CURRICULUM & SYLLABUS

(Applicable to B.E. Part-Time Mechanical Engineering Programmes)

With effect from AY-2024-25

DEPARTMENT OF MECHANICAL ENGINEERING

SRI CHANDRASEKHARENDRA SARASWATHI VISWA MAHAVIDYALAYA

SCSVMV

(Deemed to be University U/S 3 of UGC Act 1956)

Accredited with "A" Grade by NAAC

Enathur, Kanchipuram – 631 561

REGULATIONS 2024

These regulations are applicable to the students admitted from the AY 2024-25 onwards.

➢ PRELIMINARY DEFINITIONS AND NOMENCLATURE

- "**Degree**" referred to as Under-Graduate (UG) Degree, i.e., B.E. Degree.
- **"**Programme" referred to as discipline of B.E. Degree programme like Mechanical Engineering.
- **"Course"** referred to as a theory/practical subject studied in a semester.

➢ ELIGIBILITY FOR ADMISSION

- Diploma in the relevant Discipline / Field / Programme.
- Minimum of Two years Full Time work experience in a registered Firm / Company / Industry / Educational / Government / Autonomous organizations in the relevant field in which admission sought .

➢ STRUCTURE OF PROGRAMMES

1. Categorization of Courses

Each B.E., (Part Time) programme will have a curriculum with syllabi comprising of Theory and Practical courses with well-defined Program Outcomes and Programme Educational Objectives (PEO) as per Outcome Based Education (OBE). The content of each course is designed based on the Course Outcomes (CO). The courses of a programme are categorized as follows:

- **Basic Science Courses (BSC)** include Mathematics, Physics, Chemistry, Biology, Environmental Sciences, etc.
- **Engineering Science Courses (ESC)** include Engineering Practices, Engineering Graphics, Basics of Electrical / Electronics / Mechanical / Computer Engineering, Instrumentation etc.
- **Professional Core Courses (PCC)** include the core courses relevant to the Mechanical Engineering & chosen specialization.
- **Professional Core Elective Courses (PCEC)** include the elective courses relevant to the chosen specialization.

- **Professional Specialised Courses (PSC)** include the specialised courses relevant to the chosen specialization.
- **Humanities and Social Sciences including Management courses (HSMC) & Open Electives Courses (OEC)** provide an opportunity to study a course from any discipline that includes the courses relevant to the chosen specialization. The student can choose from the curriculum of other B.E. / B. Tech. programmes and the courses offered by the Departments under the Faculty of Science and Humanities.
- **Project Mechanical Engineering courses (PROJ-ME)**
- **Mandatory Courses (MC) non-credit courses such as** Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge

2. Number of courses per semester

The Curriculum of a semester shall normally have a blend of 4 to 5 lecture courses, except the final semesters, and 1-2 laboratory courses. However, the total number of courses per semester shall not exceed 7. Pre-final semester may have 1 design Project. The final semester may have a blend of 2 or 3 lecture courses and 1 innovative Project.

3. Credit Assignment

In assigning the credits for the courses, 1-hour lecture/week, 1-hour tutorial/week, 2 hours practical/week, 2 hours project work or seminar/week is equivalent to 1 credit.

4. Medium of Instruction

The medium of instruction is English for all courses.

DURATION OF THE PROGRAMMES

1. A student is normally expected to complete the B.E. (Part time) Programme in 3 years 6 Months (7 Semesters), but in any case, not more than 7 years (14 Semesters).
2. Each semester shall normally consist of 90 working days (including examination days). The Head of the Department shall ensure that every faculty imparts instruction as per the number of periods specified in the syllabus, covering the full content of the syllabus for the course being taught.

3. The total duration for completion of the programme reckoned from the commencement of the first semester to which the student was admitted shall not exceed the maximum duration irrespective of the period of break of study.

COURSE ENROLLMENT AND REGISTRATION

1. Student, on admission, shall be assigned to a Faculty Advisor, who shall advice and counsel the student about the details of the academic programme and the choice of courses, considering the student's academic background and career objectives.
2. After registering for a course, a student shall attend the classes, satisfy the attendance requirements, earn continuous assessment marks and appear for the end semester examinations.
3. Each student on admission shall register for all the courses prescribed in the curriculum.
4. If a student fails to secure a pass in any theory or Laboratory course (including elective theory), he/she shall register for the same course in the immediate semester examinations by retaining the Continuous Assessment Marks already earned.
5. The student shall register Design and Fabrication Project in VI Semester and Project Work in VII Semester.
6. The student who fails in any Project work shall register for the course again. In this case, the student shall attend the reviews and fulfil the attendance requirements.

REQUIREMENTS FOR APPEARING FOR THE END SEMESTER EXAMINATION

1. Student who has fulfilled the following conditions shall be deemed to have satisfied the attendance requirements for appearing for the end semester examination of a particular course.
2. Ideally every student is expected to attend all periods and earn 100% attendance. However, the student shall secure not less than 80% attendance, course wise, taking into account the number of periods required for that course, as specified in the curriculum.
3. If a student secures attendance between 70% and less than 80% in any course in the current semester, due to medical reasons (hospitalization / accident / specific illness)

or due to participation in the College / University / State / National / International level Sports events, with prior permission from the Sports director, and Head of the Department concerned, the student shall be given exemption from the prescribed attendance requirement and the student shall be permitted to appear for the end semester examination of that course.

4. In all such cases, the students should submit the required documents on joining after the absence to the Head of the Department through the Faculty Advisor.
5. A student with an attendance between 40% and 70% in any course will fall under the category **"Semester Break"**, which means Students will not be permitted to attend the Regular End Semester Examinations for that course. If a student has short fall of attendance in all the registered courses in "Semester Break", he/she would be permitted to move to the higher semester and has to repeat the current semester in the subsequent semester.
6. The student, whose attendance falls below 40% for a course in any semester, will be categorized as **"Detained"**, which means detained in the particular course for want of attendance and they will not be permitted to write the End semester exam for that course. Students will be asked to repeat the same course in the next year.
7. A student who has already appeared for a course in a semester and passed the examination is not entitled to reappear for the same course for improvement of grades.

FACULTY ADVISOR

To help the students in planning their courses of study and for general advice on the academic programme, the Head of the Department of the students will attach a certain number of students to a faculty of the Department, who shall function as Faculty Advisor for those students throughout their period of study. The Faculty Advisor shall advise the students in registering and reappearance (Arrear) registering of courses, authorize the process, monitor their attendance and progress and counsel them periodically. If necessary, the Faculty Advisor may also discuss with or inform the parents about the progress / performance of the students concerned.

CLASS COMMITTEE

The objective of the Class Committee is to improve the teaching-learning process. The functions of the class committee include:

1. Resolving difficulties experienced by students in the classroom and in the laboratories.
2. Clarifying the regulations of the degree programme and the details of rules therein.
3. Discussing the progress of academic schedule and deviations if any.
4. Evaluating the performance of the students of the class after each test and finding the ways and means of improvement.
5. Class committee consisting of faculty members who are teaching in that class, student representatives and a Head of the Department
6. The class committee shall meet 2-3 times in a semester as specified in the academic calendar. The Dean (Engg. & Tech) may participate in any class committee of the institution.
7. During these meetings, the representative of the class shall meaningfully interact and express the opinions and suggestions of the other students of the class to improve the effectiveness of the teaching-learning process.
8. The Head of the Department is required to prepare the minutes of the meeting, signed by the members and submit the same to Dean. In each meeting, the action taken report of the previous meeting is to be presented by the HOD.

SYSTEM OF EXAMINATION

Performance in each course of study shall be evaluated for a maximum of 100 marks based on one of the following:

1. Continuous assessment throughout the semester and a terminal examination at the end of the semester. The continuous assessment will carry 40 marks while the end-semester examination will carry 60 marks.
2. The end semester examination (Theory & Practical) of 3 hours duration shall be conducted by the Controller of Examinations between October to December during the Odd Semesters and between April to May during the Even semesters. All Practical examinations shall be conducted and evaluated at the Department itself on behalf of the Controller of Examinations.

3. For all the practical courses, students shall obtain bonafide certificate for the Observation cum Record completed from the Faculty in-charges / Head of the Department on or before the day of the practical examination.
4. For the project works, students shall obtain bonafide certificate for the project work completed from the project Guide and Head of the Department, at the end of the semester.
5. The semester examination for project work shall comprise of evaluation of the final report submitted by the project group (of not exceeding 4 students) by an external examiner. Further, the performance of each student of the project group would be evaluated in a viva-voce examination conducted by a committee consisting of an external examiner appointed by the Head of the Department/the Controller of Examination, Head of the Department or faculty nominated by Head of the Department and Guide of the project group.
6. Student can apply for re-valuation of his/her semester examination answer paper in theory courses within the stipulated period from the declaration of results, on payment of a prescribed fee, as specified by the Controller of Examinations from time to time. The Controller of Examination will arrange for going through the answer scripts by the students and to make appeals. The re-valuation results will be published before the commencement of supplementary examinations. Re-valuation is not permitted for practical courses, project work and industry supported courses.

PROCEDURE FOR AWARDING MARKS FOR CONTINUOUS ASSESSMENT

1. Theory courses

1. The award of marks for continuous assessment shall be normally based on two internal assessment tests and five Assignments / tutorials / seminars. The apportioning of marks shall be as follows:
    - 30 marks for tests
    - 10 marks for assignments/tutorials/seminars/Attendance

    However, the assessment pattern for awarding the continuous assessment marks may be designed by the course designers based on the nature of the course and is to be approved by the Academic Council.

2. The first and second Continuous Assessment Tests will be normally conducted at the mid and end of the semester respectively. Each test carries maximum of 30 marks.
3. There will be five assignments for each course which will be considered for awarding marks for assignment.
4. Both test and assignment marks put together is 40 marks maximum.
5. If a student fails in a theory course, the Continuous Assessment Marks already earned will be retained for subsequent reappearances.

2. Practical courses

The continuous assessment mark will be awarded as follows:

Observation-cum-Record in regular class works	: **15 marks**
Model Test	: **15 marks**
Viva	: **10 marks**

3. Project work

Head of the Department shall constitute a review committee comprises of Head of the Department or Faculty member nominated by Head of the Department and two faculty members. The student shall make presentation on the progress made by him / her before the committee. The total marks obtained in the three reviews shall be averaged to 40 marks.

- Every faculty member is required to maintain an Attendance and Continuous Assessment Record which consists of attendance marked for each lecture or practical or project work classes, the tests & assignment marks and record of class works (topics covered) separately for each course.

ELIGIBILITY FOR PASS IN EACH COURSE

1. A student who secures not less than 50% of total marks (both continuous assessment and end semester examination marks put together) in theory courses, practical courses shall be declared to have passed the examination.
2. If a student fails to secure a pass in a particular course, it is mandatory that he/she shall register for that course in the subsequent semester and attend the end semester examination. He/she should continue to register and appear for the examination till he /she secures a pass.

3. Award of Grades

Range of Total marks (Continuous assessment + End semester examination)	Letter Grade	Grade Point (GP)
Between 90 to 100	S	10
Between 80 to 89	A	9
Between 70 to 79	B	8
Between 60 to 69	C	7
Between 55 to 59	D	6
Between 50 to 54	E	5
Between 0 to 49	F	0
Absent	AB	0

Grade Point Average $GPA=\frac{\sum_{i=1}^{N} C_i G_{P_i}}{\sum_{i=1}^{N} C_i}$

N is the number of courses registered in a particular semester,
GP_i is the grade point obtained in i^{th} course and
C_i is the number of credits assigned to i^{th} course.

Cumulative GPA (CGPA) will be calculated when the student is declared to be eligible for the award of the degree. CGPA calculation is based on all the courses considered for the award of the degree.

ELIGIBILITY FOR THE AWARD OF DEGREE

A student shall be declared to be eligible for the award of the degree if he/she has satisfied the following:

1. A student seeking B.E., (Part time) degree shall be required to undergo the prescribed courses of study and evaluation in the college for the specified duration and to pass all the examinations prescribed therefore.
2. He/ she should register for the courses prescribed in the curriculum of the respective degree programme, fulfil the requirement of credits in each category of credit distribution, pass in all mandatory courses in the curriculum and earn the specified total minimum number of credits.
3. No disciplinary action pending against the student.

CLASSIFICATION OF THE DEGREE AWARDED

1. First class with Distinction

A student who qualifies for the award of degree having passed the examination in all registered courses in his / her first appearance (including industry supported courses), within three and half years and securing a CGPA of not less than 8.50 shall be declared to have passed in First class with distinction.

2. First Class

A student who qualifies for the award of degree having passed the examination in all the courses within three and half years and securing a CGPA of not less than 7.00 shall be declared to have passed in First class.

3. Second Class

All other students (not covered in 14.1 and 14.2) who qualify for the award of degree having passed the examination in all the courses and fulfilling the requirements shall be declared to have passed in Second Class.

DISCIPLINE

1. Every student is required to observe discipline and decorous behavior both inside and outside the college and not to indulge in any activity, which will tend to bring down the prestige of the college. The Registrar shall constitute a disciplinary committee to enquire into acts of indiscipline and notify the institution about the disciplinary action recommended for approval. In case of any serious disciplinary action which leads to suspension or dismissal.
2. If a student indulges in malpractice in any test/examinations, the student shall be liable for punitive action as prescribed by the institution from time to time.

5. REVISION OF REGULATIONS AND CURRICULUM

The standing committee/Academic Council/ of the institution reserves the right to revise or change or amend the regulations, the scheme of examinations, the curriculum and the syllabi from time to time if found necessary.

DISTRIBUTION OF CREDITS		
SL. No	**Course Category**	**Credits**
1.	**Basic Science Courses (BSC)**	04
2.	**Engineering Science Courses (ESC)**	06
3.	**Professional Core Courses (PCC)**	79
4.	**Professional Core Electives Courses (PCE)**	12
5.	**Humanities and Social Sciences including Management courses (HSMC) + Open Electives Courses (OEC)**	12
6.	**Project Mechanical Engineering courses (PROJ-ME)**	14
Total		**127**

SEMESTER - I (First year)							
SL. No	**Course Category**	**Course Code**	**Name of the Course**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	BSC	BMEP241T10	Mathematics III (PDE, Probability & Statistics)	3	1	-	**4**
2.	ESC	BMEP241T20	Engineering Mechanics	2	1	-	**3**
3.	PCC	BMEP241T30	Fluid Mechanics & Machinery	2	1	-	**3**
4.	PCC	BMEP241T40	Thermodynamics	3	-	-	**3**
5.	PCC	BMEP241T50	Materials Engineering	3	-	-	**3**
6.	PCC	BMEP241P60	Fluid Mechanics and Machinery Lab	-	-	2	**2**
7.	PCC	BMEP241P70	Materials and Metallurgy Lab	-	-	2	**2**
Total				**13**	**03**	**04**	**20**

SEMESTER - II (First year)							
SL. No	**Course Category**	**Course Code**	**Name of the Course**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	ESC	BMEP242T10	Basic Electronics Engineering	3	-	-	**3**
2.	PCC	BMEP242T20	Applied Thermodynamics	3	-	-	**3**
3.	PCC	BMEP242T30	Strength of Materials	2	1	-	**3**
4.	PCC	BMEP242T40	Kinematics of Machines	2	1	-	**3**
5.	PCC	BMEP242T50	Manufacturing Processes	3	-	-	**3**
6.	PCC	BMEP242P60	Thermal Engineering Lab	-	-	2	**2**
7.	PCC	BMEP242P70	Strength of Materials Lab	-	-	2	**2**
Total				**13**	**02**	**04**	**19**

SEMESTER - III (Second year)							
SL. No	**Course Category**	**Course Code**	**Name of the Course**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	PCC	BMEP243T10	Metrology and Quality Control	3	-	-	**3**
2.	PCC	BMEP243T20	Dynamics of Machines	2	1	-	**3**
3.	PCC	BMEP243T30	Instrumentation and Control	3	-	-	**3**
4.	PCC	BMEP243T40	Design of Machine Elements	3	-	-	**3**
5.	PCC	BMEP243T50	Manufacturing Technology	3	-	-	**3**
6.	PCC	BMEP243P60	Manufacturing Technology Lab	-	-	2	**2**
7.	PCC	BMEP243P70	Dynamics and Measurements Lab	-	-	2	**2**
Total				**14**	**01**	**04**	**19**

SEMESTER - IV (Second year)							
SL. No	**Course Category**	**Course Code**	**Name of the Course**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	HSMC	BMEP244T10	Operation Research & Management	2	1	-	**3**
2.	PCC	BMEP244T20	CAD/CAM	3	-	-	**3**
3.	PCC	BMEP244T30	Automobile Engineering	3	-	-	**3**
4.	PCC	BMEP244T40	Power Plant Engineering	3	-	-	**3**
5.	OEC	BMEP244T50	Open Elective – I	3	-	-	**3**
6.	PCC	BMEP244P60	CAD / CAM Lab	-	-	2	**2**
Total				**14**	**1**	**02**	**17**

