-Hill Publishing Co., New Delhi, 2003.
2. Mathur. M.L., Sharma. R.P. “A course in internal combustion engines”, Dhanpatrai publication, 2003.
3. Obert.E.F “Internal Combustion Engineering and Air Pollution”, International book Co., 1988.

**References:**

1. Brame, J.S.S. and King, J.G. – “Fuels Solids, Liquids, Gaseous”. Edward Arnold, 1961.
2. Francis, W, “Fuels and Fuel Technology”, Vol. I & II, Pergamon, 1965.
3. Hobson, G.D. & Pohl. W “Modern Petroleum Technology”, 1974.
4. Lansdown. A.R., Lubrication, “A practical guide to lubricant selection”, Pergamon press, 1982.
5. Raymond. C. Gunther, “Lubrication”, Chilton Book Co., 1971.

**Course Outcome(s):**

1. Describe the manufacturing & refining process of fuels and lubricants.
2. Describe various types of frictions in engine and lubrication system.
3. Explain the function and requirements of lubricants and its testing.
4. Define the properties and testing of fuels used in automobiles.
5. Describe the combustion in SI & CI engine and additives used in petrol and diesel.

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Course Code	:	PEXXX
Course Title	:	Combustion Thermodynamics and Heat Transfer
Number of Credits	:	3 (L: 3, T: 0, P: 0)

Course Category	:	PE
Pre-requisites	:	Thermodynamics and Thermal Engineering

**Course Objective(s):**

1. This course aims to provide a good platform to automobile engineering students to understand, model and appreciate concept of dynamics involved in thermal energy transformation.
2. To prepare them to carry out experimental investigation and analysis at later stages of graduation.

**Course Content:**

**Module I: Thermodynamics of Combustion:** Premixed and diffusion combustion process in IC engines. First and Second Law of Thermodynamics applied to combustion-combustion Stoichiometry- chemical equilibrium, spray formation and droplet combustion.

**Module II: Chemical Kinetics of Combustion:** Fundamentals of combustion kinetics, rate of reaction, equation of Arrhenius, activation energy. Chemical thermodynamic model for Normal Combustion.

**Module III: Flames:** Laminar premixed – flame speed correlations- quenching, flammability, and ignition, flame stabilization, laminar diffusion flames, turbulent premixed flames-Reynolds and Damkohler numbers and their significance.

**Module IV: Heat Transfer in IC Engines:** Engine Heat transfer and heat Balance. Measurement of Instantaneous heat transfer rate. Heat transfer modeling. Heat transfer coefficients, radiative heat transfer.

**Module V: Experiments in IC Engines:** Cylinder pressure measurement. Rate of heat release calculation – hot wire and laser Doppler anemometry and velocimetry for flow and combustion analysis in IC engines.

**Text Books:**

1. John. B. Heywood, 'Internal Combustion Engines', Tata McGraw Hill Co., New York, 1988.

**References:**

1. Spalding. D.B., "Some fundamental of Combustion", Butterworth Science Publications, London, 1985.
2. Taylor. E.F. "The Internal Combustion Engines ", International Text Book Co., Pennsylvania, 1982.
3. V. Ganesan, 'Internal combustion Engines', Tata McGraw Hill Book Co, Eighth Reprint, 2005.
4. Ashley Campbell, "Thermodynamic analysis of combustion engine", John Wiley book company, New York, 1979.

**Course Outcome(s):**

1. Apply the knowledge of mathematics, science and engineering fundamentals to model the energy conversion phenomenon.
2. Identify and formulate power production based on the fundamentals laws of thermal engineering.



3. Envisage appropriate experiments related to heat engines.
4. Investigate the effectiveness of energy conversion process in automotive combustion for power generation for the benefit.
5. Appreciate concepts learnt in fundamentals laws of thermodynamics from which learning ideas how to sustain in energy crisis and think beyond curriculum in the field of alternative and renewable sources of energy.

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# **Industrial & Manufacturing Engineering**



## **Industrial & Manufacturing Engineering**

Course Code	:	PEXXX
Course Title	:	Advanced Materials for Green Vehicles
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Manufacturing Technology

### **Course Objective(s):**

1. To construct the fundamental knowledge on materials available for automotive industry.
2. To provide the basic skills materials selection strategies on mechanical design for an automotive component.
3. To make outline of materials data and advanced materials data for the automotive applicability.
4. To provide better Engineering Design solutions for the Engineering Problem.

### **Course Content:**

**Module I: Introduction:** Composite materials- Foam cored steel composite box beams - Plastic mouldings for open canopy shells- Reaction injection moulding –Resin transfer molding – sheet Molding compounds- Ultra light weight construction case study.

**Module II: Green composite materials from liquefied biomass:** Introduction- Liquefaction technique- Foams- Polyurethane foams (PUFs) from liquefied lignocellulosics- Phenolic foam from liquefied lignocellulosics-1Molding materials- Liquefied wood as replacement in novolac-type resin- based composites- Epoxy-type resins from liquefied biomass.

**Module III: Green Fibers:** Introduction-Kenaf- Hemp- and Flax fibers-advantages and limitation- mechanical properties and comparison with Glass fiber- limitation- Binders used- Thermal resistance and chemical resistance.

**Module IV: Biodegradable Polymer Matrix:** Poly-lactic acid (PLA) – synthesis-mechanical properties, thermal and creep properties- compression and injection molding - Factors Influencing Processing of Green Composite - Performance of Green Composite.

**Module V: Design of Green Bio-Composites:** Basics of green composite design- Failure Prediction in a Unidirectional Lamina- Maximum Stress Theory- Maximum Strain Theory- Tasi-Wu Failure Theory- Failure Prediction in Random Fiber Laminates- Tensile Testing of Bio-Composites- Impact Test of Bio-Composites.

### **Text Books:**

1. Srikanth Pilla, Charles Lu. 'Biocomposites in Automotive Applications', Second SAE International, 2015.
2. Amar K. Mohanty, Manjusri Misra. Natural Fibers, Biopolymers, and Biocomposites Second CRC Taylor and Francis, 2005.

**References:**

1. Georgios Koronis, Arlindo Silva. Green Composites for Automotive Applications First Woodhead Publisher, 2017.
2. Caroline Baillie. Green Composites: Polymer Composites and the Environment First Woodhead Publishing Limited, 2005.

**Course Outcome(s):**

1. Describe about various types materials available for automotive industry.
2. Label the composition of metallic and non-metallic elements in steels and cast iron, justify the effects of those elements on properties of steels and cast iron, compare the microstructures and properties of steels and cast iron, justify the applicability of steels and cast iron.
3. Label the composition of metallic and non-metallic elements in non-ferrous alloys, justify the effects of those elements on properties of non-ferrous alloys, compare the microstructures and properties of non-ferrous alloys, justify the applicability of non-ferrous alloys.
4. Define the properties, processing and usage of some advanced materials such as polymers, ceramics and composite materials.
5. Apply basic knowledge of materials and its properties for the mechanical design.

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Course Code	:	PEXXX
Course Title	:	VALUE ENGINEERING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	-

**Course Objective(s):**

1. Understanding the principles of marketing, its role in 21st industry requirements.
2. Study the value engineering process and able to identify its functions within the process.
3. Determine the appropriate value engineering methodology for a given project and propose appropriate training to centralized and decentralized modes.
4. Learn various decision making processes and cost evaluation models and apply them in appropriately in the product development life-cycle.
5. Explore in-depth understanding of various value engineering applications in human resources, manufacturing and marketing.
6. Demonstrate to implement value engineering solutions and propose to perfect them.

**Course Content:**

**Module I: Introduction:** Value engineering concepts, advantages, applications, problem recognition, and role in productivity, criteria for comparison, element of choice.