SEMESTER - V (Third year)							
SL. No	**Course Category**	**Course Code**	**Name of the Course**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	PCC	BMEP245T10	Heat and Mass Transfer	3	-	-	**3**
2.	PCC	BMEP245T20	Design of Transmission Systems	3	0	0	**3**
3.	PCC	BMEP245T30	Mechatronics	3	0	0	**3**
4.	PEC	-	Professional Elective – I	3	-	-	**3**
5.	PEC	-	Professional Elective – II	3	-	-	**3**
6.	PCC	BMEP245P40	Mechatronics Lab	-	-	2	**2**
7.	PCC	BMEP245P50	Heat Transfer Lab	-	-	2	**2**
Total				**15**	**0**	**4**	**19**

SEMESTER - VI (Third year)							
SL. No	**Course Category**	**Course Code**	**Name of the Course**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	PEC	-	Professional Elective – III	3	-	-	**3**
2.	PEC	-	Professional Elective – IV	3	-	-	**3**
3.	OEC	-	Open Elective – II	3	-	-	**3**
4.	PCC	BMEP246P40	Machine Drawing Practical	-	-	2	**2**
5.	PCC	BMEP246P50	Computer aided analysis lab	0	0	2	**2**
6.	PROJ-ME	BMEP246Z60	Design & Fabrication project	0	0	4	**4**
Total				**09**	**0**	**08**	**17**

SEMESTER - VII (Fourth year)							
SL. No	**Course Category**	**Course Code**	**Name of the Course**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	PCC	BMEP247T10	Automation in Manufacturing	3	-	-	**3**
2.	HSMC	BMEP247T20	Engineering Economics	3	-	-	**3**
3.	PROJ-ME	BMEP247Z30	Project Work	-	-	10	**10**
Total				**06**	**0**	**10**	**16**

PROFESSIONAL ELECTIVE COURSES							
SL. No	**Category**	**Code**	**Course Title**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	**PEC-I**	BMEP245E1A	Finite Element Analysis	**3**	**-**	**-**	**3**
2.		BMEP245E1B	Fluid Power Systems				
3.		BMEP245E1C	Product Design & Development				
4.		BMEP245E1D	3D Printing				
5.		BMEP245E1E	Tribology				
6.	**PEC-II**	BMEP245E2A	Refrigeration & Air Conditioning	**3**	**-**	**-**	**3**
7.		BMEP245E2B	I.C. Engines				
8.		BMEP245E2C	Turbo Machines				
9.		BMEP245E2D	Energy Conservation in Industries				
10.		BMEP245E2E	Gas Dynamics & Jet Propulsion				
11.	**PEC-III**	BMEP246E3A	Sustainable Manufacturing	**3**	**-**	**-**	**3**
12.		BMEP246E3B	Design for Manufacturing				
13.		BMEP246E3C	Theory of Metal Forming				
14.		BMEP246E3D	Digital Manufacturing				
15.		BMEP246E3E	Composite Materials				
16.	**PEC-IV**	BMEP246E4A	Total Quality Management	**3**	**-**	**-**	**3**
17.		BMEP246E4B	Entrepreneurship Development				
18.		BMEP246E4C	Non-Traditional Machining Process				
19.		BMEP246E4D	Non Destructive Evaluation				
20.		BMEP246E4E	Flexible Manufacturing Systems				
21.		BMEP246E4F	INDUSTRY 4.0				

OPEN ELECTIVE COURSES							
SL. No	**Category**	**Code**	**Course Title**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	**OEC – I**	BMEP244OEA	Cloud Computing	**3**	**-**	**-**	**3**
2.		BMEP244OEB	Web Design				
3.		BMEP244OEC	Digital Image Processing				
4.		BMEP244OED	Data Analysis				
5.		BMEP244OEE	Astro-Physics				
6.		BMEP244OEF	Business Administration				
7.		BMEP244OEG	Chemistry in Crime Investigation				
8.		BMEP244OEH	Bioinformatics				
9.		BMEP244OEI	Finance for Non Finance Managers				
10.		BMEP244OEJ	Fuel Cell and Batteries				
11.		BMEP244OEK	French Primer				
12.		BMEP244OEL	Japanese				
13.		BMEP244OEM	German Primer				
14.		BMEP244OEN	Communication Skills				
15.		BMEP244OEO	Hindi Literatures				
16.	**OEC - II**	BMEP246OEA	Autotronics	**3**	**-**	**-**	**3**
17.		BMEP246OEB	Artificial Intelligence & Machine Learning				
18.		BMEP246OEC	Nano Technology & Surface Engineering				
19.		BMEP246OED	Disaster Management & Mitigation				
20.		BMEP246OEE	Robotics				
21.		BMEP246OEF	HR Management				
22.		BMEP246OEG	Nuclear and particle physics				
23.		BMEP246OEH	Internet of Things (IOT)				
24.		BMEP246OEI	Psychology				
25.		BMEP246OEJ	Statistical methods with excel				
26.		BMEP246OEK	Key Board				
27.		BMEP246OEL	Logistics and Supply Chain				
28.		BMEP246OEM	Panini Grammar				
29.		BMEP246OEN	Violin				
30.		BMEP246OEO	Vocal Music				

SEMESTER - I

Course Title	MATHEMATICS – III (PDE, Probability & Statistics)	Credits	L T P C
Course Code			3 0 0 4
Course Category	ESC		

COURSE OBJECTIVES

- To provide an overview of probability and statistical inferences to engineers
- To introduce the solution methodologies for second order Partial Differential Equations with applications in engineering

UNIT-I: Basic Probability **9**

Probability spaces, conditional probability, Independent random variables, sums of independent random variables, Bayes' Theorem, Discrete and Continuous one-dimensional random variables - Expectations, Moments, Variance of a sum, Moment generating function, Tchebyshev's Inequality.

UNIT-II: Probability Distributions **9**

Discrete Distributions – Binomial, Poisson and Negative Binomial distributions, Continuous Distributions - Normal, Exponential and Gamma distributions.

UNIT-III: Basic Statistics **9**

Measures of Central tendency: Averages, mean, median, mode, Measures of dispersion – Range, Mean deviation, Quartile deviation and Standard deviation, Moments, skewness and Kurtosis, Correlation and regression – Rank correlation.

UNIT-IV: Applied Statistics **9**

Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations- Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

UNIT-V: Applications of Partial Differential Equations **9**

Method of separation of variables – Vibration of a stretched string: Wave equation – Solution of Wave equation - D'Alembert's solution of wave equation – One dimensional heat flow – Solution of heat equation.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	They understand the concept of basic probability, conditional probability and Baye's theorem and its application of analysis the Engineering problems.	**PO2, PO4-PO9**
2.	They Know to apply the discrete and continuous distributions in probability for the real life problems.	**PO3-PO6, PO8, PO9**
3.	They identify and improve their basic ideas of statistics including measures of central tendency, dispersion, correlation and regression.	**PO1, PO4, PO9-PO11**
4.	Analyzing the large and small samples using tools like z, t, F and chi-square.	**PO1, PO4-PO6, PO8-PO12**
5.	Design solution to PDE and to solve field problems in engineering involving PDEs.	**PO2-PO4, PO6, PO7, PO10, PO12**

TEXT BOOK	
1.	T. Veerarajan, Probability, Statistics and Random Processes, Third edition, Tata McGraw-Hill, New Delhi, 2010.
2.	S.P. Gupta, Statistical Methods, 31st edition, Sultan Chand & sons, New Delhi, 2002.
3.	Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
REFERENCES	
1.	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
2.	S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.
3.	W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.
4.	N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.

Course Title	ENGINEERING MECHANICS	Credits	L T P C
Course Code			3 0 0 3
Course Category	ESC		

OBJECTIVES

- To familiarize the basics laws of physics, vector operations and forces.
- To understand the principles of beams, supports and equilibrium of rigid bodies.
- To know the area and mass property calculations of various sections and solids.
- To study and analyse the dynamics of particles by various methods.
- To understand the applications of friction and rigid body dynamics.

UNIT-I STATICS OF PARTICLES **9**

Introduction – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces, Principle of transmissibility, Vectors – Vectorial representation of forces and moments – Vector operations: additions, subtraction, dot product, cross product – Coplanar Forces – Resolution and Composition of forces – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Single equivalent force.

UNIT-II EQUILIBRIUM OF RIGID BODIES **9**

Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions – Examples

UNIT-III PROPERTIES OF SURFACES AND SOLIDS **9**

Determination of Area and Volume – First moment of area and the Centroid of sections – Rectangle, circle, triangle from integration – T section, I section, - Angle section, Hollow section by using standard formula – second and product moments of plane area – Rectangle, triangle, circle from integration – T section, I section, Angle section, Hollow section by using standard formula – Parallel axis theorem and perpendicular axis theorem – Polar moment of inertia – Principal moments of inertia of plane areas – Principal axes of inertia – Mass moment of inertia – Derivation of mass moment of inertia for rectangular section, prism, sphere from first principle – Relation to area moment of inertia.

UNIT-IV DYNAMICS OF PARTICLES **9**

Displacements, Velocity and acceleration, their relationship – Relative motion – Curvilinear motion – Newton's law – Work Energy Equation of particles – Impulse- Momentum principle – Impact of elastic bodies.

UNIT-V FRICTION AND RIGID BODY DYNAMICS **9**

Frictional force – Laws of Coloumb friction – simple contact friction – Rolling resistance – Belt friction-Ladder friction- Translation and Rotation of Rigid Bodies – Velocity and acceleration – General Plane motion of bodies.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Get familiarized with the basic laws of physics, vector operations and forces.	**PO1**
2.	Understand the principles of beams, supports and equilibrium of rigid bodies.	**PO1, PO2**
3.	Calculate the area and mass properties of various sections and solids.	**PO1, PO2**
4.	Know about dynamics of particles and their analysis by various methods.	**PO1, PO2, PO3**
5.	Know about the applications of friction and rigid body dynamics.	**PO1, PO2**

TEXT BOOK	
1.	Rajasekaran, S, Sankarasubramanian, G., "Fundamentals of Engineering Mechanics", Vikas Publishing House Pvt. Ltd., (2007), 3rd Edition.
2.	Beer, F.P and Johnson Jr. E.R. "Vector Mechanics for Engineers", Vol. 1 Statics and Vol. 2 Dynamics, Tata McGraw-Hill International Edition, 2017, 11th edition
REFERENCES	
1.	Hibbeler, R.C., "Engineering Mechanics", Vol. 1 Statics, Vol. 2 Dynamics, Pearson Education Asia Pvt. Ltd., (2017).
2.	Palanichamy, M.S., Nagam, S., "Engineering Mechanics – Statics & Dynamics", Tata McGraw-Hill, (2001).
3.	Irving H. Shames, "Engineering Mechanics – Statics and Dynamics", IV Edition – Pearson Education Asia Pvt. Ltd.,(2008).
4.	Ashok Gupta, "Interactive Engineering Mechanics – Statics – A Virtual Tutor (CDROM)", Pearson Education Asia Pvt., Ltd., (2002).
5.	K.L. Kumar, "Engineering Mechanics" Tata McGraw-hill, 2017, 4th Edition
6.	S.S. Bhavikatti, " Engineering Mechanics", New Age International Publishers, 2006
7.	R. S. Khurmi, " Engineering Mechanics", S. Chand Publishers, 2018.

Course Title	FLUID MECHANICS & MACHINERY	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the properties of fluids and concept of control volume.
- To understand the applications of the conservation laws to flow through pipes.
- To understand the importance of dimensional analysis
- To understand the importance of various types of flow in pumps.
- To understand the importance of various types of flow in turbines.

UNIT–I FLUID PROPERTIES & FLOW CHARACTERISTICS **9**

Units and dimensions - Types of flows - Properties of fluids - mass density, specific weight, specific volume, specific gravity, viscosity, compressibility, vapor pressure – Gas laws - Surface tension and capillarity. Flow characteristics – concept of control volume – Bernoulli's Theorem – Concept of control volume – Application of continuity equation, energy equation, momentum equation and moment of momentum equation

UNIT - II FLOW THROUGH CIRCULAR CONDUITS **9**

Hydraulic and energy gradient - Laminar flow through circular conduits and circular annuli- Hydraulic and energy gradient-Boundary layer concepts – types of boundary layer thickness – Darcy Weisbach equation – friction factor- Moody diagram- commercial pipes- minor losses – Flow through pipes in series and parallel

UNIT–III-DIMENSIONAL ANALYSIS **9**

Dimensional analysis – methods of dimensional analysis - Similitude –types of similitude – Dimensionless parameters- Application of dimensionless parameters – Model analysis

UNIT–IV HYDRAULIC PUMPS **9**

Impact of jets - Euler's equation - Theory of roto-dynamic machines – various efficiencies - velocity triangles - Centrifugal pumps– Multi stage centrifugal pumps - working principle - work done by the impeller - performance curves – Priming – Cavitation - Reciprocating pump- working principle – Air vessels – Indicator diagram - Rotary pumps – Working Principles.

UNIT–V HYDRAULIC TURBINES **9**

Hydraulic turbines – Classification - working principles - Pelton wheel, Kaplan turbine - Francis turbine - velocity triangles - theory of draft tubes – Performance – Specific speed – Unit Quantities - Selection of turbines - governing of turbines - hydraulic coupling - Torque converter

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Apply mathematical knowledge to predict the properties and characteristics of a fluid.	**PO1, PO2**
2.	Analyse and calculate major and minor losses associated with pipe flow in piping networks.	**PO1, PO2**
3.	Mathematically predict the nature of physical quantities	**PO1, PO2**
4.	Analyse the performance of pumps	**PO2**
5.	Analyse the performance of turbines	**PO2**
TEXT BOOK		
1.	K.L. Kumar, Engineering Fluid Mechanics, S. Chand Publishing, 2016.	
2.	Modi P.N. & Seth, S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi 2013.	
REFERENCES		
1.	S. K. Som, G. Biswas, S Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill, 2008, 3rd Edition.	
2.	K. R. Arora, Fluid Mechanics Hydraulics and Hydraulic Machines, Standard Publishers, 2007, 9th Edition.	
3.	C. P. Kothandaraman & R. Rudramoorthy. Fluid Mechanics and Machinery, New Academia Science, 2011, 3rd Edition.	
4.	Douglas J.F, Solving Problems in Fluid Mechanics Vol I & II, John Wiley & Sons Inc., 1986.	
5.	Victor L. Streeter and E. Benjamin Wylie & Keith W.Bedford. Fluid Mechanics, Mc Graw-Hill 1999, 8th Edition.	

Course Title	THERMODYNAMICS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To learn about the basic concepts of thermodynamics & first law of thermodynamics
- To learn about application of II law and to understand the concept of entropy/availability
- To evaluate the changes in properties of pure substances
- To understand various thermodynamic relations & ideal gas concept
- To learn about the concept of psychrometry

UNIT - I BASIC CONCEPTS AND FIRST LAW 9

Concept of continuum- microscopic and macroscopic approach-Path and point functions - Properties – Thermodynamics system and their types - Thermodynamic Equilibrium - State, path and process - Quasi-static, reversible and irreversible processes - Modes of work - P-V diagram - Zeroth law of thermodynamics – Concept of temperature & heat - First law of thermodynamics - application to closed and open systems – steady and unsteady flow processes

UNIT- II SECOND LAW & AVAILABILITY ANALYSIS 9

Statements of second law and its corollaries – Carnot theorem - Carnot cycle & Reversed Carnot cycle - Clausius inequality. Concept of entropy, entropy of ideal gas - Principle of increase in entropy. Applications of II Law. Available and non-available energy of a source and finite body. Energy and irreversibility. Expressions for the energy of a closed system and open systems. Energy balance and entropy generation. Irreversibility. I and II law Efficiency

UNIT - III PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE 9

Formation of steam & its thermodynamic properties - P-v, P-T, T-v, T-s, h-s diagrams. P-v-T surface. Use of Steam Table & Mollier Chart - Application of I and II law for pure substances. Ideal and actual Rankine cycles, Cycle Improvement Methods - Reheat and Regenerative cycles.

UNIT - IV IDEAL GAS & THERMODYNAMIC RELATIONS 9

Properties of Ideal gas- Ideal and real gas comparison- Equations of state for ideal and real gases- Reduced properties. Compressibility factor- Generalized Compressibility Chart -. Simple Calculations. Maxwell relations, Tds equations, Specific heat capacities - Energy equation - Joule-Thomson co-efficient, Clausius -Clapeyron equation – Third law of thermodynamics.