**Module II: Organization:** Level of value engineering in the organization, size and skill of VE staff, small plant, VE activity, unique and quantitative evaluation of ideas.

**Module III: Value Engineering Job Plan:** Introduction, orientation, information phase, speculation phase, analysis phase. Selection and Evaluation of value engineering

Projects, Project selection, methods selection, value standards, application of value engineering methodology.

**Module IV: Analysis Function:** Anatomy of the function, use esteem and exchange values, basic vs. secondary vs. unnecessary functions. Approach of function, Evaluation of function, determining function, classifying function, evaluation of costs, evaluation of worth, determining worth, evaluation of value.

**Module V: Value Engineering Techniques:** Selecting products and operation for value engineering action, value engineering programmes, determining and evaluating function(s) assigning rupee equivalents, developing alternate means to required functions, decision making for optimum alternative, use of decision matrix, queuing theory and Monte Carlo method make or buy, measuring profits, reporting results, follow up, Use of advanced technique like Function Analysis System.

**Module VI: Versatility of Value Engineering:** Value engineering operation in maintenance and repair activities, value engineering in non-hardware projects. Initiating a value engineering programme Introduction, training plan, career development for value engineering specialties. Fast diagramming: cost models, life cycle costs.

**Module VI: Value Engineering Level of Effort:** Value engineering team, co-coordinator, designer, different services, definitions, construction management contracts, value engineering case studies.

#### **Text Books:**

1. Anil Kumar Mukhopadhyaya, "Value Engineering: Concepts Techniques and applications", SAGE Publications 2010.
2. Del L. Younker, "Value Engineering analysis and methodology", Marcel Dekker Inc, New York, 2004.

#### **References:**

1. Alphonse Dell'Isola, "Value Engineering: Practical Applications for Design, Construction, Maintenance & Operations", R S Means Co., 1997.
2. Richard Park, "Value Engineering: A Plan for Invention", St. Lucie Press, 1999.
3. Miles, L.D., "Techniques of Value Analysis and Engineering", McGraw Hill second Edition, 1989.
4. Khanna, O.P., "Industrial Engineering and Management", Dhanpat Rai & Sons, 1993.

#### **Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Computational Fluid Dynamics	Dr. K. M. Singh	IIT Roorkee

#### **Course Outcome(s):**

1. Estimate a product cost based on value engineering principles in terms of its values, functions and worthiness.
2. Study the product and articulate it in various phases of value engineering.
3. Understand and select appropriate methods, standards and apply them on value engineering project and propose appropriate training.

4. Apply querying theory and FAST to prefect a value engineering project implementation.
5. Understand various case studies related to value engineering project implementation.

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Course Code	:	PEXXX
Course Title	:	Commercial Fleet Operation
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	-

**Course Objective(s):** Focus on fleet policy development, safety programs initiatives, vehicle selector creation based on exhaustive lifecycle cost analyses, implementation of a corporate sustainability program, and the establishment of metrics to manage fleet suppliers.

**Course Content:**

**Module I: Transit Operation:** Modes of transport, road transport - Types of roads, advantages, motor transport in India, Route planning - Route location, stop location, route schedules, vehicle and labor scheduling. Traffic control - Traffic signals, signal timing.

**Module II: Costs & Fares:** Operating costs and types of vehicles - types of fare structure, types of fare collecting methods - Requirement of buses and frequency, construction of bus station.

**Module III: Forms of Ownership:** Sole proprietorship, partnership, private limited company, public limited company, statutory company, local authority undertaking / municipal transport company, joint venture.

**Module IV: Garage Management and Vehicle Maintenance:** Garage administration, types of garages, one spanner, two spanner, three spanner, break down truck symbol, government approved workshops – Tools- Objectives of maintenance, breakdown maintenance, preventive maintenance, tyre maintenance tips and failures. Fuel saving techniques and fitness certificate.

**Module V: Legal Aspects:** Motor Vehicle Act 1988, Registration, necessity of permits, insurance, test of competence to drive, mistake / offences for which a driver can be punished, adult workers - Hours of work, running time, split duty, journey time, round journey time, layover, frequency.

**Text Books:**

1. John Dolu, manage "Fleet management ", McGraw-Hill Co., 1984.
2. Crouse, William H, Anglin, Donald L, "Automotive Mechanics", McGraw-Hill Companies, 2007.



**References:**

1. Government Publication, "The Motor Vehicle Act ", 1988.
2. Kitchin L.D, "Bus operation ", Illiffe and Sons Ltd., London, 1992.
3. Gilles, Tim, "Automotive Service – Inspection, Maintenance, and Repair", Alar Elken Publications, 2007.

**Course Outcome(s):**

1. Understand science and technology behind current and future modes of transportation.
2. Apply economic principles to management decisions
3. Comprehend commercial vehicle regulations and legal knowledge along with a practical understanding of key areas

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Course Code	:	PEXXX
Course Title	:	Quality Assurance and Reliability
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE

**Course Objective(s):**

1. Understand quality management processes
2. Distinguish between the various activities of quality assurance, quality planning and quality control
3. Understand the importance of standards in the quality management process and their impact on the final product.

**Course Content:**

**Module I: Introduction and Process Control for Variables:** Introduction, definition of quality, basic concept of quality, definition of SQC, benefits and limitation of SQC, Quality assurance, Quality cost-Variation in process- factors – process capability – process capability studies and simple problems – Theory of control chart- uses of control chart – Control chart for variables – X chart, R chart and  $\sigma$  chart.

**Module II: Process Control for Attributes:** Control chart for attributes –control chart for proportion or fraction defectives – p chart and np chart – control chart for defects – C and U charts, State of control and process out of control identification in charts.

**Module III: Acceptance Sampling:** Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling techniques – O.C. curves – producer’s Risk and consumer’s Risk. AQL, LTPD, AOQL concepts-standard sampling plans for AQL and LTPD- uses of standard sampling plans.

**Module IV: Life Testing - Reliability:** Life testing – Objective – failure data analysis, Mean failure rate, mean time to failure, mean time between failure, hazard rate, system reliability, series, parallel and mixed configuration – simple problems. Maintainability and availability – simple problems. Acceptance sampling based on reliability test – O.C Curves.

**Module V: Quality and Reliability:** Reliability improvements – techniques- use of

Pareto analysis – design for reliability – redundancy unit and standby redundancy – Optimization in reliability – Product design – Product analysis – Product development – Product life cycles.

**Text Books:**

1. Douglas Montgomery, “Introduction to Statistical Quality Control” John Wiley and Sons Inc., New York, 2001.
2. L.S.Srinath, “Reliability Engineering” Affiliated East west press, 1991.

**References:**

1. S.C. Sharma & M.P. Poonia, Total Quality Management, Khanna Publishing House.
2. Monohar Mahajan, “Statistical Quality Control”, Dhanpat Rai & Sons, 2001.
3. R.C.Gupta, “Statistical Quality control”, Khanna Publishers, 1997.
4. Besterfield D.H., “Quality Control”, Prentice Hall, 1993.

**Course Outcome(s):**

1. Understand the concepts of quality assurance, process charts for variables for improvement and management.
2. List the process charts for attributes and identify the process charts that are out of control
3. Describe the acceptance sampling methods and paraphrase their impacts based on producer’s and consumer’s risk
4. Organize reliability data analysis and Get acquainted with various reliability prediction and evolution methods.
5. Compare and learn the fundamentals of reliability management and risk assessment.

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Course Code	:	PEXXX
Course Title	:	Process Planning and Cost Estimation
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	-

**Course Objective(s):**

1. Investigate the effectiveness of a range of production planning systems globally including demand forecasting, efficiencies, costings, material ordering, inventory control, lead times, and quality assurance requirements.
2. Interpret production data to create production plans or schedules including production capacity requirements, technical and specification documentation and delivery schedules.
3. Ability to understand and analyze managerial problems in industry so that they are able to use resources (capitals, materials, staffing, and machines) more effectively.