UNIT V PSYCHROMETRY 9

Psychrometric properties - Psychrometric chart - Psychrometric processes – Adiabatic saturation - Sensible heating and cooling, humidification, dehumidification, Evaporative cooling and adiabatic mixing of air streams - Property calculations

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Apply the first law of thermodynamics for simple open and closed systems under steady and unsteady conditions.	**PO1, PO2**
2.	Apply second law of thermodynamics to open and closed systems and calculate entropy and availability	**PO1, PO2**
3.	Apply Rankine cycle to steam power plant and compare few cycle improvement methods.	**PO2, PO3**
4.	Derive simple thermodynamic relations of ideal and real gases.	**PO1**
5.	Calculate the properties of gas mixtures and moist air and its use in psychrometric processes.	**PO1, PO2**

TEXT BOOK	
1.	Yunus A, Cengel & Michael A. Boles, "Thermodynamics – An Engineering Approach", McGraw Hill Education, 8th edition, 2017.
REFERENCES	
1.	Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2012.
2.	Borgnakke & Sonnatag, "Fundamental of Thermodynamics", John Wiley, 8th edition, 2016.
3.	Chattopadhyay P, "Engineering Thermodynamics", Oxford University Press, 2016.
4.	J.P Holman, Thermodynamics – Tata McGraw Hill, 2012, 9th edition.
5.	Nag. P. K., "Engineering Thermodynamics", 6th edition, Tata McGraw-Hill, New Delhi, 2017.
6.	Vanwylen & Sonntag, Introduction to Thermodynamics, Classical & Statistical – Wiley Eastern, 2007, 4th edition.

Course Title	MATERIALS ENGINEERING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- Understanding of the correlation between the internal structure of materials, their mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
- To provide a detailed interpretation of equilibrium phase diagrams.
- Learning about different phases and heat treatment methods to tailor the properties of Fe-C alloys.

UNIT-I: Crystal Structure **9**

Unit cells, Metallic crystal structures, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress.

UNIT-II: Mechanical Property measurement **9**

Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell, Brinell and Vickers and their relation to strength. Fracture mechanics: Introduction to Stress-intensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, Introduction to nondestructive testing (NDT).

UNIT–III: Alloys, Substitutional and interstitial solid solutions-Phase diagrams **9**

Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron-carbon phase diagram and microstructure aspects of ledeburite, austenite, ferrite and cementite, cast iron.

UNIT–IV: Heat treatment of Steel **9**

Annealing, tempering, normalizing and spheroidising, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening.

UNIT–V: Metals and Alloys **9**

Alloying of steel, properties of stainless steel and tool steels, maraging steels- cast irons; grey, white, malleable and spheroidal cast irons- copper and copper alloys; brass, bronze and cupro-nickel; Aluminum and Al-Cu – Mg alloys- Nickel based super alloys and Titanium alloys.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Identify crystal structures for various materials and understand the defects in such structures.	**PO1, PO2**
2.	Understand how to tailor material properties of ferrous and non-ferrous alloys and how to quantify mechanical integrity and failure in materials	**PO1, PO2**
3.	Understand the micro structural aspects and phases of Fe-C systems.	**PO4**
4.	Understand the various heat treatment process.	**PO2**
5.	properties and applications of ferrous and non ferrous metals.	**PO1, PO2**
EXT BOOK		
1.	W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.	
2.	Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.	
3.	V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 2004, 5th Edition.	
4.	U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 2011.	
REFERENCES		
1.	W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.	
2.	Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.	
3.	V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 2004, 5th Edition.	
4.	U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 2011.	

Course Title	FLUID MECHANICS AND MACHINERY LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES

- To understand the concept of Bernoulli's Theorem.
- To study the performance behaviour of various pumps.
- To study the performance behaviour of various turbines.
- To calibrate venturi / Orifice meter.
- To study the major and minor energy losses and also to study the application of Notches and Weirs.

LIST OF EXPERIMENTS

1.	Verification of Bernoulli's theorem
2.	Calibration of orifice meter and Venturi meter
3.	Flow through nozzle
4.	Flow through notches and weirs
5.	Flow through pipes and losses in pipes
6.	Buoyancy experiment – Meta centric height
7.	Performance characteristics of centrifugal pump
8.	Performance characteristics of reciprocating pump
9.	Performance characteristics of gear pump
10.	Performance characteristics of submergible pump
11.	Performance Characteristics of Francis turbine
12.	Performance Characteristics of Pelton wheel
13.	Performance Characteristics of Kaplan turbine

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Draw the performance Characteristics curves of various pumps and analyse their behaviour.	**PO1, PO4**
1.	Draw the performance Characteristics curves of various turbines and analyse their behaviour.	**PO1, PO4**
2.	Use the measurement equipments for fluid flow.	**PO1, PO4**
3.	Understand Bernoulli's theorem	**PO1, PO2**
4.	Determine the friction factor for a given set of pipes	**PO1, PO4**

TEXT BOOK	
1.	K.L. Kumar, Engineering Fluid Mechanics, S. Chand Publishing, 2016.
2.	Modi P.N. & Seth, S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi 2013.
REFERENCES	
1.	S. K. Som, G. Biswas, S Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill, 2008, 3rd Edition.
2.	K. R. Arora, Fluid Mechanics Hydraulics and Hydraulic Machines, Standard Publishers, 2007, 9th Edition.
3.	C. P. Kothandaraman & R. Rudramoorthy. Fluid Mechanics and Machinery, New Academia Science, 2011, 3rd Edition.

Course Title	MATERIALS AND METALLURGY LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES

- To know the micro structure of different materials
- To impart the required material for products based on micro structure
- To know the properties of materials at higher elevated temperatures
- To refine grain size by heat treatment properties

LIST OF EXPERIMENTS

1.	Preparation of specimen, macro / micro etching techniques for metallographic examination
2.	Study and use of metallurgical microscope, different types and their operations
3.	Identification of plain and high carbon steel, quenched and tempered steel
4.	Identification of stainless steel – HSS and alloy steel.
5.	Identification of Grey C.I, White C.I, Malleable iron, SG iron.
6.	Identification of Cu alloys, Mg alloys, Al alloys, Ni alloys, Bearings metals
7.	Measurements of harden ability – Jomny end quench test
8.	Grain size measurement by comparison with ASTM chart
9.	Study of microstructure and hardness value before and after heat treatment such as annealing, normalizing, hardening and tempering.
10.	Demonstration of various sand testing methods (moisture determination, permeability testing, & green strength testing)

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Know and analyze the microstructures	**PO2**
2.	Understand various crystal structures and relationship to properties	**PO2, PO4**
3.	Understanding metals and their use in industries	**PO2, PO4**
4.	Understanding heat treatment procedures and the change of properties	**PO2, PO4**
5.	Know the improving material properties by different heat treatment processes.	**PO2, PO4**

TEXT BOOK

1.	W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.
2.	Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.

REFERENCES

1.	W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.
2.	Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.
3.	V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 2004, 5th Edition.

SEMESTER – II

Course Title	BASIC ELECTRONICS ENGINEERING	Credits	L T P C
Course Code			3 0 0 3
Course Category	ESC		

OBJECTIVES

- To provide an overview of electronic device components to Mechanical engineering students.

UNIT-I: Semiconductor Devices and Applications **9**

Introduction to P-N junction Diode and V-I characteristics, Half wave and Full-wave rectifiers, capacitor filter. Zener diode and its characteristics, Zener diode as voltage regulator. Regulated power supply IC based on 78XX and 79XX series, Introduction to BJT, its input-output and transfer characteristics, BJT as a single stage CE amplifier, frequency response and bandwidth.

UNIT-II: Operational amplifier and its applications **9**

Introduction to operational amplifiers, Op-amp input modes and parameters, Op-amp in open loop configuration, op-amp with negative feedback, study of practical op-amp IC 741, inverting and non-inverting amplifier applications: summing and difference amplifier, unity gain buffer, comparator, integrator and differentiator.

UNIT-III: Timing Circuits and Oscillators **9**

RC-timing circuits, IC 555 and its applications as astable and mono-stable multi-vibrators, positive feedback, Barkhausen's criteria for oscillation, R-C phase shift and Wein bridge oscillator.

UNIT-IV: Digital Electronics Fundamentals **9**

Difference between analog and digital signals, Boolean algebra, Basic and Universal Gates, Symbols, Truth tables, logic expressions, Logic simplification using K- map, Logic ICs, half and full adder/subtractor, multiplexers, demultiplexers, flip-flops, shift registers, counters, Block diagram of microprocessor/microcontroller and their applications.

UNIT-V: Electronic Communication Systems **9**

The elements of communication system, IEEE frequency spectrum, Transmission media: wired and wireless, need of modulation, AM and FM modulation schemes, Mobile communication systems: cellular concept and block diagram of GSM system.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the principles of semiconductor devices and their applications.	**PO1, PO2**
2.	Design an application using Operational amplifier.	**PO2**
3.	Understand the working of timing circuits and oscillators.	**PO1, PO2**
4.	Understand logic gates, flip flop as a building block of digital systems.	**PO1, PO2**
5.	Learn the basics of Electronic communication system.	**PO1**

TEXT BOOK	
1.	Floyd ," Electronic Devices" Pearson Education 9th edition, 2012.
2.	R.P. Jain , "Modern Digital Electronics", Tata Mc Graw Hill, 3rd Edition, 2007.
3.	Frenzel, "Communication Electronics: Principles and Applications", Tata Mc Graw Hill, 3rd Edition, 2001
REFERENCES	
1.	Floyd ," Electronic Devices" Pearson Education 9th edition, 2012.
2.	R.P. Jain , "Modern Digital Electronics", Tata Mc Graw Hill, 3rd Edition, 2007.
3.	Frenzel, "Communication Electronics: Principles and Applications", Tata Mc Graw Hill, 3rd Edition, 2001

Course Title	APPLIED THERMODYNAMICS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To apply the concept of thermodynamics to steam Nozzle & to understand the velocity triangle diagram of various turbines
- To understand the various systems of I.C. Engines
- To analyse the different gas power cycles
- The principles of reciprocating & rotary air compressors are studied
- To apply the concepts of thermodynamics to refrigeration & Air conditioning

UNIT- I Flow Through Nozzle & Steam Turbines **9**

One-dimensional flow of steam through nozzle – Nozzle types - Critical pressure ratio – Nozzle efficiency - Super saturated flow in nozzles. Impulse and Reaction turbine Principles - Compounding – Types - Velocity diagrams for simple and multistage turbines - Speed regulations – Governors.

UNIT–II I.C. Engines **9**

Classification – Working Principle - Components and their function. Valve timing & port timing diagram - actual and theoretical p-V diagram of four stroke and two stroke engines. Simple Carburettor Diesel pump and injector system - Ignition System - Principles of Combustion and knocking in SI and CI Engines. Lubrication and Cooling systems. Performance calculations.

UNIT-III Gas Power Cycles **9**

Air Standard Cycles - Otto, Diesel, Dual & Brayton cycle Analysis – methods of cycle improvement. Regenerative, intercooled, reheated cycles and their combinations –Performance Calculations.

UNIT–IV Air Compressors **9**

Reciprocating Air Compressors – Classifications - Working principle – work done - Effect of clearance volume - Single and multi-stage compressors, Volumetric efficiency – calculation of power requirement – Rotary compressors (Working Principle).

UNIT–V Refrigeration & Air Conditioning **9**

Refrigeration cycles- Reversed Carnot – Bell Coleman cycle - Vapour compression system –Super heating/Sub cooling - Vapour absorption refrigeration system- Properties of refrigerants. – Simple Problems on VCR system Principles of air-conditioning - Types of A/C Systems –Industrial, Summer, Winter - Comfort and Year-round air conditioners – Window & Centralised A/C - Concept of GSHF – RSHF – ESHF.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Analyse the problems of nozzles & turbines.	**PO2**
2.	Explain the functioning & features of I.C. Engines & Calculate the performance of I.C. Engines.	**PO2, PO4**
3.	Analyse & solve the problems of air standard cycles.	**PO2, PO4**
4.	Analyse the performance behaviour of single & multi stage reciprocating air compressors.	**PO2, PO4**
5.	Understand the different Refrigeration & A/C systems and solve the problems of VCR system.	**PO1, PO2**

TEXT BOOK	
1.	Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, "Dhanpat Rai & sons , 2016
2.	Rajput. R. K., "Thermal Engineering" S. Chand Publishers, 2017
REFERENCES	
1.	Arora.C.P, "Refrigeration and Air Conditioning ," Tata McGraw-Hill Publishers 2017
2.	Ganesan V.." Internal Combustion Engines",3rd Edition, Tata McGraw-Hill 2017
3.	Rudramoorthy, R, "Thermal Engineering ",Tata McGraw-Hill, New Delhi,2003
4.	Sarkar, B.K,"Thermal Engineering" Tata McGraw-Hill Publishers, 2007
5.	P. L. Ballaney, Thermal Engineering, Khanna Publishers, 2007, 24th Edition.

Course Title	STRENGTH OF MATERIALS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the nature of stresses developed in simple and composite bars.
- To understand the nature of stresses developed in beams.
- To understand the slope and deflection developed in beams.
- To calculate the elastic deformation occurring in various simple geometries for different types of loading.
- To understand the nature of stresses developed in cylinders and spheres for various types of simple loads.

UNIT - I SIMPLE STRESS AND STRAIN **9**

Deformation in solids– Hooke's law– stress and strain –tension, compression and shear stresses– composite bars - elastic constants and their relations–Volumetric, linear and shear strains.

UNIT - II SHEAR FORCE AND BENDING MOMENT DIAGRAM **9**

Beams and types–Transverse loading on beams– shear force and bend moment diagrams– Types of beam supports–Simply supported, over-hanging beams and cantilevers– Theory of bending of beams–bending stress distribution and neutral axis–shear stress distribution– point and distributed loads.

UNIT – III DEFLECTION OF BEAMS **9**

Deflection of a beam using double integration method, moment area method and macaulay's method–computation of slopes and deflection in beams–Maxwell's reciprocal theorems.

UNIT – IV TORSION OF SHAFT AND SPRINGS **9**

Torsion–Stresses and deformation in circular and hollow shafts– stepped shafts–Deflection of shafts fixed at both ends–Stresses and deflection of helical springs, laminated spring - principal stresses and principal planes–Mohr's circle.

UNIT – V THIN AND THICK CYLINDER **9**

Axial and hoop stresses in cylinders subjected to internal pressure–Deformation of thick and thin cylinders–Deformation in spherical shells subjected to internal pressure.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Recognize various types loads applied on machine components of simple and composite bars.	**PO2, PO3**
2.	Recognize the stresses developed on various types of beams.	**PO2**
3.	Recognize the slope and deflection developed on various types of beams.	**PO2, PO3**
4.	Evaluate the strains and deformation that will result due to the elastic stresses developed within the materials for simple types of loading.	**PO2, PO3, PO4**
5.	Understand the nature of internal stresses.	**PO2**

TEXT BOOK	
1.	S. Ramamrutham and R. Narayan, Strength of Materials, Dhanpat Rai and Sons, New Delhi.2007, 15th Editon.
2.	L.S. Srinath, Advanced Mechanics of Solids, Tata McGraw HIll, 2009, 3rd Edition
REFERENCES	
1.	Beer & Johnson, Mechanics of materials, SI Metric Edition, McGraw Hill, ISE, 2017.
2.	Gere and Timensenko, Mechanics of Materials, CBS Publishers, 2006.
3.	S.P. Timoshenko J.N Goodier, Theory of Elasticity, Mc Graw Hill International Edition, 2017.
4.	S.M.A.Kazimi, Solid Mechanics, Tata McGraw Hill Publishing Company Ltd., 2004.
5.	Timoshenko & D.H. Young, J.V. Rao, Sukumar Pati, Engineering Mechanics, McGraw Hill, 2017.
6.	J. B. K Das & P.L. Srinivasa Murthy, Mechanics of Materials, Sapna Book House, 2018.

Course Title	KINEMATICS OF MACHINES	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the basic components and layout of linkages in the assembly of a system / machine.
- To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
- To understand the motion resulting from a specified set of linkages, design few linkage mechanisms and cam mechanisms for specified output motions.
- To understand the basic concepts of toothed gearing and kinematics of gear trains and the effects of friction in motion transmission and in machine components.

UNIT–I: Introduction to links, Pairs and Chains **9**

Links, Pairs, Chains, Mechanisms, Inversion of machines, Structure - Degrees of freedom, inversion, Four bar chains. Velocity and acceleration: Velocity and acceleration of simple mechanism by relative velocity method. Klein's constructions for slider crank chain oscillating cylinder and swivel bearing mechanisms. Analytical solution for slider crank mechanisms.

UNIT–II: Cams **9**

Introduction to Cams, Types of cams and followers, displacement, velocity & acceleration curves for uniform velocity, uniform acceleration and retardation. SHM, cycloidal curves, lay out of profile of plate cams of the above types with reciprocating and oscillating followers – knife edge rollers and flat faced followers, cylindrical and face cams, polynomial cams, cams with special contours.

UNIT–III: Theory of gearing **9**

Introduction to Toothed gears, law of gearing, minimum number of teeth, length of arc of contact, interference.