**Course Content:**

**Module I: Work Study and Ergonomics:** Method study – Definition – Objectives-Motion economy- Principles – Tools and Techniques- Applications – Work measurements-purpose – use – procedure – tools and techniques- Standard time –Ergonomics – principles – applications.

**Module II: Process Planning:** Definition–Objective–Scope–approaches to process planning-Process planning activities – Finished part requirements- operating sequences- machine selection–material selection parameters-Set of documents for process planning- Developing manufacturing logic and knowledge- production time calculation – selection of cost optimal processes.

**Module III: Introduction to Cost Estimation:** Objective of cost estimation- costing – cost accounting- classification of cost- Elements of cost.

**Module IV: Cost Estimation:** Types of estimates – methods of estimates – data requirements and sources- collection of cost- allowances in estimation.

**Module V: Production Cost Estimation:** Estimation of material cost, labour cost and over heads, allocation of overheads –Estimation for different types of jobs.

**Text Books:**

1. Sinha. B.P., "Mechanical Estimating and Costing", Tata McGraw-Hill, Publishing Co., 1995.

**References:**

1. Phillip. F Ostwalal and Jairo Munez, "Manufacturing Processes and systems", John Wiley, 1998
2. Russell. R.S and Tailor, B.W, "Operations Management", PHI, 2003.
3. Chitale. A.V. and Gupta. R.C. "Product Design and Manufacturing", PHI, 2002.

**Course Outcome(s):**

1. Implement production plans or schedules to optimize production and reduce waste
2. Understand and apply professional and ethical responsibility and reduce unwanted time in production
3. Understand Production and Operations Management and its role in creating competitive advantage for business organizations
4. Understand and apply the engineering concept reduce the cost and time with effective manner
5. Understand and apply the stocking level at the minimum rate.

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Course Code	:	PEXXX
Course Title	:	Lean Methods for Automobile Engineers
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Manufacturing Technology

**Course Objective(s):**

1. Exposed to lean fundamental concepts, and distinguish between traditional manufacturing and lean manufacturing.
2. Understanding and applying various lean methods.
3. Understanding and applying various lean tools.
4. Demonstrate to implement lean solutions and propose to solutions to sustain them.

5. Learn to reconcile lean with other systems.
6. Interpret and communicate the solution of the problem in organized manner.

**Course Content:**

**Module I: Introduction:** Seven forms of waste and their description; Historical evolution of lean manufacturing; Global competition, Customer requirements, Requirements of other stake holders, Meaning of Lean Manufacturing System (LMS), Meaning of Value and waste, need for LMS, Symptoms of underperforming organizations, Meeting the customer requirement, Elements of LMS.

**Module II: Primary Tools used in LMS I:** Meaning and Purpose of 5S Work place organization, 5S process – Sort, Set in order, Shine, Standardize, Sustain, Implementing 5S, Meaning and purpose of TPM, Pillars of TPM, Conditions for TPM success, TPM implementation process, Overall Equipment Effectiveness and problems on computation of OEE.

**Module III: Primary Tools used in LMS II:** Process Mapping and Value Stream Mapping (VSM) – Need for process maps, advantages, types and its construction, steps in preparing VSM; Concept of work Cell and its design, Line balancing algorithms and problems.

**Module IV: Secondary Tools used in LMS:** Cause and effect diagram, Pareto chart, Radar chart, Poke Yoke, Kanban, Automation, SMED, Standardized fixture, DFMA, JIT, Visual workplace, problems on Pareto analysis and computation of number of Kanban.

**Module V: LMS Rules:** Stability, Management, Standardized work, Pull system, Continuous improvement. Lean Implementation: Training, selecting the projects, preparing project charter, project implementation, Project review. Implementing LMS for higher productivity: Operator, process, machinery and equipment, workplace organization, Inventory, LMS Design Process.

**Text Books:**

1. N. Gopalakrishnan, Simplified Lean Manufacture, PHI, 2010.
2. Pascal Dennis, Lean Production Simplified, Productivity Press, 2007.

**References:**

1. Jeffrey Liker, The Toyota Way, Tata McGraw-Hill, 2004.

**Course Outcome(s):**

1. Understand the importance of Lean in Today's environment (interdisciplinary activities), clearly distinguish the problem statement and link with five lean principles, study for a system and identify the activities to value creation (VA, NVA and NNVA).
2. Examine the problem, analyse it and propose appropriate lean methods to solve it.
3. Demonstrate to propose appropriate tools for the given problems.
4. Design and develop a systematic plan to implement lean solutions for given problems.

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## **Miscellaneous Courses**



## Miscellaneous

Course Code	:	PEXXX
Course Title	:	Sensor Fusion
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Automotive Electrical and Electronics System

### **Course Objective(s):**

1. Exposed to data fusion for automotive applications in on-board and off board needs.
2. Understanding and applying various modelling techniques of sensor.
3. Understanding and applying various algorithms for sensor modelling.
4. Demonstrate to implement high performance data structures for sensor fusion.

### **Course Content:**

**Module I: Foundations of Data Fusion:** Sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data - Limitation of Data Fusion. Mathematical tools used: Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta – heuristics.

**Module II: Sensor Modelling:** Sensor types and classification- features of sensors-sensor management-situation assessment process- Bayesian Network Model-linear opinion pool- Independent Opinion Pool-Independent Likelihood Pool.

**Module III: Taxonomy of Algorithms for Multi-Sensor Data Fusion:** Data association and correlation. Process Model for Correlation, Positional Fusion Algorithms, Identity Fusion Algorithms, Hypothesis Generation, Hypothesis Evaluation, Hypothesis Selection Techniques, Ancillary Support Algorithms.

**Module IV: Decentralized Estimation for Multisensory Systems:** Multi Sensor Systems- Decentralized systems- Decentralized estimators - limitations of fully connected decentralization - Scalable decentralized estimation – Nodal transformation-distributed and decentralized Kalman and information filters.

**Module V: High Performance Data Structures:** Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system.

### **Text Books:**

1. David L. Hall, “Mathematical techniques in Multisensor data fusion”, Artech House, Boston, 1992.
2. R.R. Brooks and S.S.Iyengar, “Multisensor Fusion: Fundamentals and Applications with Software”, Prentice Hall Inc., New Jersey, 1998.

### **References:**

1. Arthur G.O. Mutambara, “Decentralized Estimation and Control for Multisensor Systems” First Edition, CRC Press; 1998.
2. H M Mitchell, “Data Fusion: Concepts and Ideas”, Second Edition, Springer, 2012.

3. Jitendra R. Raol, "Multi-sensor Data Fusion with MATLAB", First Edition, CRC Press; 2009.

**Course Outcome(s):**

1. Explain the principles and components of sensor fusion systems,
2. Identify and explain the differences between linear and nonlinear models and their implications on sensor fusion,
3. Construct models of multi-sensor systems and use least-squares algorithms for sensor fusion
4. Construct continuous- and discrete-time state-space models based on ordinary differential equations, difference equations, and physical sensor models,
5. Develop and compare state-space models and Kalman as well as particle filtering algorithms for solving sensor fusion problems.

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Course Code	:	PEXXX
Course Title	:	Vehicle Communication Systems
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Automotive Electrical and Electronics System

**Course Objective(s):**

To introduce the students with the emerging technologies and their standards with applications for vehicular communication systems

**Course Content:**

**Module I: Architectures for Vehicular Communication Systems:** Vehicle-to-infrastructure Communications-Performance of cellular Communication-System model for the evaluation of the impact of V2I communications on LTE resource utilization - Channel-aware V2I communications for efficient utilization of cellular resources.

**Module II: Vehicular AD HOC Networks Protocols, Algorithms, Routing and Information:** Introduction-General overview of VANETs-Primary applications - Enabling technologies - Technical challenges - Societal challenges.

**Module III: Medium Access Control in Vehicular AD HOC Networks:** Requirements and challenges-standards-MAC for Multichannel-Future trends-MAC for multichannel-QoS scheme in MAC.

**Module IV: Information Dissemination in Vehicular Networks:** Broadcast-based dissemination-Toward a next generation of beaconing systems - Multi-hop dissemination and store-carry-Forward-Cellular multicast.

**Module V: Broadcasting in Vehicular Networks:** System Design-Factors affecting Reliability-Improving reliability by considering traffic Patterns-Delay-tolerant networking in vehicular communication systems.



**Text Books:**

1. Wai Chen, " Vehicular Communications and Networks", Woodhead Publishing is an imprint of Elsevier, Cambridge, UK, 2015.
2. AnisLaouiti, Amir Ayyub, Mohamad Naufal Mohamad Saad, "Vehicular Ad-Hoc Networks for Smart Cities: Second International Workshop, 2016 (Advances in Intelligent Systems and Computing)" Springer, Berlin 2016.

**References:**

1. Marc Emmelmann, Bernd Bochow, C. Christopher Kellum, "Vehicular Networking- Automotive Applications and Beyond" John Wiley, UK, 2010.
2. Kan Zheng Lin Zhang Wei Xiang Wenbo Wang, "Heterogeneous Vehicular Networks", Springer Cham-Briefs in Electrical and Computer Engineering, Berlin, 2016.

**Course Outcome(s):**

1. Understand the basic principles, standards, and system architecture of Vehicular Ad-hoc Networks.
2. Study and analyse V2I and I2V for vehicle safety and enhanced operations.

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Course Code	:	PEXXX
Course Title	:	Alternative Sources of Energy
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Thermodynamics and Thermal Engineering

**Course Objective(s):** To know about different sources of alternate energy and use them based upon given conditions.

**Course Content:**

**Module I: Energy Demand and Supply:** Energy supply-fossil fuel- nuclear fuel-renewable –energy prices- OPEC-politics-energy reserves- resources- the finite life of a resource.

**Module II: Energy Storage:** Demand for Electricity- Need to Store Energy- Electromechanical Storage - Thermal Storage - Chemical Storage: Batteries- Hydrogen Storage: The Hydrogen Economy- Fuel Cells- High-Temperature Fuel Cells - Thermodynamic Losses and Fuel Cell Efficiency.

**Module III: Economics of Energy Projects:** Fundamental Concepts and Definitions- The Decision Making Process- The Time-Value of Money - Simple and Compound Interest- Cash Flow, Equivalence and Present Value - Cash Flow Calculations- Investment Appraisal Methods- NPV and Governmental Incentives or Disincentives.

**Module IV: Photovoltaic Power Plants:** Generation of electricity- output characteristics- dark-current electric parameters of a photovoltaic panel- model of a PV

panel consisting of n cells in parallel- electric power supply- economic analysis of solar energy.

**Module V: Fuel Cell Power Plants:** Practical issues related to fuel cell stacking- low- and high-temperature fuel cells- constructional features - proton exchange-membrane fuel cells-DMFC-Solid oxide- load curve peak shaving with fuel cells- Maximal Load curve flatness at constant output power- reformers, electrolyzer systems, and related precautions.

**Text Books:**

1. Gupta, O.P., Energy Technology, Khanna Publishing House, Delhi.
2. Michaelides E, "Alternate Energy Sources", Springer Heidelberg Dordrecht London New York-2012.
3. Faret F and Simoes, "Integration of Alternative Sources of Energy", Wiley and IEE, John Wiley & Sons, INC., Publication, 2006.

**References:**

1. Neresian, "Energy for the 21st Century: A comprehensive guide to Conventional and Alternatives Sources", Springer- Verlag Berlin Heidelberg,2012.
2. Mariano Martín," Alternative Energy Sources and Technologies: Process Design and Operation " Springer international Publishing, 2016.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Non-Conventional Energy Resources	Dr. Prathap Haridoss	IIT Madras

**Course Outcome(s):**

1. Comprehend demand and supply of energy and its role.
2. Choose appropriate energy storage based on their characteristics.
3. Assess the costs and benefits associated with energy projects.
4. Explain solar cells and fuel cells.

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Course Code	:	PEXXX
Course Title	:	Signals and Systems
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Automotive Electrical and Electronics System

**Course Objective(s):** The primary objective of this course is to provide a thorough understanding and analysis of signals and systems for sensors, controller and actuator signals of automotive systems.

**Course Content:**

**Module I: Signals and Systems:** Introduction –Continuous Time (CT) & Discrete Time (DT) signals –Signal operations -Basic CT & DT signals -Representation of signals using impulse function –Classification of CT & DT signals –CT &DT Systems –Basic System Properties.

**Module II: Linear Time Invariant Systems:** Discrete time LTI systems: Convolution Sum –Continuous time LTI systems: Convolution Integral –Properties of LTI systems – Unit step response of an LTI system –LTI systems described by linear constant-coefficient differential and difference equations.

**Module III: Fourier Analysis of CT Signals and Systems:** Response of LTI systems to complex exponentials -Representation of CT periodic signals by Continuous Time Fourier Series (CTFS) –Convergence of CTFS –Properties of CTFS -Representation of CT aperiodic signals by Continuous Time Fourier Transform (CTFT) –Convergence of CTFT –Fourier transform for CT periodic signals -Properties of CTFT -Frequency response of systems characterized by linear constant-coefficient differential equations.

**Module IV: Fourier Analysis of DT Signals and Systems:** Representation of DT periodic signals by Discrete Time Fourier Series (DTFS) -Properties of DTFS - Representation of DT aperiodic signals by Discrete Time Fourier Transform (DTFT) – Convergence of DTFT –Fourier transform for DT periodic signals -Properties of DTFT - Frequency response of systems characterized by linear constant-coefficient difference equations.

**Module V: Z-Transform Analysis of Signals and Systems:** z-transform –Properties of z-transform –Inverse z-transform –Long division, Partial fraction and Cauchy’s residue Methods –Stability and Causality in z domain –Analysis of systems characterized by linear constant-coefficient difference equations –Solution of difference equations with initial conditions.

**Text Books:**

1. Alan V Oppenheim, Alan S Wilsky, and S Hamid Nawab, “Signals and Systems”, PHI Learning Private Limited, New Delhi, 2010.
2. Dimitris G Manolakis and Vinay K. Ingle, “Applied Digital Signal Processing Theory and Practice”, Cambridge University Press, 2011.

**References:**

1. Simon Haykin and Barry Van Veen, “Signals and Systems”, Wiley India, New Delhi, 2010.
2. Samir S Soliman and Srinath M D, “Continuous and Discrete Signals and Systems”, Prentice Hall International, New Delhi, 2010.
3. Lathi B P, “Linear Systems and Signals”, Oxford University Press, Chennai, 2010.
4. Anand R, Signals & Systems, Khanna Publishing House.

### Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Signals and Systems	Prof. Kushal K. Shah	IISER Bhopal

### Course Outcome(s):

1. Represent & classify signals, Systems & identify LTI systems
2. Derive Fourier series for continuous time signals and find Fourier transform for different signals
3. Analyse the Continuous Time systems by performing Convolution
4. Understand Discrete-time systems and LTI systems.
5. Analyse DT systems & their realization using Z-transforms

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Course Code	:	PEXXX
Course Title	:	Automotive Testing
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Automotive Powertrain Automotive Chassis

### Course Objective(s):

1. Analyze the aero foil vehicle model by wind tunnel test.
2. Understand the testing procedure of vehicle body elements in improving the ride vibration.
3. Analyze the fuel consumption by road rest procedure for various driving cycles.
4. Understand the suspension and steering system procedure in directional control.
5. Analyze the energy consumption of wheels, brakes and cooling system.