UNIT–IV: Gear trains **9**

Introduction to gear trains, Types, velocity ratio and torque calculation in epicyclic gear trains and differential gear train.

UNIT-V: Drives and Lubrication **9**

Belt and rope drives, single plate, multiple plate, cone clutches, power transmitted, Brakes. Lubrication: Theory of lubrication, hydrostatic and hydrodynamic bearings, frictional loss, power in bearing.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the basics of mechanism	**PO1**
2.	Calculate velocity and acceleration in simple mechanisms	**PO2, PO4**
3.	Develop CAM profiles	**PO2**
4.	Solve problems on gears and gear trains	**PO2**
5.	Examine friction in machine elements	**PO2, PO4**

TEXT BOOK	
1.	Amitabh Ghosh and Ashok Kumar Mallik, Theory of mechanism and Machines – 3nd Edition, Affiliated East West Press Limited, 2017.
2.	J.E.Shigley and J.J.Vicker Jr. Theory of Machines and Mechanism, 2nd ed. Mc GrawHill ISE 1995
3.	R.S. Khurmi & Gupta. J.K, A text book of Theory of Machines, S. Chand & Co., 2008, 14th Edition.
REFERENCES	
1.	J.Hannah and R.C Stephens, Mechanics of Machines – Edward Arnold, 1999.
2.	Beer & Johnston 11th Edition, Vector Mechanics for Engineers. McGraw Hill. ISE 2017.
3.	Thomas Bevan – 3rd Edition, The Theory of Machines – CBS, Pearson 2009.
4.	P.L.Ballaney, Theory of Machines, Khanna Publishers, 2005, 24th Edition.
5.	S.S.Rattan, Theory of Machines, Tata McGraw Hill, 2017, 2nd Edition, 2017.
6.	Rao .J.S. & Dukkipati. R.V. Mechanism and Machine Theory, 2nd ed. Wiley Eastern Ltd., 2007,
7.	Hamilton H. Mabie & Charles F. Reinnoltz, Mechanisms and Dynamics of Machinery, 4th ed. John Wiley & Sons, 1995
8.	Thomson W.T, Theory of Vibration and Applications, Prentice Hall Inc, 1997.
9.	Sadhu Singh, Theory of Machines, Pearson Education Ltd, 2011.
10.	Ashok G. Ambekar, Mechanism and Machine Theory, Eastern Economy Edition. 2007.
11.	John. J. Uicker, Theory of Machines and Mechanisms, Oxford University Press, 2008, 3rd Edition.

Course Title	MANUFACTURING PROCESSES	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To motivate and challenge students to understand the basic casting techniques.
- To introduce the concepts of basic metal forming processes
- To provide the concept and basic mechanics of metal cutting, working of standard machine tools such as lathe, shaping and allied machines, milling and drilling.
- To learn the various joining process.
- To learn the basic concepts of unconventional machining processes

UNIT–I: CASTING AND MOLDING **9**

Sand casting – Sand moulds - Type of patterns – Pattern materials – Pattern allowances – Types of Moulding sand – Properties – Core making– Working principle of Special casting processes – Shell, investment casting - die casting – Centrifugal casting – Sand Casting defects – Inspection methods

UNIT–II: METAL FORMING PROCESSES **9**

Hot working and cold working of metals – Forging processes – Open, impression and closed die forging – Characteristics of the process – Types of Forging Machines – Typical forging operations – Rolling of metals – Types of Rolling mills - Shape rolling operations – Defects in rolled parts - Principle of rod and wire drawing - Tube drawing –– Principles of Extrusion – Types of Extrusion – Hot and Cold extrusion –– Equipment used

UNIT–III: SHEET METAL FORMING **9**

Forming Operations- Blanking-blank size calculation, draw ratio, drawing force, Piercing, Punching, Trimming, Stretch Forming, Deep Drawing, Shearing, Metal Spinning, Bending, Tube bending, Tube forming -Embossing & Coining, Types of Dies, Progressive, Compound and Combination dies.Forming Methods - Explosive Forming, Electro Hydraulic Forming, Electro Magnetic Forming, Dynapack Machine, Rubber Forming, Super Plastic Forming.

UNIT–IV: JOINING/FASTENING PROCESSES **9**

Fusion welding processes – Types of Gas welding – Equipments used – Flame characteristics – Filler and Flux materials - Arc welding equipments - Electrodes – Coating and specifications – Principles of Resistance welding – Spot/butt, seam welding – Gas metal arc welding – Flux cored – Submerged arc welding – Electro slag welding – TIG welding – Principle and application of special welding processes - Plasma arc welding – Electron beam welding – Friction welding – Diffusion welding – Weld defects – Brazing and soldering process – Methods and process capabilities – Filler materials and fluxes – Types of Adhesive bonding.

UNIT–V: Unconventional Machining Processes **9**

Introduction, Classification, Applications, Benefits Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining, Ultrasonic Machining, principles and process parameters Electrical Discharge Machining, principle and processes parameters, MRR, surface finish maskant, process parameters, MRR and surface finish. Laser Beam Machining (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Apply the concepts of different metal casting processes, associated defects	**PO2**
2.	Gain the knowledge in various metal forming processes.	**PO2**
3.	Understand the sheet metal and forming processes.	**PO2, PO3**
4.	Understand the application of welding process	**PO2**
5.	Understand the different unconventional Manufacturing Methods employed for making different products.	**PO1, PO2**
TEXT BOOK		
1.	Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)- Pearson India, 2014	
2.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 3rd Edition, 2009.	
3.	J.T. Black & Ronald A. Kohser, Degarmo's Materials and Processes in Manufacturing, John Wiley & Sons, 12th Edition 2017.	
REFERENCES		
1.	Banga T.R, Agarwal. R.K. & Manghrani. T.M., "Foundry Engineering", Khanna Publishers, New Delhi, 1995	
2.	Jain.R.K. "Production Technology" Khanna Publishers, 1988	
3.	Bhattacharyya.A. "Metal Cutting Theory and Practice", Central Book Publishers, 1984	
4.	S. K. Hajra Chowdhery, & A. K. Hajra Chowdhery, Elements of Workshop Technology, Vol 1 & 2, Media Promoters and Publishers, 2007, 14th Edition.	

Course Title	THERMAL ENGINEERING LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES
• To study the valve timing and Port timing diagram of I.C. Engines.
• To study the properties of fuels / lubricants used in I.C. engines
• To conduct the performance test on single / twin cylinder I.C. engines using different loading arrangements.
• To study the heat balance behaviour of I.C. engines
• To study the performance behaviour of compressor / blower

LIST OF EXPERIMENTS	
1.	Performance test on single stage reciprocating air compressor
2.	Performance test on constant speed centrifugal air blower
3.	Valve timing diagram on single cylinder four stroke petrol engine
4.	Port timing diagram on single cylinder two stroke petrol engine
5.	Load test on single cylinder petrol engine
6.	Performance test on high speed diesel engine with alternator loading
7.	Preparation of heat balance sheet on diesel engine
8.	Performance test on slow speed – diesel engine
9.	Performance test on twin cylinder diesel engine
10.	Performance, Noise and Smoke Measurement of diesel engine.
11.	Performance characteristic and Morse test on a multi cylinder petrol engine
12.	Testing of fuels and lubricants using Saybolt and Redwood viscometer
13.	Flash and fire point of fuels and lubricating oil.
14.	Performance testing of Solar flat plate collector.
15.	Performance testing of concentric (Parabolic) collector

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Analyse the performance behaviour of petrol / diesel engine.	**PO2**
2.	Draw up the heat balance sheet of I.C. engines	**PO4**
3.	Analyse the power developed by each cylinder in a multi cylinder engine	**PO2**
4.	Analyse the properties of fuels / lubricants used in I.C. engines.	**PO2**
5.	Understand the various strokes & scavenging process of I.C. engines.	**PO4**

TEXT BOOK	
1.	Arora.C.P, "Refrigeration and Air Conditioning ," Tata McGraw-Hill Publishers 2017
2.	Ganesan V.." Internal Combustion Engines",3rd Edition, Tata McGraw-Hill 2017
REFERENCES	
1.	Rudramoorthy, R, "Thermal Engineering ",Tata McGraw-Hill, New Delhi,2003
2.	Sarkar, B.K,"Thermal Engineering" Tata McGraw-Hill Publishers, 2007
3.	P. L. Ballaney, Thermal Engineering, Khanna Publishers, 2007, 24th Edition.

Course Title	STRENGTH OF MATERIALS LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES

- To supplement the theoretical knowledge gained in Mechanics of Solids with practical testing for determining the strength of materials under externally applied loads.
- This would enable the student to have a clear understanding of the design for strength and stiffness.

LIST OF EXPERIMENTS

1.	Tension test on MS rod and twisted bar (UTM)
2.	Compression test on bricks and concrete blocks (UTM)
3.	Comparison of hardness value of steel, copper and aluminium using Rockwell, Brinelland Vickers hardness measuring machines
4.	Estimation of notch toughness of steel using impact testing machine
5.	Fatigue test on steel
6.	Compression test on wood
7.	Estimation of spring constant under tension and compression
8.	Tension test on MS wire (Tensile Testing Machine)
9.	Double shear test (UTM)
10.	Torsion test on mild steel.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Perform different destructive testing.	**PO2, PO4**
2.	Characterise materials.	**PO2, PO4**
3.	Find the properties of materials	**PO2, PO4**
4.	Compare the material properties	**PO2, PO4**
5.	Perform different hardness testing	**PO2, PO4**

TEXT BOOK

1.	Beer & Johnson, Mechanics of materials, SI Metric Edition, McGraw Hill, ISE, 2017.
2.	Gere and Timensenko, Mechanics of Materials, CBS Publishers, 2006.

REFERENCES

1.	S.P. Timoshenko J.N Goodier, Theory of Elasticity, Mc Graw Hill International Edition, 2017.
2.	S.M.A.Kazimi, Solid Mechanics, Tata McGraw Hill Publishing Company Ltd., 2004.
3.	Timoshenko & D.H. Young, J.V. Rao, Sukumar Pati, Engineering Mechanics, McGraw Hill, 2017.
4.	J. B. K Das & P.L. Srinivasa Murthy, Mechanics of Materials, Sapna Book House, 2018.

SEMESTER – III

Course Title	METROLOGY AND QUALITY CONTROL **Note :** Use of approved statistical table permitted in the examination	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the concept of metrology and principles of measuring instruments
- To understand the concept of different types of comparative measurements
- To gain the knowledge about calibration technique in measuring instruments
- To impart knowledge on quality control and control charts
- To impart the knowledge on control charts for variables

UNIT - I BASICS OF METROLOGY **9**

Definition of metrology - Objective of metrology - Precision and Accuracy - Sources of errors - Concept of Repeatability, Sensitivity, Readability and Reliability – Linear measurements – types – Vernier caliper – Micrometer – types - Vernier height gauges – depth gauges – Slip gauges – Angular measurements – Types - Vernier and optical Bevel protractor - Sine Principle and Sine Bar - Optical Instruments for angular measurement – Autocollimator - Angle Gauge.

UNIT – II COMPARATIVE MEASUREMENT **9**

Comparators – Introduction – Characteristics and uses – types – mechanical – Optical – profile projector – Electrical – pneumatic – Testing of straightness – Flatness – parallelism and circularity- Limit gauges – types- Taylors principle - Snap gauges – plain plug gauges – progressive plug gauges - Ring gauges – Thread pitch gauges - feeler gauges – radius gauges – engineers square and parallel – dial gauges – types – plunger type – needle type – Magnetic V block.

UNIT - III CALIBRATION AND MEASURING MACHNES **9**

Introduction – sensitivity – Range – standards – Traceability - Calibration of Vernier caliper – Micrometer – Dial gauges – Measurement using surface roughness tester – Co-ordinate measuring machine – Types - Tool makers microscope - Gear measurement – Gear tooth caliper – Circular pitch measuring machine – Parkinson gear tester – shore hardness tester – Surface plates – bore gauges – Machine tool metrology for Lathe.

UNIT - IV QUALITY CONTROL FOR VARIABLES **9**

Introduction, definition of quality – Facts of quality - basic concept of quality, definition of SQC, benefits and limitation of SQC, Quality assurance - Concepts of Quality control - 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 (P & C) chart – six sigma concept – Elements of quality costs.

UNIT - V	PROCESS CONTROL FOR ATTRIBUTES	9
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 – Acceptance sampling plan – Types - 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.		
Note : Use of approved statistical table permitted in the examination		

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the basics of metrology and linear and angular measuring instruments	**PO1, PO2**
2.	Explain the working principles of comparators and limit gauges	**PO2**
3.	Determine the status of the measuring instruments and different parameters using measuring machines	**PO2**
4.	Understand the concepts of quality and to Solve the problems in process control charts for variables	**PO2, PO4**
5.	Solve the problems in process control charts for attributes	**PO4**
TEXT BOOK		
1.	R.K.JAIN, Engineering Metrology, Khanna publishers, 21st edition, 1984	
2.	GRANT, EUGENE.L "Statistical Quality Control", Tata McGraw-Hill, 7th edition, 2005	
REFERENCES		
1.	MONOHAR MAHAJAN, "Statistical Quality Control", Dhanpat Rai & Sons, 2001.	
2.	R.C.GUPTA, "Statistical Quality control", Khanna Publishers, 9th edition, 1998.	
3.	BESTERFIELD D.H., "Quality Control", Prentice Hall, 7th edition, 2003.	
4.	SHARMA S.C., "Inspection Quality Control and Reliability", Khanna Publishers, 2002.	

Course Title	DYNAMICS OF MACHINES	Credits	L T P C
Course Code			2 1 0 3
Course Category	PCC		

OBJECTIVES

- To understand the undesirable effects of unbalances resulting from prescribed motions in mechanism
- To understand the force motion relationship in components subjected to external forces and analysis of standard mechanisms.
- To understand the principle in mechanisms used for speed control and stability control.
- To understand the effect of dynamics of free vibrations.
- To understand the effect of dynamics of forced vibrations.

UNIT – I **9**

BALANCING - Static and dynamic balancing of rotating masses in different planes, partial balancing of reciprocating masses of in – line, V, W and radial engines. Hammer blow and swaying couple in locomotive, direct and reverse crank method.

UNIT – II **9**

INERTIA FORCE - Inertia force and inertia torque calculation. Turning moment diagrams, reciprocating engine mechanisms, fluctuation of energy and speed, Weight of flywheels.

UNIT – III **9**

GOVERNORS AND GYROSCOPE - Function of governors – porter, proell and spring-loaded governors, sensitivity, stability, hunting and isochronisms, effect of friction, calculation of equilibrium speeds and ranges of speed of governors. Gyroscope – couple and effect, in ship and motor cycle, car, aircraft and space vehicles, Gyroscope stabilization.

UNIT – IV **9**

FREE VIBRATION - Undamped free vibration of single degree of freedom system, simple pendulum, compound pendulum, inclined spring-mass system, equivalent stiffness of spring combinations – springs in series, springs in parallel, combined series and parallel springs. Damped free vibration of single degree of freedom systems, types of damping, free vibrations with viscous damping, critically damped system, under damped system.

UNIT – V **9**

FORCED VIBRATION - Forced vibration of single degree of freedom system. Constant harmonic excitation, steady state vibration, magnification factor with frequency ratio for various damping. Transverse vibrations of beams –natural frequency by energy method, Dunkerly method-Vibration isolation and transmissibility, whirling of shafts. Torsional vibrations: Torsional vibrations of single and multiple rotor systems, Equivalent shafts, Geared systems, Holzer's method.

CO	COURSE UTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Analyze the effects of unbalances in mechanism	**PO2**
2.	Analyze the force motion relationship of standard mechanisms	**PO1, PO2**
3.	Analyze and calculate speed control and stability control in mechanisms.	**PO2**
4.	Analyze the effect of dynamics of free vibrations.	**PO2**
5.	Analyze the effect of dynamics of forced vibrations	**PO2**

TEXT BOOK	
1.	AMITABH GHOSH AND ASHOK KUMAR MALLIK, Theory of mechanism and Machines – 3nd Edition, Affiliated East West Press Limited, 2007.
2.	J.E.SHIGLEY AND J.J.VICKER Jr. Theory of Machines and Mechanism, 2nd ed. Mc GrawHill ISE 1995
3.	R.S. KHURMI & GUPTA .J.K, A text book of Theory of Machines, S. Chand & Co., 2008, 14th Edition.
4.	G.K.GROVER, Mechanical Vibrations, New Chand and Brothers, Roorkee.
REFERENCES	
1.	J.HANNAH AND R.C STEPHENS ARNOLD, Mechanics of Machines – ISE 1986.
2.	BEER & JOHNSTON 5TH Edition, Vector Mechanics for Engineers. McGraw Hill. ISE 1988.
3.	THOMAS BEVAN – 3rd Edition, The Theory of Machines – CBS 1984.
4.	P.L.BALLANEY, Theory of Machines, Khanna Publishers, 2005, 24th Edition.
5.	S.S.RATTAN, Theory of Machines, Tata McGraw Hill. 2008, 2nd Edition.
6.	RAO .J.S. & DUKKIPATI. R.V. Mechanism and Machine Theory, 2nd ed. Wiley Eastern Ltd., 2007,
7.	HAMILTON H. MABIE & CHARLES F. REINNOLTZ, Mechanisms and Dynamics of Machinery, 4th ed. John Wiley & Sons, 1995
8.	THOMSON W.T, Theory of Vibration and Applications, Prentice Hall India, 1975
9.	Sadhu Singh, Theory of Machines, Pearson Education Ltd, 2007.
10.	Ashok G. Ambekar, Mechanism and Machine Theory , Eastern Economy Edition. 2007.
11.	John. J. Uicker, Theory of Machines and Mechanisms, Oxford University Press, 2008, 3rd Edition.
12.	S. S. Rao, Mechanical Vibrations, Pearson Education, 2007, 4th Edition.

Course Title	INSTRUMENTATION AND CONTROL	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To provide a basic knowledge about measurement systems and their components
- To learn about various sensors used for measurement of mechanical quantities
- To identify the type of measuring instrument required for a specific application.
- To learn about system stability and control
- To integrate the measurement systems for process monitoring and control

UNIT – I **9**

General concept – Generalised measurement system-Units and standards-measuring instruments: sensitivity, stability, range, accuracy and precision-static and dynamic response-repeatability-systematic and random errors-correction, calibration - Introduction to Dimensional and Geometric Tolerancing – interchangeability.

UNIT – II **9**

PRESSURE MEASUREMENT: Gravitational, Bourdon, Elastic transducers, strain gauge, Pressure cells, Measurement of high and low pressure, Dynamic characteristic of pressure measuring devices.

TEMPERATURE MEASUREMENT: Bi-metallic, pressure and resistance thermometer, Thermocouples, Pyrometer and Thermistors, Calibration. Pressure and temperature measurement in rotating systems – slip rings.

FLOW MEASUREMENTS: Orifice, flow nozzle, venturi, pitot tube, rotometer, Turbine type Anemometer, Hot-wire anemometer, Magnetic flow meter, Ultrasonic flow meter - Calibration.

DENSITY MEASUREMENT: Phenometer, Hydrometer, differential bubbling, Liquid level Measurements. VISCOSITY: Capillary tube viscometer, efflux viscometer, falling sphere viscometer, Rotating cylinder viscometer.

HUMIDITY: Sling psychrometer, Absorption hydrometer, Dew point meter.

UNIT – III **9**

STRAIN: Strain gauges, types, surfaces preparation and bonding technique, Wheatstone Circuit, Temperature compensation, Gauge rosettes, Calibration.

FORCE MEASUREMENT: Scales and balance, Elastic force meter, Strain gauge, Load cells Hydraulic and pneumatic load cells.

TORQUE MEASUREMENT: Mechanical torsion meter, Optical torsion meter, Electrical torsion meter, Strain gauge torsion meter.

UNIT – IV **9**

CONTROL SYSTEMS**:** Open and closed systems, Servomechanisms, Transfer function, Signal flow graphs, Block diagram algebra, Hydraulic and pneumatic control systems. Two-way control, proportional control, differential and integral control. Simple problems.

UNIT – V **9**

Time response of first order and second order systems. Concept of stability. Necessary Condition for stability, Routh stability constraint, Polar and Bode plots, Nyquist stability Criterion. Simple problems.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the measurement of various quantities using instruments.	**PO1**
2.	Understand the types of sensors used in mechanical systems	**PO1, PO2**
3.	Understand their accuracy & range of usage of the instrument	**PO1, PO2**
4.	Understand the techniques for controlling devices automatically.	**PO1, PO2**
5.	Understand the techniques used in process monitoring and control systems.	**PO1, PO2**
TEXT BOOK		
1.	Instrumentation and control systems by W. Bolton, 2nd edition, Newnes, 2000	
2.	Thomas G. Beckwith, Roy D. Marangoni, John H. LienhardV , Mechanical Measurements (6th Edition), Pearson Education India, 2007	
3.	Gregory K. McMillan, Process/Industrial Instruments and Controls Handbook, Fifth Edition, Tata McGraw-Hill: New York, 1999.	
REFERENCES		
1.	B.G. KUO, Automatic Control Systems, Tata McGraw Hill, ISE.	
2.	D' AZZO AND HOUPIS, Feedback Control Systems - Analysis and synthesis, Tata McGraw Hill. ISE.	
3.	KUMAR. D.S. Mechanical Measurements & Control, Metropolitan Book Co., 1989	
4.	SIROHI RS. & RADHAKRISHNAN H.C, Mechanical Measurement, New Age International (P) Ltd., 2005, 3rd Edition.	
5.	RANGAN C.S, SARMA G.S & MANI VSV, Instrumentation Device and Systems, TMH, 1989	
6.	DOEBLIN, Measurement Systems Application and Design, TMH, 1990	
7.	A. K. Sawhney, Mechanical Measurements and Instrumentation, Dhanpat Rai & Company (P) Ltd, 2007, 12th Edition	
8.	R.K. Jain, Mechanical and Industrial Measurements, Khanna Publishers, 2004, 12th Edition.	
9.	M. Gopal, Control Systems, TMH, 2007, 2nd Edition.	

Course Title	DESIGN OF MACHINE ELEMENTS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To familiarize various steps involved in the design process and failure of machine parts.
- To understand the design principles of shafts with cyclic loads and various springs.
- To know the design procedures of shafts, keys and couplings
- To study and analyse welded and riveted joints.
- To understand and design various types of joints for assembly.

UNIT – I **9**

Introduction to design process – factor influencing the machine design, selection of material based on its physical properties. Direct, bending and torsional stress equation, impact and shock loading. Criteria of failure – factor of safety, design stress, theories of failures – simple problems.

UNIT – II **9**

Variable and cyclic loads – fatigue strength and limit, S-N curve, stress concentration factor, size factor, surface finish factor, combined cyclic stress, Soderberg and Goodman's equations. Design of helical, leaf, disc, and torsional springs under constant load and varying load.

UNIT – III **9**

Design of solid and hollow shaft based on strength, rigidity, combined twisting and bending, shafts with fluctuating loads. Keys – types, design and drawing of keys, keyways. Couplings – types, design of rigid and flexible couplings.

UNIT – IV **9**

Welded joints – strength of transverse and parallel fillet joints, stress concentration factor for welded joints, Eccentrically loaded joints. Riveted joints – failure of riveted joints, strength, efficiency, design of riveted joints for pressure vessel and structure.

UNIT – V **9**

Threaded fasteners, design of socket and spigot cotter joint, sleeve and cotter joint, gib and cotter joint, knuckle joints, and pipe joints.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Get familiarized in various steps involved in the design process.	**PO1, PO2**
2.	Understand and design shafts with cyclic stresses and various springs.	**PO2, PO3**
3.	Design shafts with different loads, keys and couplings.	**PO3**
4.	Design and evaluate the features of welded and riveted joints.	**PO3**
5.	Design various types of joints for assembly of machine structures.	**PO2, PO3**

TEXT BOOK	
1.	JOSEPH EDWARD SHIGHLEY, Mechanical Engineering Design, McGraw Hill. 2008, 8th Edition.
2.	R.S. KHURMI & GUPTA JK, A text book of Machine Design, S. Chand & Co.,
3.	DONALDSON. C, Tool Design, Tata McGraw Hill & Co.
REFERENCES	
1.	A.S. HALL, A.R. HOLOWENKO, AND H.G. LAUGHLIM, Theory And Problems In Machine Design Schaum's series
2.	HALL AND ALLEN. S. Machine Design, Schaum's Series. 2008, TMH.
3.	M.F. Spolts, Design of Machine Elements, Pearson Eduction, 2005, 7th Edition.
4.	Gitin M. Maitra, Hand Book of Mechanical Design, 2nd Edition.
5.	J. B. K Das, Design of Machine Elements, Sapna Book House, 2007, 2nd Edition.
6.	A. S. Ravindra, Design of Machine Elements, Best Publishers, 2005. 2nd Edition.
7.	V. B. Bhandari, Design of Machine Elements, TMH, 2007.
Hand book	
1.	Design data book, PSG College of technology, Coimbatore. (Use of approved data books are permitted in all the examinations)

Course Title	MANUFACTURING TECHNOLOGY	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the concepts metal cutting
- To provide knowledge on various types of lathes used
- To understand the difference between shaper planner and slotter in manufacturing domain
- To provide knowledge on different types of grinding machines and related tools for manufacturing various components
- To identify the basic gear manufacturing machines used in industries

UNIT – I **9**

THEORY OF METAL CUTTING - Introduction, mechanics of metal cutting –Chip formation, Types of Chips, Cutting force calculations, Torque and Power Calculations in Machining, nomenclature of single point cutting tool, Tool materials, Influence of tool Geometry, Tool Life, machining time calculation, Machinability – evaluating and rating, metal cutting economics, problems in Merchant's
circle, tool life, and machining time.

UNIT – II **9**

LATHE-Centre lathe, constructional features, cutting tool geometry, various operations, taper turning methods, thread cutting methods, special attachments, machining time and power estimation. Capstan and turret lathes – automats – single spindle, Swiss type, automatic screw type,
multi spindle - Turret Indexing mechanism, bar feed mechanism.

UNIT – III **9**

SHAPER, PLANER AND MILLING PROCESSES - Shaper, Planer and Slotter: Introduction, types, specification, mechanism - holding devices, hydraulic drives in shaper, difference between shaper and planer.
Introduction, types and specifications, mechanisms, holding devices, types of milling operation. Milling tool nomenclature and its specifications, Indexing – Types-Simple, Compounding and differentials.

UNIT – IV **9**

Abrasive processes: grinding wheel – specifications and selection, types of grinding process– cylindrical grinding, surface grinding, centreless grinding, internal grinding- micro finishing methods - Typical applications – concepts of surface integrity, broaching machines: broach
construction – push, pull, surface and continuous broaching machines.

UNIT – V **9**

Gear manufacturing processes - Gear Machining-Forming or Form cutting - Gear generating process- Gear shaping, Gear hobbing Gear planning, Gear broaching. Bevel gear generation.
Gear finishing process- Gear Finishing Methods – Gear Shaving, Gear Grinding, Gear lapping, Gear honing.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the mechanics of metal cutting process	**PO1**
2.	Understand the various types of lathe machines	**PO1**
3.	Understand the shaper, planer and slotter machines	**PO1**
4.	Understand the application grinding operation in manufacturing	**PO1**
5.	Understand the gear manufacturing used in industries	**PO1**
TEXT BOOK		
1.	Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)-Pearson India, 2014.	
2.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 3rd Edition, 2009.	
3.	Degarmo's Materials and Processes in Manufacturing, Black & Kohser, Wiley, 2008.	
4.	Hajra Choudhury, "Elements of Workshop Technology, Vol. I and II", Media Promotors Pvt Ltd., Mumbai, 2001.	
REFERENCES		
1.	B.S. Magendran Parashar & R.K. Mittal,"Elements of Manufacturing Processes", Prentice Hall of India, 2003	
2.	P.N. Rao,"Manufacturing Technology",Tata McGraw-Hill Publishing Limited, II Edition, 2002.	
3.	P.C. Sharma, "A text book of production technology",S. Chand and Company, IV Edition, 2003.	
4.	Beddoes.J and Bibby M.J, 'Principles of Metal Manufacturing Processes', Elsevier, 2006	

Course Title	MANUFACTURING TECHNOLOGY LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES

- To learn the basic hand tools and to know the need for safety in the work place
- To gain hands on experience in foundry operations, smithy, welding and lathe processes
- To gain skill and hands on experience on smithy work
- To gain skill and hands on experience on welding processes
- To gain skill and hands on experience on lathe operations

LIST OF EXPERIMENTS

FOUNDRY	
1.	Study of moulding tools, equipment's, and furnaces
2.	Preparation of green sand moulding for cubical block, gland, bush, straight pipe, bend pipe, tee- pipe, grooved pulley, involving 2 boxes
3.	Sand testings – Permeability, green sand strength and compressibility.
4.	Metal casting techniques (demo only)
SMITHY	
1.	Study of tools and forges
2.	Converting a square out of round rod
3.	Making L – bend, J- hook, U- clamp
4.	Making a square/hexagonal headed bolt
WELDING	
1.	Exercises in electric arc welding like Butt joint, Lap joint, Tee joint and fillet
2.	Gas welding and gas cutting – template cutting
3.	MIG and TIG welding
LATHE	
1.	Study of lathe – types – accessories – capabilities and process – specification
2.	Lathe operation – plain & step turning, taper turning, grooving and under cutting, knurling, thread cutting (single, multistart and internal), eccentric turning
3.	Exercise on drilling, reaming, boring & tapping
4.	Exercise on capstan lathe/ Turret Lathe.
5.	Single point tool grinding using bench grinder (DEMO).

SPECIAL MACHINES		
1.	Machining of plane and inclined surfaces, grooving, dovetail cutting using shaping machine.	
2.	Cutting of spur, helical, bevel gear and milling of polygon surface using milling machine.	
3.	Making of spur gear using gear Hobbing machine.	
4.	Making of helical gear using gear Hobbing machine.	
5.	Cutting of keyway (internal & external) using slotting machine	
6.	Exercises involving cylindrical grinder	
7.	Exercises involving surface grinder	
8.	Exercises involving tool & cutter grinder	
9.	Exercises involving center less grinder	
CO	**COURSE OUTCOMES**	**PO**
Upon completion of this course, Students should be able to		
1.	Use foundry tools to make the green sand mould for the given component	**PO5, PO9**
2.	Use of smithy tools to make product for a given component	**PO5, PO9**
3.	Perform welding operations for a given component	**PO5, PO9**
4.	Perform simple turning and facing in a given component	**PO5, PO9**
5.	Understand the semi automats and perform drilling on the given component using lathe machine Make a product using lathe operations	**PO5, PO9**
TEXT BOOK		
1.	Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)-Pearson India, 2014.	
2.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 3rd Edition, 2009.	
REFERENCES		
1.	B.S. Magendran Parashar & R.K. Mittal,"Elements of Manufacturing Processes", Prentice Hall of India, 2003	
2.	P.N. Rao,"Manufacturing Technology",Tata McGraw-Hill Publishing Limited, II Edition, 2002.	
3.	P.C. Sharma, "A text book of production technology",S. Chand and Company, IV Edition, 2003.	

Course Title	DYNAMICS MEASUREMENTS LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES

- To make the students understand about the basic measuring devices.
- To teach the students about the metrological devices such as profile projector, microscopes etc.
- To understand the functions of pressure, temperature, speed and force measuring devices.
- To study about the motion measuring devices and balancing devices.
- To understand the functions and applications of vibration devices and governors.

LIST OF EXPERIMENTS

METROLOGY LAB	
1.	Use precision measuring instruments and calibration – Vernier caliper – Vernier height gauge – micrometer (outside) dial gauge and depth gauge
2.	Measurement of gear tooth thickness by Gear tooth Vernier
3.	Measurements of angles and tapers using bevel tooth protractors, sine bar and sine centers
4.	Measuring fundamental dimensions of gear using profile projector
5.	Testing squareness of try square using slip gauges
6.	Determination of tool angle using tool makers microscope
7.	Use of mechanical comparator for determining – flatness
8.	Use of bore gauges or measuring internal diameter
9.	Taper and bore measurements using spheres
10.	Checking straightness of a surface plate using Autocollimator
11.	Measurement of surface roughness using roughness meter.
INSTRUMENTATION	
1.	Pressure measuring devices – pressure & vacuum gauge calibration
2.	Temperature measuring devices – Thermocouples
3.	Speed measuring device – Stroboscope, tachometer
4.	Force measuring device – load cells, proving rings
5.	Torque measuring device – Rope & Prony brake arrangements
6.	Strain measurement - strain gauge
7.	Displacement measuring device – LVDT
8.	Velocity and acceleration measurement – Accelerometer - Piezo electric accelerators
9.	Vibration measurement – Vibrometer

DYNAMICS		
1.	Study of cutting force using lathe/drill tool dynamometer	
2.	Determination of critical speed of whirling of shaft	
3.	Static & dynamic balancing of rotors	
4.	Dynamic balancing of masses using computerised m/c.	
5.	Determination of M.I by suspension of Simple and compound pendulum method	
6.	Study of undamped of free vibration of equivalent spring mass system	
7.	Study of undamped torsional vibrations of single rotor system	
8.	Porter, Proell and Hartnell Governors	
9.	Characteristics of Hydrodynamics – journal bearing.	
10.	Cam and follower analysis.	
CO	**COURSE OUTCOMES**	**PO**
Upon completion of this course, Students should be able to		
1.	Understand about the purpose of basic measuring devices.	**PO5, PO9**
2.	Understand the functions of metrological devices such as profile projector, microscopes etc.	**PO5, PO9**
3.	Know about the applications and working procedure of pressure, temperature, speed and force measuring devices.	**PO5, PO9**
4.	Understand the working procedure and applications of measuring devices and balancing devices.	**PO5, PO9**
5.	Know the functions and applications of vibration devices and governors.	**PO5, PO9**
TEXT BOOK		
1.	R. K. JAIN, Engineering Metrology, Khanna publishers, 21st edition, 1984	
REFERENCES		
1.	K. Padma Raju & Y. J. Reddy, Instrumentation and Control systems, McGraw Hill Education, 2007.	