### Course Content:

**Module I: Wind Tunnel Test:** Test requirements – ground boundary simulation-wind tunnel selection and Reynolds number capability, model requirements, model details, model mounting, test procedure. Crash test –types.

**Module II: Ride Vibration and Body Test:** Vibration measurement instrument – accelerometer and signal conditioning, graphical presentation. Dynamic simulation sled testing, methodology, vehicle acceleration measurement and documentation. Dolly roll over test, dolly roll over fixture, photographic / video coverage, instrumentation. Vehicle roof strength test – test procedure and test measurements. Door system crush test –procedure and measurements.

**Module III: Fuel Consumption Test:** Type I & II, test route selection, vehicle test speeds, cargo weights, driver selection, test data form, calculations. Test on rough terrain, pot holes with laden and unladen conditions.

**Module IV: Suspension and Stability for Directional Control:** Measurement of dimensional and geometric characteristics, measurement of centre of gravity position, measurement of moments and products of inertia, measurement of suspension kinematic characteristics, measurement of suspension elastic and coulomb friction characteristics, measurement of shock absorber characteristics.

**Module V: Steering Control System Directional Control Test:** Analysis of constant radius test, constant steer angle test, constant speed variable radius test, constant speed variable steer angle test, response gain test.

**Module VI: Wheels and Braking Performance Test:** Dynamic cornering fatigue, dynamic radial fatigue tests – procedure, bending moment and radial load calculations. Impact test – road hazard impact test for wheel and tyre assemblies, test procedures, failure criteria and performance criteria. Bumpers - types of tests, pendulum test, fixed collision barrier test, procedure, performance criteria. Air and hydraulic brake test, air brake actuator, valves test, performance requirements. Parking brake – drawbar pull test, grade holding test.

**Module VII: Energy Consumption Test:** Engine cooling fan, air conditioning and brake compressors, hydraulic pumps power consumption. Antilock brake systems energy consumption.

**Text Books:**

1. Crouse W.H. and Anglin D.L., “Automotive Mechanics” Tata McGraw Hill Publishing Company, 2004.
2. Rangan, Mani and Sharma, “Instrumentation”, Tata McGraw Hill Publishers, New Delhi, 2004.
3. Babu, A.K., “Automobile Mechanics”, Khanna Publishing House, Delhi.

**References:**

1. SAE Hand book, Vol. 3, SAE Publications, 2000.
2. Jain R K. “Mechanical and Industrial Measurements”, Khanna Publishers, Delhi, 1999.
3. Tim Gilles, “Automotive Service” Delmar Publishers, 1998.
4. Beckwith TG. and Buck N L., “Mechanical Measurements”, Addition Wesley Publishing Company Limited, 1995.

**Course Outcome(s):**

1. Analyze the aero foil vehicle model by wind tunnel test.
2. Understand the testing procedure of vehicle body elements in improving the ride vibration.
3. Analyze the fuel consumption by road rest procedure for various driving cycles.
4. Understand the suspension and steering system procedure in directional control.
5. Analyze the energy consumption of wheels, brakes and cooling system.

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Course Code	:	PEXXX
Course Title	:	Control Systems
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	Automotive Electrical and Electronics System

**Course Objective(s):**

1. To make students to understand the linear time invariant control systems.
2. To make students to analyze and evaluate the transfer function for typical automotive control systems.
3. To make students to understand concept of time domain and frequency domain analysis in control systems.
4. To make students to expose the typical software tool for analysis of control systems.

**Course Content:**

**Module I: Introduction and Mathematical Modelling:** - Introduction to control systems, differential equations of physical systems, dynamics of robotic mechanisms, transfer functions, block diagram algebra, signal flow graphs, feedback and non-feedback systems, reduction of parameter variations, control over dynamics, control effects of disturbances signals, linearizing effects, regenerative feedback- linear approximation of nonlinear systems, stepper motor and hydraulic systems.

**Module II: Time Response and Stability in Time Domain:** Standard test signals- time response of first order systems-time response of second-order systems, steady state errors and error constants- effects- effects of adding zero to systems- design specification of second order systems-design consideration for higher-order systems-performance indices- robotic control systems- state variable analysis- approximation of higher order systems by lower order systems- concept of stability- necessary conditions- Routh stability criterion-relative stability analysis.

**Module III: Frequency Response Analysis and Stability in Frequency Domain:** correlation between time domain and frequency response, polar plots and bode plots, all-pass and minimum pass systems, experimental determination of transfer functions, log magnitude versus phase plots, Nyquist stability criterion, assessment of relative stability, closed loop frequency response, sensitivity analysis.

**Module IV: Introduction to Design and State Variable Analysis and Design:** P, PI and PID controllers, cascade compensation in time domain and frequency, feedback compensation and robust control systems design- Concepts of state, state variables and state model, state models for linear continuous –time systems, state variables and linear discrete –time systems, solutions of state equations, concepts of controllability and observability, pole zero placement by state feedback.

**Module V: Non-Linear Systems:** Linearization- non-linear examples-non-linear state variable model- linear approximation through Taylor series- state estimation- introduction –Kalman Filter- examples-case studies.

**Text Books:**

1. Nagrath, I. J. and Gopal, M., “Control Systems Engineering”, New Age International Publishers, 2014.
2. Ogatta, K., “Modern Control Engineering”, Pearson/ Prentice Hall of India Pvt. Ltd., New Delhi, 2013.

**References:**

1. Nise, Norman. S., “Control Systems Engineering”, John Wiley and Sons Inc., 2012.
2. Ambikapathy, Control System, Khanna Publishing House.
3. Umez-Eronini, “System Dynamics & Control”, PWS Publishing Company, 1999.
4. Astrom,Karl. J., “Advance PID Controller Control”, Instrumentation Society of America, 1995.

**Alternative NPTEL/SWAYAM Course:**

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Control systems	Prof. C.S.Shankar Ram	IIT Madras

**Course Outcome(s):**

1. Distinguish open loop and feedback control systems. Determine the transfer function.
2. Analysis of time and frequency domain control systems parameters.
3. Evaluate the control systems for stability characteristics.
4. Predict the control systems characteristics for assessment.
5. Determine matrix for function for multiple input multiple output systems.

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Course Code	:	PEXXX
Course Title	:	Automotive Energy Sources
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	-

**Course Content:**

**Module I: Energy Demand and Supply:** Energy supply-fossil fuel- nuclear fuel-renewable –energy prices- OPEC-politics-energy reserves- resources- the finite life of a resource.

**Module II: Energy Storage:** Demand for Electricity- Need to Store Energy- Electromechanical Storage - Thermal Storage - Chemical Storage: Batteries- Hydrogen Storage: The Hydrogen Economy- Fuel Cells- High-Temperature Fuel Cells - Thermodynamic Losses and Fuel Cell Efficiency.

**Module III: Economics of Energy Projects:** Fundamental Concepts and Definitions- The Decision Making Process- The Time-Value of Money - Simple and Compound Interest- Cash Flow, Equivalence and Present Value - Cash Flow Calculations- Investment Appraisal Methods- NPV and Governmental Incentives or Disincentives.

**Module IV: Photovoltaic Power Plants:** Generation of electricity- output characteristics- dark-current electric parameters of a photovoltaic panel- model of a PV panel consisting of n cells in parallel- electric power supply- economic analysis of solar energy.

**Module V: Power Plant Fuel Cells:** Practical issues related to fuel cell stacking- low- and high-temperature fuel cells- constructional features - proton exchange-membrane fuel cells-DMFC-Solid oxide- load curve peak shaving with fuel cells- Maximal Load curve flatness at constant output power- reformers, electrolyzer systems, and related precautions.