SEMESTER – IV

Course Title	OPERATION RESEARCH & MANAGEMENT	Credits	L T P C
Course Code			3 0 0 3
Course Category	HSMC		

OBJECTIVES

- To provide acquaintance and training in using optimization techniques under limited resources for the engineering and business problems.

UNIT - I LINEAR MODELS **9**

The phase of an operation research study – Linear programming – Graphical method– Simplex algorithm – Duality formulation – Sensitivity analysis.

UNIT - II TRANSPORTATION MODELS AND NETWORK MODELS **9**

Transportation Assignment Models –Traveling Salesman problem-Networks models – Shortest route – Minimal spanning tree – Maximum flow models –Project network – CPM and PERT networks – Critical path scheduling – Sequencing models.

UNIT - III INVENTORY MODELS **9**

Inventory models – Economic order quantity models – Quantity discount models – Stochastic inventory models – Multi product models – Inventory control models in practice.

UNIT - IV QUEUEING MODELS **9**

Queueing models - Queuing systems and structures – Notation parameter – Single server and multi server models – Poisson input – Exponential service – Constant rate service – Infinite population – Simulation.

UNIT - V DECISION MODELS **9**

Decision models – Game theory – Two person zero sum games – Graphical solution- Algebraic solution– Linear Programming solution – Replacement models – Models based on service life – Economic life– Single / Multi variable search technique – Dynamic Programming – Simple Problem.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Properly formulate Linear Programming models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these LP problems.	**PO4, PO5**
2.	Appropriately formulate Network models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these Network problems.	**PO4, PO5**
3.	Fittingly formulate Inventory models for service and manufacturing systems.	**PO4, PO5**
4.	Appropriately formulate Queuing models for service and manufacturing systems and apply operations research techniques and algorithms to solve these Queuing problems.	**PO4, PO5**
5.	Properly formulate Decision models and replace models for service and manufacturing systems.	**PO4, PO5**

TEXT BOOK	
1.	Hillier and Libeberman, "Operations Research", Holden Day, 2005
2.	Taha H.A., "Operations Research", Sixth Edition, Prentice Hall of India, 2003.
REFERENCES	
1.	Bazara M.J., Jarvis and Sherali H., "Linear Programming and Network Flows", John Wiley, 2009.
2.	Budnick F.S., "Principles of Operations Research for Management", Richard D Irwin, 1990.
3.	Philip D.T. and Ravindran A., "Operations Research", John Wiley, 1992.
4.	Shennoy G.V. and Srivastava U.K., "Operation Research for Management", Wiley Eastern, 1994.
5.	Tulsian and Pasdey V., "Quantitative Techniques", Pearson Asia, 2002.

Course Title	CAD/CAM	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the basics of CAD/CAM.
- To gain exposure over the concepts of computer graphics.
- To learn about the geometric issues concerned to the manufacturing and its related areas.
- To understand the latest advances in the manufacturing perspectives.
- To provide an overview of how computers are being used in design, development of manufacturing plants.

UNIT- I - COMPUTER AIDED DESIGN **9**

Product Development Cycle – Introduction to CAD/CAM – Graphics I/O Devices -Bresenham's Algorithm and DDA, Graphics software, Clipping, Hidden line/surface removal, Color models Lighting and shading - Graphics Standards – Neutral File formats –IGES, STEP

UNIT-II–PRINCIPLES OF COMPUTER GRAPHICS **9**

Geometric Modelling – Wireframe, Surface and Solid – Parametric representation of curves & surfaces - CSG and B-Rep- World/device coordinate representations, 2D and 3Dgeometric transformations, Matrix representation, translation, scaling, shearing, rotation and reflection, composite transformations, concatenation.

UNIT- III CNC MACHINE TOOLS **9**

Introduction to NC, CNC, DNC- Manual part Programming – Computer Assisted Part Programming – Examples using NC codes- Adaptive Control – Canned cycles and subroutines – CAD / CAM approach to NC part programming – APT language, machining from 3D models.

UNIT- IV GROUP TECHNOLOGY, CAPP & FMS **9**

Introduction to part families-parts classification and cooling – group technology machine cells-benefits of group technology – Process Planning – CAPP & types of CAPP – Flexible manufacturing systems (FMS) – the FMS concept-transfer systems – head changing FMS –Introduction to Rapid prototyping, Knowledge Based Engineering.

UNIT V COMPUTER INTEGRATED MANUFACTURING **9**

CIM wheel – CIM Database- CIM-OSI Model– Networking Standards in CIM Environment – Network structure – Network architecture –TCP/IP, MAP – Virtual Reality, Augmented Reality- Artificial Intelligence and Expert system in CIM.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the basics of CAD/CAM.	**PO1**
2.	Exposure over the concepts of computer graphics.	**PO5**
3.	Learn about the geometric issues concerned to the manufacturing and its related areas.	**PO5**
4.	Understand the latest advances in the manufacturing perspectives.	**PO5**
5.	Provide an overview of how computers are being used in design, development of manufacturing plants.	**PO5**
TEXT BOOK		
1.	P.N. Rao, CAD/CAM: Principles and Applications 3rd Edition, Tata McGraw Hill, India, 2010.	
2.	Ibrahim Zeid and R. Sivasubramaniam, Mastering CAD/CAM, 2nd Edition, Tata McGraw Hill, India, 2009	
REFERENCES		
1.	Mikell P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education, 2007	
2.	James A. Rehg, Henry W. Kraebber, "Computer Integrated Manufacturing", Pearson Education. 2007	
3.	Donald Hearn and M.Pauline Baker "Computer Graphics" with OpenGL Prentice Hall, International, 2010	

Course Title	AUTOMOBILE ENGINEERING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the construction and working principle of various parts of an automobile.
- To understand the various engine auxiliary systems.
- To learn the construction and working principle of various transmission systems.
- To learn the construction and working principle of Steering, Brakes and Suspension systems
- To study the alternate sources of energy for IC Engines.

UNIT - I VEHICLE STRUCTURE AND ENGINES **9**

Types of automobiles - vehicle construction and different layouts, chassis, frame and body, Vehicle aerodynamics (various resistances and moments involved), IC engines –components-functions and materials, variable valve timing (VVT).

UNIT - II ENGINE AUXILIARY SYSTEMS **9**

Electronically controlled gasoline injection system for SI engines, Electronically controlled diesel injection system (Unit injector system, Rotary distributor type and common rail direct injection system), Electronic ignition system (Transistorized coil ignition system, capacitive discharge ignition system), Turbo chargers (WGT, VGT), Engine emission control by three-way catalytic converter system, Emission norms (Euro and BS)

UNIT - III TRANSMISSION SYSTEMS **9**

Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss drive and Torque Tube drive – four wheel drive.

UNIT - IV STEERING, BRAKES AND SUSPENSION SYSTEMS **9**

Principle of steering - Steering geometry and wheel alignment – Steering linkages – Power Steering, Wheels & Tyres – construction – tyre wear - Types of Front and rear axle, stub axles. Types of Suspension Systems, torsion bar – shock absorbers Pneumatic and Hydraulic braking Systems, Antilock Braking System (ABS), electronic brake force distribution (EBD) and Traction Control.

UNIT - V ALTERNATIVE ENERGY SOURCES **9**

Use of Natural Gas, Liquefied Petroleum Gas, Bio-diesel, Bio-ethanol, Gasohol and Hydrogen in Automobiles-Engine modifications–Performance, Combustion and Emission Characteristics of SI and CI engines with these alternate fuels - Electric and Hybrid Vehicles, Fuel Cell (Note: Practical training in dismantling and assembling of engine parts and transmission systems should be given to the students.).

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Recognize the various parts of the automobile and their functions and materials.	**PO1, PO6**
2.	Discuss the engine auxiliary systems and engine emission control.	**PO1, PO6**
3.	Distinguish the working of different types of transmission systems	**PO1, PO6**
4.	Explain the Steering, Brakes and Suspension Systems.	**PO1, PO6**
5.	Predict possible alternate sources of energy for IC Engines.	**PO1, PO6**

TEXT BOOK	
1.	Jain K.K. and Asthana. R.B, "Automobile Engineering" Tata McGraw Hill Publishers, New Delhi, 2017.
2.	Kirpal Singh, "Automobile Engineering", Vol 1 & 2, Seventh Edition, Standard Publishers, New Delhi, 15th Edition 2017.
3.	William H Crouse, Automotive Mechanics. Tata McGraw-Hill. 2010
REFERENCES	
1.	Ganesan V. "Internal Combustion Engines", Fourth Edition, Tata McGraw-Hill, 2017
2.	Heinz Heisler, "Advanced Engine Technology," SAE International Publications USA, 1998
3.	Joseph Heitner, "Automotive Mechanics," East-West Press, 2017.
4.	Martin W, Stockel and Martin T Stockle , "Automotive Mechanics Fundamentals," The Good heart - Will Cox Company Inc, USA ,1978
5.	Newton K,Steeds W and Garret T K. "Motor Vehicles", Butterworth Publishers, IE, 1996

Course Title	POWER PLANT ENGINEERING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the layout and various systems of coal based thermal power plant.
- To have the knowledge of types of boilers, mountings/accessories.
- To understand the layout and various systems of gas, diesel and hydel power plants.
- To understand the layout and various systems of nuclear power plant.
- To study the economics of power plant &estimate the costs of electrical energy generation.

UNIT – I THERMAL POWER PLANT **9**

Essential of steam power plant equipment – power station design – characteristics of steam power plant – layout – Stokers - Types– pulverized fuel firing – Principles of FBC – Types & arrangement of different FBC plants – Ash handling – dust collectors – draft measurements – chimneys – calculation of chimney heights – feed water treatment – air preheater – superheaters, condenser, cooling towers.

UNIT - II STEAM GENERATORS **9**

Boilers – types of modern high-pressure boiler – boiler mountings and accessories – thermal efficiency of boiler – boiler performance – selection of fuel for boiler – boiler maintenance – selection of boiler – heat balance sheet for boiler – Indian boiler act.

UNIT – III GAS TURBINE, HYDEL& DIESEL POWER PLANT **9**

Gas turbine power plant layout - Classification &comparison of different types – governing system. Hydroelectric power plant layout - Classification – storage reservoir plants – pump storage plants – MHD power plant. Diesel power plant layout - Various systems of diesel power plant.

UNIT - IV NUCLEAR POWER PLANT **9**

Nuclear Reactor - General components– types of reactors – pressurized water reactor (PWR), Boiling water reactor (BWR), heavy water cooled and moderated - reactor, gas cooled reactor, liquid metal cooled reactor, fast breeder reactor, site selection of nuclear power plant, comparison of nuclear power plant with thermal power plant. Nuclear materials – fuels – coolant – moderators & reflecting materials – control rod – shielding materials.

UNIT - V POWER PLANT ECONOMICS **9**

Load curves – Terminologies – effect of variable load on power plant design & operation – requirement of peak load plants – fixed or operating cost – load diversion – Power tariff methods – comparison of economics of various power plants – environmental hazards of various power plants.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Explain the layout, construction and working of the components inside a thermal power plant.	**PO1**
2.	Discuss the types of steam boilers & its performance	**PO1**
3.	Explain the layout, construction and working of the components inside a Diesel, Gas and hydel power plants.	**PO1**
4.	Explain the layout, construction and working of the components inside nuclear power plant.	**PO1**
5.	Explain the applications of power plants while extend their knowledge to power plant economics and environmental hazards and estimate the costs of electrical energy generation.	**PO6, PO7**

TEXT BOOK	
1.	El-Wakil. M.M., "Power Plant Technology", Tata McGraw – Hill Publishing Company Ltd., 2019
2.	ARCHIEW, CULP Jr., Principle of Energy Conversation, Tata McGraw Hill, 1979
3.	P. K. NAG, Power Plant Engineering, Tata McGraw Hill, 2017.4th Edition
4.	G. R. NAGPAL, Power Plant Engineering, Khanna Publishers, Sixteenth edition, 1995
REFERENCES	
1.	VOPAL AND STORTZKI, Power Plant Engineering, PHI, year.
2.	DOMKUNDWAR, Power Plant Engineering, Dhanpat Rai & Sons., Eight Edition, 2016.
3.	JOEL WEISMAN AND ROY ECKART, Morden Power Plant Engineering, Prentice Hall, 1985.
4.	Thomas C. Elliott, Kao Chen and Robert C. Swanekamp, "Power Plant Engineering", Second Edition, Standard Handbook of Tata McGraw – Hill, 2nd edition, 2012.
5.	V. Kadambi, An Introduction to Energy Conversion, New Age Publication Ltd, 2011

Course Title	CAD/CAM LABORATORY	Credits	L T P C
Course Code	BMEP185P50		0 0 3 2
Course Category	PCC		

OBJECTIVES

- To gain practical experience in handling 2D drafting and 3D modelling software systems.
- To study the features of CNC machine tool.
- To expose students to modern control systems (Fanuc, Sinumeric etc.,)
- To know the application of various CNC machines like CNC lathe, CNC Vertical machining centre, CNC EDM and CNC wire-cut and study of rapid prototyping.

LIST OF EXPERIMENTS

3-D GEOMETRIC MODELLING (24- PERIODS)	
Creation of 3-D assembly model of following machine elements using 3-D modelling software Introduction of 3D Modelling software	
1.	Flange Coupling
2.	Plummer Block
3.	Screw Jack
4.	Lathe Tailstock
5.	Universal Joint
6.	Machine Vice
7.	Connecting rod
8.	Piston
9.	Crankshaft
MANUAL PART PROGRAMMING (21 PERIODS)	
I. Part Programming - CNC Machining Centre	
1.	Linear Cutting.
2.	Circular cutting.
3.	Cutter Radius Compensation.
4.	Canned Cycle Operations.
II. Part Programming - CNC Turning Centre	
1.	Straight, Taper and Radius Turning.
2.	Thread Cutting.
3.	Rough and Finish Turning Cycle.
4.	Drilling and Tapping Cycle.
III. Computer Aided Part Programming	
1.	CL Data and Post process generation using CAM packages.
2.	Application of CAPP in Machining and Turning Centre.
3.	Study of CNC EDM, CNC EDM Wire-Cut and rapid Prototyping.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Gain practical experience in handling 2D drafting and 3D modelling software systems.	**PO1, PO5**
2.	Study the features of CNC machine tool.	**PO1, PO5**
3.	Expose students to modern control systems (Fanuc, Sinumerik etc.,)	**PO1, PO5**
4.	Know the application of various CNC machines like CNC lathe, CNC Vertical machining centre, CNC EDM and CNC wire-cut and study of rapid prototyping.	**PO1, PO5**
TEXT BOOK		
1.	Prof. Sham Tickoo, Pro/Engineer Wildfire 4.0: For Engineers And Designers, Dreamtech Press, 2008.	
2.	K. Venugopal, Engineering Drawing & Graphics, New Age International, 2016.	
REFERENCES		
1.	Thomas Ewing French, Charles J. Vierck, Robert Jay Foster, Engineering Drawing and Graphic Technology, McGraw-Hill, 1993.	
2.	Frederick E. Giesecke, Alva E. Mitchell, Henry C. Spencer , Technical Drawing with Engineering Graphics, Mechanical Design Technology, 2016.	
3.	Kuang-Hua Chang, Machining Simulation Using SOLIDWORKS CAM, SDC Publications, 2019.	
4.	Hans B. Kief, Helmut A. Roschiwal, CNC Handbook, McGraw Hill Professional, 2012.	

SEMESTER – V

Course Title	HEAT AND MASS TRANSFER	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the mechanisms of conduction heat transfer under steady and transient conditions.
- To understand the mechanisms of convection heat transfer and boundary layer concept.
- To learn the thermal analysis and sizing of heat exchangers.
- To learn the concepts of radiative heat transfer & its related laws.
- To learn the basic concepts of mass transfer.

UNIT - I CONDUCTION **9**

General Differential equation of Heat Conduction– Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction –– plane and Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infinite and Infinite Solids –Use of Heisler's charts.

UNIT - II CONVECTION **9**

Free and Forced Convection - Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection of external flow over Plates and Cylinders and Internal flow through tubes – Dimensional analysis (Forced & free convection)

UNIT - III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS **9**

Nusselt's theory of condensation - Regimes of Pool boiling and Flow boiling. Correlations in boiling and condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factor - Analysis – LMTD method - NTU method.

UNIT - IV RADIATION **9**

Black Body Radiation – Radiation laws - Grey body radiation - Shape Factor – Electrical Analogy – Radiation Shields - Radiation through gases.

UNIT - V MASS TRANSFER **9**

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state molecular Diffusion – Convective Mass Transfer – Momentum, Heat and Mass Transfer Analogy –Convective Mass Transfer Correlations.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Apply heat conduction equations to different surface configurations under steady state and transient conditions and solve problems	**PO1, PO2**
2.	Apply free and forced convective heat transfer correlations to internal and external flows through/over various surface configurations and solve problems	**PO2, PO4**
3.	Explain the phenomena of boiling and condensation, apply LMTD and NTU methods of thermal analysis to different types of heat exchanger configurations and solve problems	**PO2**
4.	Explain basic laws for Radiation and apply these principles to radiative heat transfer between different types of surfaces to solve problems	**PO1, PO2**
5.	Apply diffusive and convective mass transfer equations and correlations to solve problems for different applications.	**PO2**

TEXT BOOK	
1.	Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2000
2.	Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw Hill, 5thEdition, 2015.
3.	R.C. Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, 2009.
REFERENCES	
1.	Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 1998.
2.	Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 1998.
3.	Nag, P.K., "Heat Transfer", Tata McGraw Hill, New Delhi, 2002
4.	Ozisik, M.N., "Heat Transfer", Tata McGraw Hill Book Co., 1994.

Course Title	DESIGN OF TRANSMISSION SYSTEMS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To understand the design concepts and applications of bearings, belt, chain and rope drives.
- To know the basic concepts and applications of clutches, brakes and cams and to design them for suitable applications.
- To know the design procedure and to design spur and helical gears for industrial applications.
- To understand the working procedure and to design various machine parts like power screws, worm gears, bevel gears and ratchet mechanism.
- To understand the design procedure for gear box of an automobile.

UNIT – I **9**

BEARINGS AND DRIVES - Design of sliding contact bearings using Somerfield number – design using Mckee's equation, selection of rolling contact bearing for radial and axial load combination and for varying load cycles.

Design of flat belt and 'V' belt using manufacturer's data, introduction to continuously variable speed transmission, design of step cone pulley, design of chain drives, design of hoisting and hauling ropes.

UNIT – II **9**

BRAKES, SCREWS AND CAMS - Design of clutches – Various service factors – dry and wet clutches, design of brakes - heat generation and dissipation in brakes – force analysis in drum brakes with external shoes – permissible bearing pressure – selection of brake material – braking power – power absorbed - bearing load calculations – width of shoe, design of band brakes – simple and differential type – width and thickness design. Introduction to design of disk brakes – brake lining fade.

Design of cams for parabolic, SHM, and cycloid follower motions, undercutting in cams – torque required to drive cams – polynomial motion cams – cam size determination – inertia force calculation – contact stress calculation.

UNIT – III **9**

DESIGN OF SPUR AND HELICAL GEARS - Design of spur and helical gears – design of Geneva wheel mechanism, power rating calculations based on strength and wear considerations – gear tooth correction.

UNIT – IV **9**

DESIGN OF POWER SCREWS - Design of power screws – wear and strength considerations – design of lead screws for machine tools, design of screw jacks and toggle jacks. Design of bevel and worm gears, design of Ratchet & Pawl mechanism.

UNIT – V **9**

MULTI SPEED GEAR BOXES - Design of speed reducers, design of multi speed gearboxes for Automobile - machine tools, structural and ray diagrams.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the design concepts and applications of bearings, belt, chain and rope drives.	**PO1, PO3**
2.	Know the concepts and applications of clutches, brakes and cams and to design them for suitable applications.	**PO1, PO3**
3.	Design spur and helical gears for industrial applications.	**PO1, PO3**
4.	Explain the working procedure and to design various machine parts like power screws, worm gears, bevel gears and ratchet mechanism.	**PO1, PO3**
5.	Understand the design procedure for gear box of an automobile.	**PO1, PO3**
TEXT BOOK		
1.	SUNDARARAJAMURTHY.T.V AND SHANMUGAM, Machine Design, Khanna Publishers.	
2.	JOSEPH EDWARD SHIGHLEY, Mechanical Engineering Design, McGraw Hill. 2008, 8th Edition.	
3.	R.S. KHURMI & GUPTA JK, A text book of Machine Design, S. Chand & Co.,	
4.	DONALDSON. C, Tool Design, Tata McGraw Hill & Co.	
REFERENCES		
1.	V. DOBROVOLSKY, Machine Elements, Mir Publication, 1978.	
2.	SHIGLEY, Mechanical Engineering Design, McGraw Hill.	
3.	MAITRA, Handbook of Gear Design, Tata McGraw Hill.	
4.	A.S. HALL, A.R. HOLOWENKO, AND H.G. LAUGHLIM, Theory And ProblemsIn Machine Design Schaum's series	
5.	HALL AND ALLEN. S. Machine Design, Schaum's Series. 2008, TMH.	
6.	M.F. Spolts, Design of Machine Elements, Pearson Eduction, 2005, 7th Edition.	
7.	Gitin M. Maitra, Hand Book of Mechanical Design, 2nd Edition.	
8.	J. B. K Das, Design of Machine Elements, Sapna Book House, 2007, 2nd Edition.	
9.	A. S. Ravindra, Design of Machine Elements, Best Publishers, 2005. 2nd Edition.	
10.	V. B. Bhandari, Design of Machine Elements, TMH, 2007.	
11.	A.S.HOLOWENKO, A.R., AND LAUGHLIN H.G Theory and problems in Machine Design, Hall, Schaum series.	
Hand Book		
1.	Design data book, PSG College of technology, Coimbatore. (Use of approved data books are permitted in all the examinations)	

Course Title	MECHATRONICS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To impart knowledge about the working principle of various sensors and transducers to measure the displacement, flow, temperature, force in Mechatronics systems which are very much essential to understand the emerging field of automation.
- To understand the principles of the various actuating systems, system models which are involved for the various Mechatronics systems.
- To develop mathematical models for various systems such as mechanical, electrical, thermal, electro mechanical and hydro mechanical systems
- To study about the working principle of Programmable logic controller (PLC) and its components and also, some case studies are discussed on the Mechatronics systems.
- To understand the different stage of design process and also know about the working of mechanical components through case studies.

UNIT – I **9**

Mechatronics, Sensors and Transducers: Introduction to Mechatronics Systems – Measurement Systems – Control Systems – Microprocessor based Controllers–Sensors and Transducers – Performance Terminology – Sensors for Displacement, Position and Proximity; Velocity, Motion, Force, Fluid Pressure, Liquid Flow, Liquid Level, Temperature, Light Sensors – Selection of Sensors.

UNIT – II **9**

Actuation Systems: Pneumatic and Hydraulic System –Directional Control Valves – Rotary Actuators. Mechanical Actuation Systems – Cam – Gear Train – Ratchet and pawl – Belt and Chain Drives –Bearings– Electrical Actuation Systems – Mechanical Switches – Solid State Switches –Solenoids – D.C Motors – A.C Motors – Stepper Motors.

UNIT – III **9**

System Models and Controllers: Building blocks of Mechanical, Electrical, Fluid and Thermal Systems, Rotational – Translational Systems, Electro-Mechanical Systems – Hydraulic – Mechanical Systems– Continuous and discrete process Controllers – Control Mode: Two –Step mode – Proportional Mode – Derivative Mode – Integral Mode – PID Controllers – Digital Controllers – Velocity Control – Adaptive Control – Digital Logic Control – Micro Processor Control.

UNIT – IV **9**

Programming Logic Controllers: Programmable Logic Controllers – Basic Structure – Memory – Input / Output Processing –Programming – Mnemonics – Timers, Internal relays and counters – Shift Registers – Master and Jump Controls – Data Handling – Analogs Input /Output – Selection of a PLC – PLC Applications.

UNIT – V **9**

Design of Mechatronics Systems: Stages in designing Mechatronics Systems – Traditional and Mechatronics Design – Possible Design Solutions–Case Studies: Pick and place robot –automatic Car Park Systems – Engine Management Systems Automatic Camera, Washing machine.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Demonstrate the basic structure of mechatronics system, different sensors and its characteristics.	**PO1**
2.	Evaluate various types of hydraulic and pneumatic actuators used in mechatronics and they will be able to design and develop simple hydraulic and pneumatic automation circuits.	**PO2, PO3**
3.	Illustrate the empirical models for the Mechanical, Electrical, Thermal, Fluid, Electro-mechanical and Hydro-mechanical Systems.	**PO2, PO3**
4.	Get the knowledge on the working principles of the different components of the programmable logic controller (PLC) with Ladder diagrams.	**PO2, PO3**
5.	Realize the working of the different real-world systems used in our daily life through various case studies.	**PO2, PO3**
TEXT BOOK		
1.	W. Bolton, "Mechatronics", Pearson Education, 3rd Edition, 2007.	
2.	HMT Ltd, Mechatronics, Tata McGraw Hill, 2007.	
REFERENCES		
1.	Michael B. Histand and David G. Alciatore, " Introduction to Mechatronics and Measurement Systems", McGraw-Hill International Editions, 2007. 3rd Edition	
2.	Bradley D. A., Dawson D., Buru N.C. and. Loader A.J, "Mechatronics", Chapman and Hall, 1993.	
3.	Dan Necsulesu, "Mechatronics", Pearson Education Asia, 2002 (Indian Reprint).	
4.	Lawrence J. Kamm, "Understanding Electro – Mechanical Engineering", An Introduction to Mechatronics, Prentice – Hall of India Pvt., Ltd., 2000.	
5.	Nitaigour Premchand Mahadik, "Mechatronics", Tata McGraw-Hill publishing Company Ltd, 2003	
6.	Prof. C. R. Venkataramana, Mechatronics, Sapna Book House, 2003.	

Course Title	HEAT TRANSFER LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES

- To study the conduction heat transfer phenomena, predict the thermal conductivity of materials.
- To study the convection heat transfer phenomena, predict the heat transfer co-efficient.
- To study the radiation heat transfer phenomena, predict the Stefan Boltzmann constant and emissivity.
- To analyse the performance of heat exchangers.
- To study the performance of refrigeration cycle / components

LIST OF EXPERIMENTS

1.	Thermal conductivity of metal rod
2.	Thermal conductivity measurement of pipe insulation using lagged pipe apparatus.
3.	Determination of heat transfer coefficient under natural convection mode.
4.	Determination of heat transfer coefficient under forced convection mode.
5.	Determination of Thermal conductivity of composite wall.
6.	Determination of Thermal conductivity of insulating powder.
7.	Heat transfer from pin-fin apparatus (natural & forced convection modes)
8.	Determination of Stefan – Boltzmann constant.
9.	Determination of emissivity of a grey surface.
10.	Effectiveness of Parallel / counter flow heat exchanger.
11.	Effectiveness of Shell & tube heat exchanger.
12.	Determination of heat transfer coefficient of film & dropwise condensation
13.	Determination of COP of a refrigeration system .

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Conduct tests on heat conduction apparatus and evaluate thermal conductivity of materials.	**PO4, PO5**
2.	Conduct tests on natural and forced convective heat transfer apparatus and evaluate heat transfer coefficient.	**PO5**
3.	Conduct tests on radiative heat transfer apparatus and evaluate Stefan Boltzmann constant and emissivity.	**PO5**
4.	Conduct tests to evaluate the performance of parallel/counter flow heat exchanger & shell & tube heat exchanger apparatus.	**PO2, PO5**
5.	Conduct tests to evaluate the performance of refrigeration test rig.	**PO2, PO5**

TEXT BOOK

1.	Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2000
2.	Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw Hill, 5th Edition, 2015.

REFERENCES

1.	Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 1998.
2.	Nag, P.K., "Heat Transfer", Tata McGraw Hill, New Delhi, 2002

Course Title	MECHATRONICS LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES

- To understand the functions of the various valves, logic gates and cylinders used in hydraulic & pneumatic systems through the simulation and PLC programming on the real-world systems
- To understand the working of servo systems and microcontrollers for a suitable application.
- To design and simulate the hydraulic and pneumatic circuits by using LABVIEW software.

LIST OF EXPERIMENTS

1.	Design and testing of fluid power circuits to control. (i) velocity (ii) direction and (iii) force of single and double acting actuators
2.	Design of circuits with logic sequence using electro pneumatic trainer kit.
3.	Simulation of basic hydraulic, Pneumatic and electric circuits using software.
4.	Circuits with multiple cylinder sequences in electro pneumatic using PLC.
5.	Servo controller interfacing for open loop.
6.	Servo controller interfacing for closed loop.
7.	PID controller interfacing.
8.	Stepper motor interfacing with 8051 Micro controllers. (i) full step resolution (ii) half step resolution
9.	Modeling and analysis of basic electrical, hydraulic and pneumatic systems using Lab View software.
10.	Computerized data logging system with control for process variables like Pressure, flow and temperature.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Study the sensors, components for pneumatic and hydraulic actuating systems.	**PO1, PO4, PO5**
2.	Demonstrate the functioning of mechatronics systems with various pneumatic, hydraulic and electrical systems.	**PO1, PO4, PO5**
3.	Develop pneumatic/hydraulic circuit for Industrial applications using automation software	**PO1, PO4, PO5**
4.	Demonstrate the functioning of control systems with the help of DC motors and stepper motors.	**PO1, PO4, PO5**
5.	Develop an understanding of PLC ladder diagram related to industrial automation systems and measure its performance.	**PO1, PO4, PO5**

TEXT BOOK

1.	W. Bolton, "Mechatronics", Pearson Education, 3rd Edition, 2007.
2.	HMT Ltd, Mechatronics, Tata McGraw Hill, 2007.

REFERENCES

1.	Michael B. Histand and David G. Alciatore, " Introduction to Mechatronics and Measurement Systems", McGraw-Hill International Editions, 2007. 3rd Edition
2.	Bradley D. A., Dawson D., Buru N.C. and. Loader A.J, "Mechatronics", Chapman and Hall, 1993.

SEMESTER – VI

Course Title	MACHINE DRAWING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To familiarize with the standard conventions for different materials and machine parts in working drawings.
- To understand the general aspects of Limits, Fits and Tolerances in the various parts of the machine drawings.
- To make part drawings including sectional views for various machine elements.
- To get the knowledge on the surface finish and welding symbols on the various machine elements.
- To prepare assembly drawings given the details of part drawings.

UNIT – I **9**

Indian standard code of practice for engineering drawing - BIS specifications - Conventional representations of threaded parts, springs, gear and common features - conventions for sectioning and dimensioning

UNIT – II **9**

General aspects of Limits, Tolerance – types – representation of tolerances on drawing, Fits – types – selection and specification of fits – allowance

UNIT – III **9**

Geometric tolerances – Form and positional tolerances – Surface finish and welding symbols on the machine elements

UNIT – IV **9**

Assembly and Detailed drawings of the various Machine Elements

UNIT – V **9**

Joints: Cotter joint and knuckle joint - **Couplings:** Flange coupling and Universal coupling - **Engine parts:** Connecting rod and Cross head for horizontal and vertical engines - **Machine tool parts:** Plummer block, Lathe Tail stock, Screw Jack, Machine Vices Swivel bearing, Tool head shaper

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the significance of the standard codes and specifications of the machine components	**PO1**
2.	Realize the importance of the conventional representations of machine parts, such as springs, gears and various threaded sections	**PO1, PO2**
3.	Understand the fundamentals of the fits, tolerance and allowances of the various machine parts	**PO1, PO2**
4.	Understand the working principles of an assembly of the final product from the various machine parts effectively	**PO2, PO3**
5.	Apply their knowledge to produce new machine parts to meet the standards effectively	**PO2, PO3**

TEXT BOOK	
1.	Gopalakrishna K.R., "Machine Drawing", 22nd Edition, Subhas Stores Books Corner, Bangalore, 2013
2.	K.L. Narayana, P.Kannaiah & K.Venkata Reddy., "Machine Drawing", New Age Publishers, 4th Edition, 2012
3.	Dhawan., "Machine Drawing", S. Chand Publications, 1st Revised Edition,1998
REFERENCES	
1.	N. D. Bhatt and V.M. Panchal, "Machine Drawing", 48th Edition, Charotar Publishers, 2013
2.	Junnarkar, N.D., "Machine Drawing", 1st Edition, Pearson Education, 2004
3.	N. Siddeshwar, P. Kanniah, V.V.S. Sastri, "Machine Drawing" , published by Tata Mc GrawHill, 2006
4.	Machine drawing – P.S. Gill S.K. Kataria & Sons Delhi
5.	P.S.G. Design Databook", Coimbatore

Course Title	COMPUTER AIDED ANALYSIS LABORATORY	Credits	L T P C
Course Code			0 0 3 2
Course Category	PCC		

OBJECTIVES

- To gain knowledge and develop skill for the 1D, 2D and 3D component to find out stress distribution and reactions
- To gain knowledge and develop skill for an Axisymmetric component analysis
- To gain knowledge and develop skill on modal and harmonic analysis of 2D and 3D components
- To gain knowledge and develop skill to find out temperature distribution on of 2D and 3D components

LIST OF EXPERIMENTS

1.	Force and stress analysis using link elements in trusses, cables etc.
2.	Stress and deflection analysis in beams with different support conditions.
3.	Stress analysis of flat plates and simple shells.
4.	Stress analysis of axi – symmetric components.
5.	Thermal stress and heat transfer analysis of plates.
6.	Thermal stress analysis of cylindrical shells.
7.	Vibration analysis of spring-mass systems.
8.	Model analysis of beams.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Use of finite element analysis knowledge to analyze the 1D, 2D and 3D components for stress analysis.	**PO2, PO5**
2.	Use of finite element analysis knowledge to analyze the 1D, 2D and 3D components modal and analysis.	**PO2, PO5**
3.	Use of finite element analysis knowledge to analyze the 1D, 2D and 3D components modal and harmonic analysis.	**PO2, PO5**
4.	Use of finite element analysis knowledge to analyze the 1D, 2D and 3D components thermal analysis	**PO2, PO5**

TEXT BOOK

1.	Tadeusz Stolarski , Y. Nakasone, S. Yoshimoto., Engineering Analysis with ANSYS Software 2nd Edition, Butterworth-Heinemann, 2018.
2.	Saeed Moaven, Finite Element Analysis: Theory and Application with ANSYS, Pearson Education, 2019.