**TEXT BOOKS:**

1. Michaelides E, “Alternate Energy Sources”, Springer Heidelberg Dordrecht London New Yor-2012.
2. Faret F and Simoes, “Integration of Alternative Sources of Energy”, Wiley and IEE, John Wiley & Sons, INC., Publication, 2006.

**REFERENCES:**

1. Neresian, “Energy for the 21st Century: A comprehensive guide to Conventional and Alternatives Sources”, Springer- Verlag Berlin Heidelberg,2012.
2. Mariano Martín,“ Alternative Energy Sources and Technologies: Process Design and Operation ” Springer international Publishing, 2016.

**Course Outcome(s):**

1. Explain energy demand and supply.
2. Identify different alternate energy storage techniques.
3. Evaluate economic feasibility of energy projects.
4. Explain photovoltaic panels and powerplants.
5. Describe different types of fuel cells.

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Course Code	:	PEXXX
Course Title	:	Autonomous and Connected Vehicles
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	-

**Course Content:**



**Module I: Introduction:** Requirements and level of autonomous, sensors, hardware software, safety assurance and modelling vehicle dynamics, Connected Vehicles in the IoV.

**Module II: State Estimation and Localization:** least squares, linear and non-linear Kalman filters, GNSS/INS SENSING for pose estimation, LIDAR sensing, Autonomous Vehicle State Estimator, Spatial Intelligence and vehicle-to-vehicle communication.

**Module III: Visual Perception:** Basics of 3D computer vision, visual features - detection, description and matching, feedforward neural networks, 2d object detection, semantic segmentation, perception of dynamic objects in the drivable region

**Module IV: Motion Planning:** The planning problem, Mission planning in driving environments, dynamic object interactions, principles of behaviour planning, reactive planning in static environments

**CASE STUDY:** Volvo platoon, Google waymo, Tesla Auto pilot, Simulation experiments, Artificial intelligence and blockchain operations in Connected and Autonomous vehicles.

**TEXTBOOKS:**

1. Jurgen,Ronald. K. (edited), "Autonomous Vehicle for Safer Driving", SAE International, Warrendale Pennsylvania, USA, 2013.
2. Fossen,Thor. I., Pettersen,Kristin. Y. and Nijmeijer, Henk., "Sensing and Control for Autonomous Vehicles-Applications to Land, Water and Air Vehicles" Springer International Publishing AG 2017.
3. Zaigham Mahmood, "Connected Vehicles in the Internet of Things: Concepts, Technologies and Frameworks for the IoV", Springer Nature, 2020.

**REFERENCES:**

1. Fridman, Alex., Jenik, Benedikt., Reimer, Bryan., "Arguing Machines: Perception-Control system Redundancy and edge case discovery in real- world autonomous driving",ArXiv,2017.
2. Maurer, Markus., Gerdes, NaitsirhC .J. and Znel , Barbara., "Autonomous Driving- Technical, Legal and social aspects", Springer Daimler und Benz- Stiftung, Ladenburg 2015.
3. Yunpeng Wang, Daxin Tian, Zhengguo Sheng, Wang Jian, "Connected Vehicle Systems: Communication, Data, and Control", CRC Press, 2017.

**Course Outcome(s):**

1. Enumerate requirements, levels, hardware and software in autonomous vehicles.
2. Estimate vehicle state based on available data.
3. Describe various 2D and 3d computer vision features and techniques.
4. Develop motion plan for the vehicle based on the environment, behaviour and interaction of objects.
5. Describe available technologies through case studies and applications of AI and blockchain in autonomous and connected vehicles.

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Course Code	:	PEXXX
Course Title	:	Automotive Materials
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	-

### Course Content:

**Module I: Introduction:** Metals, ceramics, glasses, elastomers, polymers, composites, smart materials, members of each class, MEMS, nano science materials, and shape memory alloys. Properties of engineering materials - mechanical, thermal, wear, corrosion / oxidation. Materials for automobile industry – auto body, engine components and other accessories. Materials for intelligent system.

**Module II: Ferrous Alloys:** Iron carbon phase diagram. Steels – effects of alloying elements, types of steels, composition, structure and properties. Cast Iron – effects of alloying elements, types of cast iron, properties, structures, compositions and applications. Castability, formability, machinability, hardenability and weldability of the ferrous materials. Stainless steels, high temperature steels and super alloys.

**Module III: Non Ferrous Alloys:** Alloys of copper, aluminium, nickel, magnesium, titanium, lead, tin, zinc - compositions, heat treatments, structures, properties, applications, castability, formability, machinability, hardenability and weldability.

**Module IV: Composites:** Types of composites, volume fraction - lamellar composites production and properties of whiskers of silicon carbide, graphite, fibres of zirconia, alumina and boron nitride - metal filaments - boron filaments - glass fibres applications.

**Module V: Material Property Charts and Material Selection:** Modulus - density, strength – density, modulus – strength, specific stiffness and specific strength, fracture toughness, modulus fracture etc. Selection strategy, property limits and material indices, function objectives and constraints, performance maximizing criteria. Shape factors, elastic extrusion, elastic body and twisting, failure, bending and twisting, axial loading and column buckling, efficiency of standard sections, material limits for shape factors, microscopic shape and shape factors.

### REFERENCES:

1. Michael F Ashby, “Materials Selection in Mechanical Design”, Butterworth Heinemann, 2005.
2. Myer Kutz, “Handbook of Materials Selection” , John Wiley and Sons, New York, 2002.
3. Daniel Yesudian C, “Materials Science and Metallurgy”, Scitech Publications (India), 2004. 4. Van Vlack L H, "Elements of Materials Science and Engineering", Addison wesley, New York, 1991.
4. Guy A G, “Elements of Physical Metallurgy”, Oxford & IBH Pub. Co., 1990.

**Course Outcome(s):**

1. Describe different materials, their properties and applications in automobile industry.
2. Explain the properties, types and applications of ferrous alloys.
3. Explain the properties, types and applications of non-ferrous alloys.
4. Explain the properties, types and applications of composite materials.
5. Select appropriate material for the given application based on material properties.

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Course Code	:	PEXXX
Course Title	:	Two and Three Wheeler Technology
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	PE
Pre-requisites	:	-

**Course Content:**

**Module I: Introduction:** TWO WHEELERS: Types- standard class, touring class, sports bike, cruisers class, off road class. Main frame, types- tubular steel frame, diamond, cradle, backbone, underbone, trellis frame. THREE WHEELERS: Types- passenger carrier, goods carrier and its features. Main components of three wheeler.

**Module II: Power Unit For Two & Three Wheelers:** Two stroke SI engine-components, principle of operation, Types of two stroke engine: based on scavenging method- crank case, separately scavenged engine, based on scavenging process- cross flow, loop flow (MAN, Schnuerle, Curtis type), uni -flow (opposed piston, poppet valve, sleeve valve), based on overall port timing- symmetrical and unsymmetrical diagrams. Scavenging –efficiency, pumps. Reed valve, Rotary disc valve engine, fuel system, lubrication system, air and water cooling system, magneto coil and battery coil spark ignition system, electronic ignition system, variable timing ignition system (VTI), starting systems-kick starter, electric starting.

**Module III: Transmission & Suspension Systems For Two & Three Wheeler:** Multiple and centrifugal clutches, gear box, gear shift mechanism, Final drive- shaft drive and chain drive. Front suspension-Head stock mounted forks, leading link, Trailing link, Telescopic forks, rear suspension- conventional dual spring /damper type, prolink progressive type, Pro arm type, torsion bar, leaf spring.

**Module IV: Sub-Systems For Two & Three Wheelers:** Panel meters and controls on handle bar, Controls on foot. Electrical systems lights- replaceable bulb, sealed beam, tail light and stop light, turn signal lights, horn, fuses. Drum brakes- Brake lever, wheel brake mechanism-single leading shoe, double leading shoe brakes, disc brakes- master cylinder calliper assemble, disc, brake fluid, front and rear brake links layouts. Wheels& Tyres - spoked wheel, cast wheel, disc wheel, tyre construction, tubed and tubeless tyre, composite wheel construction, split rim wheel.

**Module V: Service And Maintenance:** Servicing and maintenance of carburetor, spark plug cleaning, ignition timing adjustment, gear box, steering head, shaft and chain drive, suspension, brake servicing and adjustment. Periodic maintenance schedules.

**TEXT BOOKS:**

1. Irving P.E, "Motor cycle engineering", Temple Press Book, London, 1992.
2. Giri N.K, "Automobile Mechanics", Khanna Publishers, New Delhi, 2006.

**REFERENCES:**

1. "The cycle Motor Manual", Temple Press Ltd, 1990.
2. "Encyclopedia of Motor Cycling 20 Volumes", Marshall Cavensih, New York and London, 1989.
3. Raymond Board, Lambretta, "A Practical Guide to Maintenance and Repair", 1987.
4. Ganesan V, "Internal Combustion Engines" Tata McGraw Hill, New Delhi, 2003.

**Course Outcome(s):**

1. Describe different types of two wheelers and three wheelers.
2. Explain the working, components and accessories of two and three wheeler power units.
3. Describe the transmission and suspension system of two and three wheelers.
4. Describe meters, controls, brakes, wheels and tyres for two and three wheelers.
5. Explain the procedure for servicing and maintenance of different components used in two and three wheelers.

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# **Appendix – III**

## **A Guide to Induction Program**



# Appendix – III: A Guide to Induction Program

## 1. Introduction

*(Induction Program was discussed and approved for all colleges by AICTE in March 2017. It was discussed and accepted by the Council of IITs for all IITs in August 2016. It was originally proposed by a Committee of IIT Directors and accepted at the meeting of all IIT Directors in March 2016.<sup>1</sup> This guide has been prepared based on the Report of the Committee of IIT Directors and the experience gained through its pilot implementation in July 2016 as accepted by the Council of IITs. Purpose of this document is to help institutions in understanding the spirit of the accepted Induction Program and implementing it.)*

Engineering colleges were established to train graduates well in the branch/department of admission, have a holistic outlook, and have a desire to work for national needs and beyond.

The graduating student must have knowledge and skills in the area of his study. However, he must also have broad understanding of society and relationships. Character needs to be nurtured as an essential quality by which he would understand and fulfill his responsibility as an engineer, a citizen and a human being. Besides the above, several meta-skills and underlying values are needed.

There is a mad rush for engineering today, without the student determining for himself his interests and his goals. This is a major factor in the current state of demotivation towards studies that exists among UG students.

The success of gaining admission into a desired institution but failure in getting the desired branch, with peer pressure generating its own problems, leads to a peer environment that is demotivating and corrosive. Start of hostel life without close parental supervision at the same time, further worsens it with also a poor daily routine.

To come out of this situation, a multi-pronged approach is needed. One will have to work closely with the newly joined students in making them feel comfortable, allow them to explore their academic interests and activities, reduce competition and make them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and build character.

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<sup>1</sup>A Committee of IIT Directors was setup in the 152nd Meeting of IIT Directors on 6th September 2015 at IIT Patna, on how to motivate undergraduate students at IITs towards studies, and to develop verbal ability. The Committee submitted its report on 19th January 2016. It was considered at the 153rd Meeting of all IIT Directors at IIT Mandi on 26 March 2016, and the accepted report came out on 31 March 2016. The Induction Program was an important recommendation, and its pilot was implemented by three IITs, namely, IIT(BHU), IIT Mandi and IIT Patna in July 2016. At the 50th meeting of the Council of IITs on 23 August 2016, recommendation on the Induction Program and the report of its pilot implementation were discussed and the program was accepted for all IITs.

## 2. Induction Program

When new students enter an institution, they come with diverse thoughts, backgrounds and preparations. It is important to help them adjust to the new environment and inculcate in them the ethos of the institution with a sense of larger purpose. Precious little is done by most of the institutions, except for an orientation program lasting a couple of days.

We propose a 3-week long induction program for the UG students entering the institution, right at the start. Normal classes start only after the induction program is over. Its purpose is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, create bonding in the batch as well as between faculty and students, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.<sup>2</sup>

The time during the Induction Program is also used to rectify some critical lacunas, for example, English background, for those students who have deficiency in it.

The following are the activities under the induction program in which the student would be fully engaged throughout the day for the entire duration of the program.

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<sup>2</sup>Induction Program as described here borrows from three programs running earlier at different institutions: (1) Foundation Program running at IIT Gandhinagar since July 2011, (2) Human Values course running at IIT Hyderabad since July 2005, and (3) Counselling Service or mentorship running at several IITs for many decades. Contribution of each one is described next.

*IIT Gandhinagar was the first IIT to recognize and implement a special 5-week Foundation Program for the incoming 1st year UG students. It took a bold step that the normal classes would start only after the five week period. It involved activities such as games, art, etc., and also science and other creative workshops and lectures by resource persons from outside.*

*IIT Hyderabad was the first one to implement a compulsory course on Human Values. Under it, classes were held by faculty through discussions in small groups of students, rather than in lecture mode. Moreover, faculty from all departments got involved in conducting the group discussions under the course. The content is non-sectarian, and the mode is dialogical rather than sermonising or lecturing. Faculty were trained beforehand, to conduct these discussions and to guide students on issues of life.*

*Counselling at some of the IITs involves setting up mentor-mentee network under which 1st year students would be divided into small groups, each assigned a senior student as a student guide, and a faculty member as a mentor. Thus, a new student gets connected to a faculty member as well as a senior student, to whom he/she could go to in case of any difficulty whether psychological, financial, academic, or otherwise. The Induction Program defined here amalgamates all the three into an integrated whole, which leads to its high effectiveness in terms of building physical activity, 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 a senior student besides a faculty member.*

*Scaling up the above amalgamation to an intake batch of 1000 plus students was done at IIT(BHU), Varanasi starting from July 2016.*



## **2.1. Physical Activity**

This would involve a daily routine of physical activity with games and sports. It would start with all students coming to the field at 6 am for light physical exercise or yoga. There would also be games in the evening or at other suitable times according to the local climate. These would help develop team work. Each student should pick one game and learn it for three weeks. There could also be gardening or other suitably designed activity where labour yields fruits from nature.

## **2.2. Creative Arts**

Every student would choose one skill related to the arts whether visual arts or performing arts. Examples are painting, sculpture, pottery, music, dance etc. The student would pursue it every day for the duration of the program.

These would allow for creative expression. It would develop a sense of aesthetics and also enhance creativity which would, hopefully, flow into engineering design later.

## **2.3. Universal Human Values**

It gets the student to explore oneself and allows one to experience the joy of learning, stand up to peer pressure, take decisions with courage, be aware of relationships with colleagues and supporting staff in the hostel and department, be sensitive to others, etc. Need for character building has been underlined earlier. A module in Universal Human Values provides the base.

Methodology of teaching this content is extremely important. It must not be through do's and don'ts, but get students to explore and think by engaging them in a dialogue. It is best taught through group discussions and real life activities rather than lecturing. The role of group discussions, however, with clarity of thought of the teachers cannot be over emphasized. It is essential for giving exposure, guiding thoughts, and realizing values.

The teachers must come from all the departments rather than only one department like HSS or from outside of the Institute. Experiments in this direction at IIT(BHU) are noteworthy and one can learn from them.<sup>3</sup>

Discussions would be conducted in small groups of about 20 students with a faculty mentor each. It is to open thinking towards the self. Universal Human Values discussions could even continue for rest of the semester as a normal course, and not stop with the induction program.

Besides drawing the attention of the student to larger issues of life, it would build relationships between teachers and students which last for their entire 4-year stay and possibly beyond.

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<sup>3</sup>The Universal Human Values Course is a result of a long series of experiments at educational institutes starting from IIT-Delhi and IIT Kanpur in the 1980s and 1990s as an elective course, NIT Raipur in late 1990s as a compulsory one-week off campus program. The courses at IIT(BHU) which started from July 2014, are taken and developed from two compulsory courses at IIIT Hyderabad first introduced in July 2005.

## 2.4. Literary

Literary activity would encompass reading, writing and possibly, debating, enacting a play etc.

## 2.5. Proficiency Modules

This period can be used to overcome some critical lacunas that students might have, for example, English, computer familiarity etc. These should run like crash courses, so that when normal courses start after the induction program, the student has overcome the lacunas substantially. We hope that problems arising due to lack of English skills, wherein students start lagging behind or failing in several subjects, for no fault of theirs, would, hopefully, become a thing of the past.

## 2.6. Lectures by Eminent People

This period can be utilized for lectures by eminent people, say, once a week. It would give the students exposure to people who are socially active or in public life.

## 2.7. Visits to Local Area

A couple of visits to the landmarks of the city, or a hospital or orphanage could be organized. This would familiarize them with the area as well as expose them to the under privileged.

## 2.8. Familiarization to Dept./Branch & Innovations

The students should be told about different method of study compared to coaching that is needed at IITs. They should be told about what getting into a branch or department means what role it plays in society, through its technology. They should also be shown the laboratories, workshops & other facilities.

## 3. Schedule

The activities during the Induction Program would have an Initial Phase, a Regular Phase and a Closing Phase. The Initial and Closing Phases would be two days each.

### 3.1. Initial Phase

Day	Time	Activity
Day 0	Whole Day	Students Arrive – Hostel Allotment (Preferably do pre-allotment)
Day 1	09:00 AM – 03:00 PM	Academic Registration
	04:30 PM – 06:00 PM	Orientation
Day 2	09:00 AM – 10:00 AM	Diagnostic test (for English etc.)
	10:00 AM – 12:25 PM	Visit to respective depts.
	12:30 PM – 01:55 PM	Lunch
	02:00 PM – 02:55 PM	Director's address
	03:00 PM – 03:30 PM	Interaction with parents
	03:30 PM – 05:00 PM	Mentor-Mentee Groups - Introduction within group. (Same as Universal Human Values Group)

### 3.2. Regular Phase

After two days is the start of the Regular Phase of Induction. With this phase there would be regular program to be followed every day.

#### 3.2.1. Daily Schedule

Some of the activities are on a daily basis, while some others are at specified periods within the Induction Program. We first show a typical daily timetable.

##### DAY 3 Onwards

Session	Time	Activity	Remarks
	06:00 AM	Wake up Call	
I	06:30 AM – 07:10 AM	Physical Activity (Mild Exercise / Yoga)	
	07:15 AM – 08:55 AM	Bath, Breakfast etc.	
II	09:10 AM – 10:55 AM	Creative Arts / Universal Human Values	Half the groups do creative arts
III	11:00 AM – 12:55 PM	Creative Arts / Universal Human Values	Complementary Alternate Groups
	01:00 PM – 02:25 PM	Lunch	
IV	02:30 PM – 03:55 PM	Afternoon Session	See below
V	04:00 PM – 05:00 PM	Afternoon Session	See below
	05:00 PM – 05:25 PM	Break / Light Tea	
VI	05:30 PM – 06:45 PM	Games / Special Lectures	
	06:50 PM – 08:25 PM	Rest and Dinner	
VII	08:30 PM – 09:25 PM	Informal Interactions (In hostels)	

Sundays are off. Saturdays have the same schedule as above or have outings.

#### 3.2.2. Afternoon Activities (Non-Daily)

The following five activities are scheduled at different times of the Induction Program, and are not held daily for everyone:

1. Familiarization to Dept./Branch & Innovations
2. Visits to Local Area
3. Lectures by Eminent People
4. Literary
5. Proficiency Modules

Here is the approximate activity schedule for the afternoons (may be changed to suit local needs):

Session	Activity	Remarks
IV	Familiarization with Dept./Branch & Innovations	For 3 Days (Day 3 to Day 5)
IV, V and VI	Visit to Local Area	For 3 Days – interspersed (e.g. Saturdays)

IV	Lectures by Eminent People	As scheduled 3-5 lectures
IV	Literary (Play / Literature / Book Reading)	For 3-5 Days
V	Proficiency Modules	Daily, but only for those who need it.

### 3.3. Closing Phase

Day	Time	Activity
Last But One Day	08:30 AM – 12:00 PM	Discussions and finalization of presentation within each group
	02:00 AM -05:00 PM	Presentation by each group in front of 4 other groups besides their own (about 100 students)
Last Day	Whole Day	Examinations (if any). May be extended to last 2 days, in case needed.

### 3.4. Follow Up after Closure

A question comes up as to what would be the follow up program after the formal 3-week Induction Program is over? The groups which are formed should function as mentor- mentee network. A student should feel free to approach his faculty mentor or the student guide, when facing any kind of problem, whether academic or financial or psychological etc. (For every 10 undergraduate first year students, there would be a senior student as a student guide, and for every 20 students, there would be a faculty mentor.) Such a group should remain for the entire 4-5-year duration of the stay of the student. Therefore, it would be good to have groups with the students as well as teachers from the same department/discipline<sup>4</sup>.

Here we list some important suggestions which have come up and which have been experimented with:

#### 3.4.1. Follow Up after Closure – Same Semester

It is suggested that the groups meet with their faculty mentors once a month, within the semester after the 3-week Induction Program is over. This should be a scheduled meeting shown in the timetable. (The groups are of course free to meet together on their own more often, for the student groups to be invited to their faculty mentor's home for dinner or tea, nature walk, etc.)

#### 3.4.2. Follow Up – Subsequent Semesters

It is extremely important that continuity be maintained in subsequent semesters. It is suggested that at the start of the subsequent semesters (up to fourth semester), three days be set aside for three full days of activities related to follow up to Induction Program. The students be shown inspiring films, do collective art work, and group discussions be conducted. Subsequently, the groups should meet at least once a month.

#### **4. Summary**

Engineering institutions were set up to generate well trained manpower in engineering with a feeling of responsibility towards oneself, one's family, and society. The incoming undergraduate students are driven by their parents and society to join engineering without understanding their own interests and talents. As a result, most students fail to link up with the goals of their own institution.

The graduating student must have values as a human being, and knowledge and meta-skills related to his/her profession as an engineer and as a citizen. Most students who get demotivated to study engineering or their branch, also lose interest in learning.

The Induction Program is designed to make the newly joined students feel comfortable, sensitize them towards exploring their academic interests and activities, reducing competition and making them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and building of character.

The Universal Human Values component, which acts as an anchor, develops awareness and sensitivity, feeling of equality, compassion and oneness, draw attention to society and nature, and character to follow through. It also makes them reflect on their relationship with their families and extended family in the college (with hostel staff and others). It also connects students with each other and with teachers so that they can share any difficulty they might be facing and seek help.

#### **References:**

Motivating UG Students Towards Studies, Rajeev Sangal, IITBHU Varanasi, Gautam Biswas, IIT Guwahati, Timothy Gonsalves, IIT Mandi, Pushpak Bhattacharya, IIT Patna, (Committee of IIT Directors).  
31 March 2016, IIT Directors' Secretariat, IIT Delhi.

**Contact:** Prof. Rajeev Sangal, Director, IIT(BHU), Varanasi ([director@iitbhu.ac.in](mailto:director@iitbhu.ac.in)).

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