REFERENCES

1.	DAVID V HUTTON "Fundamentals of Finite Element Analysis"2004. Tata McGraw-Hill Int. Ed.
2.	REDDY J.N., "An Introduction to Finite Element Method", McGraw-Hill International Student Edition, 1985
3.	Prof. Sham Tickoo, ANSYS Workbench 2019 R2: A Tutorial Approach, 3rd Edition, CADCIM Technologies, 2019.

SEMESTER – VII

Course Title	AUTOMATION IN MANUFACTURING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PCC		

OBJECTIVES

- To know the basic components of CIM and its hardware and software
- To understand about CAD/CAM and its integration with manufacturing
- To nurture the principles of computer aided process planning and GT
- To understand about different Control and monitoring systems used in CIM
- To study about FMS and its applications

UNIT - I INTRODUCTION TO AUTOMATION SYSTEM 9

Production system facilities, Manufacturing Support Systems, Automation in Production Systems, Automated Manufacturing Systems, Types of Automation, Computerized manufacturing Support System, Reasons for Automating, Manufacturing Industries and Products, Manufacturing operations, Product / Production Relationships, Production Concepts and Mathematical Models. Basic elements of an Automated System, Advanced Automation Functions, Levels of Automation.

UNIT – II INTEGRATION OF MANUFACTURING SYSTEM 9

Fundamentals of CAD, CAM and CAE, CIM Definition, CIM Wheel, CIM components, Evolution of CIM - Development of computers - Needs of CIM, Benefits of CIM. CIM Hardware & Software, CIM Models. DBMS and Network system - Data base and DBMS - requirement, features and architecture of DBMS. CIM Communications (Network) System, Communication Matrix, Network Architectures, Tools and Techniques.

UNIT - III AUTOMATED PROCESS PLANNING SYSTEM 9

Process Planning- Structure of Process Planning, Process Planning function, CAPP - Types of CAPP, Retrieval and Generative type CAPP, Concurrent engineering, Design for Manufacturing and Assembly, Advanced Manufacturing Planning. Group Technology – Introduction - coding and classification system, Production Flow Analysis, Coding System - OPTIZ, MICLASS, Benefits of Group Technology , Machine cell design.

UNIT – IV AUTOMATED CONTROL AND MONITORING SYSTEM 9

Fundamentals of NC Technology – Basic components of an NC System, NC Coordinate and Motion Control systems, Computer Numerical Control, Features of CNC, Machine Control Unit for CNC, CNC Software, DNC Machines, Application of NC machine tools Applications, Structure of CNC Machines, CNC Controllers, NC Part Programming, Computer-Assisted Part Programming.

Features and Applications of CNC Turning Centre, CNC Milling Machine, CNC Turn-Mill Centre, CNC machining Centre, CNC Tooling system and Automatic Tool Changing System, Computer Aided Quality Control - contact, non contact inspection methods, Coordinate Measuring Machine CMM - Integration of CAQC with CAD / CAM.

UNIT – V FLEXIBLE MANUFACTURING SYSTEMS		9
Introduction of FMS. Components of FMS, Type of FMS, Classification of FMS Configurations. FMS Planning, scheduling and control. Knowledge Based Scheduling, Applications and Benefits of FMS. Production Support Machines and Systems -Industrial Robots, Automated Material Handling, Automatic Guided Vehicles, Automated Storage and Retrieval system. Developments in Manufacturing Technologies- AI and Expert System, Agile manufacturing, Lean Manufacturing, Virtual Manufacturing, Simulation in Manufacturing – Factories of Future.		
CO	**COURSE OUTCOMES**	**PO**
Upon completion of this course, Students should be able to		
1.	Classify the Production system and Automated Systems in Manufacturing	**PO1, PO2, PO5**
2.	Discuss the various Components, Evolution, Network and Data base system for CIM.	**PO1, PO2, PO5**
3.	Acquire Process Planning, part coding and Group technology concept	**PO1, PO2, PO5**
4.	Get CNC machining and programming knowledge	**PO1, PO2, PO5**
5.	Obtain Knowledge in Flexible Manufacturing.	**PO1, PO2, PO5**
TEXT BOOK		
1.	KANT VAJPAYEE.S, Principles of Computer- Integrated Manufacturing; 1st ed. PHI	
2.	MIKELL P. GROOVER, Automation, Production Systems & CIM, 2nd ed. PHI.	
3.	James A.Rehg, Henry W.Kraebber, Computer- Integrated Manufacturing, second Edition, Pearson Education.	
4.	P.N. Rao, CAD/CAM Principles and Applications Second Edition, TMH.	
REFERENCES		
1.	Radhakrishnan.P, Subramanyan. S, Raju.V, 'CAD/CAM/CIM', Second Edition, New Age International publishers,	
2.	Daniel Hunt.V., 'Computer Integrated Manufacturing Hand Book', Chapman & Hall,	
3.	Groover M.P, 'Computer Aided Design and Manufacturing', Prentice Hall of India,	
4.	Yorem Koren, 'Computer Control of Manufacturing System', Tata McGraw Hill,	
5.	Ranky Paul. G., 'Computer Integrated Manufacturing', Prentice Hall International,.	
6.	ROGER MANNAM, Computer Integrated Manufacturing from Concepts of Realization 1st ed. Addison Wiley.	
7.	P. N. Rao, Computer Aided Manufacturing, TMH.	

Course Title	ENGINEERING ECONOMICS	Credits	L T P C
Course Code			3 0 0 3
Course Category	HSMC		

OBJECTIVES

- To understand about the basic principles and methodologies of economics such as demand-supply, government policies, taxes etc.
- To acquire knowledge in public sector economics which includes labour market, banking, debts etc.
- To understand the importance of managerial economics and various forms of organizations.
- To know the importance of process planning and cost estimation in engineering economics.
- To understand the procedure followed in economics of different machining operations.

UNIT – I **9**

Basic Principles and Methodology of Economics. Demand/Supply – elasticity – Government Policies and Application. Theory of the Firm and Market Structure. Basic Macroeconomic Concepts (including GDP/GNP/NI/Disposable Income) and Identities for both closed and open economies. Aggregate demand and Supply (IS/LM). Price Indices (WPI/CPI), Interest rates, Direct and Indirect Taxes.

UNIT – II **9**

Public Sector Economics –Welfare, Externalities, Labour Market. Components of Monetary and Financial System, Central Bank –Monetary Aggregates; Commercial Banks & their functions; Capital and Debt Markets. Monetary and Fiscal Policy Tools & their impact on the economy – Inflation and Phillips Curve.

UNIT – III **9**

Elements of Business/Managerial Economics and forms of organizations. Cost & Cost Control –Techniques, Types of Costs, Lifecycle costs, Budgets, Break even Analysis, Capital Budgeting, Application of Linear Programming. Investment Analysis – NPV, ROI, IRR, Payback Period, Depreciation, Time value of money (present and future worth of cash flows). Business Forecasting – Elementary techniques. Statements – Cash flow, Financial. Case Study Method.

UNIT – IV **9**

Introduction- methods of process planning-Drawing interpretation-Material evaluation – steps in process selection-.Production equipment and tooling selection Introduction to cost estimation- importance of costing and estimation, methods of costing, elements of cost estimation, types of estimates, estimating procedure, estimation of labor cost, material cost, allocation of overhead charges, calculation of depreciation cost.

UNIT – V **9**

Machining time estimation- importance of machine time calculation, machining time for different lathe operations, drilling and boring time calculations, Machining time calculation for Milling, Shaping, Planing and Grinding Production costs- different production processes for different jobs, estimation of forging cost, estimation of welding cost, estimation of foundry cost, estimation of machining cost.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Describe the role of economics in the decision-making process and perform calculations in regard to interest formulas	**PO1, PO4**
2.	Understand the Monetary and Fiscal Policy Tools	**PO1, PO4**
3.	Estimate the Present, annual and future worth comparisons for cash flows	**PO1, PO4**
4.	Explain the concept of process planning and cost estimation.	**PO1, PO4**
5.	Compute the job order cost for different type of shop floor and to calculate the machining time for various machining operations.	**PO1, PO4**

TEXT BOOK	
1.	Pannerselvam, R., Engineering Economics., Prentice Hall India Learning Private Limited; 2nd Revised edition, 2013.
2.	Donald G. Newnan, Ted G. Eschenbach., Jerome P. Lavelle., Engineering Economic Analysis, Oxford University Press; 13th edition, 2017.
REFERENCES	
1.	Leland Blank and Anthony Tarquin., Basics of Engineering Economy., McGraw-Hill Education; 2 edition, 2013.
2.	Chan S. Park., Contemporary Engineering Economics, Pearson Education, 6th Edition, 2015.

PROFESSIONAL ELECTIVE COURSES – I

Course Title	FINITE ELEMENT ANALYSIS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-I		

COURSE OBJECTIVES

- To appreciate the use of FEM to a range of Engineering Problems.
- To impart basic knowledge in finite element method
- To provide knowledge in 1D elements
- To provide knowledge in 2D elements
- To provide knowledge on isoparametric elements and Numerical Integration methods

UNIT - I INTRODUCTION **9**

Historical background – Matrix approach – Application to the continuum – Discretisation – Matrix algebra – Gaussian elimination – Governing equations for continuum – Classical Techniques in FEM – Weighted residual method – Ritz method.

UNIT - II ONE DIMENSIONAL PROBLEMS **9**

Finite element modeling – Coordinates and shape functions- Potential energy approach –Galarkin approach – Assembly of stiffness matrix and load vector – Finite element equations –Quadratic shape functions – Applications to plane trusses.

UNIT - III TWO DIMENSIONAL CONTINUUM **9**

Introduction – Finite element modelling – Scalar valued problem – Poisson equation –Laplace equation – Triangular elements – Element stiffness matrix – Force vector – Galarkin approach - Stress calculation – Temperature effects.

UNIT - IV AXISYMMETRIC CONTINUUM **9**

Axisymmetric formulation – Element stiffness matrix and force vector – Galarkin approach –Body forces and temperature effects – Stress calculations – Boundary conditions –Applications to cylinders under internal or external pressure – Rotating discs

UNIT – V ISOPARAMETRIC ELEMENTS FOR TWO DIMENSIONAL CONTINUUM **9**

The four node quadrilateral – Shape functions – Element stiffness matrix and force vector – Numerical integration - Stiffness integration – Stress calculations – Four node quadrilateral for axisymmetric problems.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Apply the numerical methods to formulate the simple finite element problems	**PO1, PO2, PO3**
2.	Apply one dimensional finite element method to solve bar and truss type problems	**PO1, PO2, PO3**
3.	Apply two-dimensional finite element method to plane stress and strain type problems	**PO1, PO2, PO3**
4.	Determine temperature distribution of one-dimensional heat transfer problems using one dimensional finite element	**PO1, PO2, PO3**
5.	Implement finite element method using isoparametric elements	**PO1, PO2, PO3**

TEXT BOOK	
1.	CHANDRUPATLA T.R., AND BELEGUNDU A.D., "Introduction to Finite Elements in Engineering", Pearson Education 2002, 3rd Edition.
2.	DAVID V HUTTON "Fundamentals of Finite Element Analysis"2004. Tata McGraw-Hill Int. Ed.
1.	RAO S.S., "The Finite Element Method in Engineering", Pergammon Press, 1989
REFERENCES	
1.	LOGAN D.L., "A First course in the Finite Element Method", Third Edition, Thomson Learning, 2002.
2.	ROBERT D.COOK., DAVID.S, MALKUCS MICHAEL E PLESHA, "Concepts and Applications of Finite Element Analysis" 4 Ed. Wiley, 2003.
3.	REDDY J.N., "An Introduction to Finite Element Method", McGraw-Hill International Student Edition, 1985
4.	O.C.ZIENKIEWICZ AND R.L.TAYLOR, "The Finite Element Methods, Vol.1", "The basic formulation and linear problems, Vol.1", Butterworth Heineman, 5th Edition, 2000.
5.	C. S. KRISHNAMOORTHY, Finite Element Analysis, TMH, 2007, 2nd Edition.
6.	K. J. BATHE, Finite Element Procedures, PHI, 2006,
7.	DESAI ABEL, Introduction to Finite Element Method, CBS Publishers, 2005.
8.	S. M. MURIGENDRAPPA, Fundamental of Finite Element Method, Interline Publishing, 2006.

Course Title	FLUID POWER SYSTEMS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-I		

COURSE OBJECTIVES

- To provide student with knowledge on the application of fluid power and about various types of hydraulic pumps.
- To provide students with an understanding of the fluids and components utilized in modern industrial fluid power system.
- To develop a measurable degree of competence in the design, construction and operation of fluid power circuits.
- To provide students with knowledge on pneumatics and is applications in industries.
- To teach the students about the various trouble shooting methods and applications of hydraulic and pneumatic systems.

UNIT - I FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS **9**

Introduction to Fluid power- Advantages and Applications- Fluid power systems – Types of fluids –Pascal's Law and its application- Principles of flow, Pumping Theory – Pump Classification, Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criterion of Linear, Rotary- Fixed and Variable displacement pumps.

UNIT - II HYDRAULIC ACTUATORS AND VALVES **9**

Hydraulic Actuators: Linear and Rotary– Types and construction, Hydraulic cushioning - Hydraulic control valves: Direction control, Flow control and Pressure control valves-Types, Construction and Operation- Servo and Proportional valves – Types of actuation, Reservoirs, Cylinder mountings, Fluid Power ANSI Symbols.

UNIT - III HYDRAULIC SYSTEMS **9**

Accumulators - application circuits, Intensifiers - application circuit, hydraulic circuits- Regenerative, Counter balance, Sequencing, Automatic Reciprocation, Synchronization, Speed control, Electrical control elements, Electro-hydraulic circuits: Cylinder control by limit switch, Reciprocation, Cylinder sequencing.

UNIT - IV PNEUMATIC SYSTEMS **9**

Properties of air– Perfect Gas Laws - Compressors- Filter, Regulator, Lubricator, Muffler, Air control Valves, Actuators. Pneumatic Circuits: Speed control, Quick exhaust, Air-Oil-reservoir circuit, Design of pneumatic circuit by cascade method.

UNIT - V TROUBLE SHOOTING AND APPLICATIONS **9**

Maintenance, Trouble Shooting in Hydraulic and Pneumatic systems. Design of hydraulic circuits for Shaper, Milling, Grinding,Pressing and Hydraulic lift–Conveyer feed system - Low cost Automation.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Acquire knowledge of the working principles of fluid power systems and hydraulic pumps.	**PO1, PO2**
2.	Acquire knowledge of the working principles of hydraulic actuators and control components.	**PO1, PO2**
3.	Understand different types of hydraulic circuits and systems.	**PO1, PO2**
4.	Explain the working of different pneumatic circuits and systems.	**PO1, PO2**
5.	Summarize the various troubleshooting methods and applications of hydraulic and pneumatic systems	**PO1, PO2**
TEXT BOOK		
1.	Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 2009.	
2.	Shanmugasundaram.K, "Hydraulic and Pneumatic Controls", S Chand & Co, 2006.	
REFERENCES		
1.	Majumdar, S.R., "Oil Hydraulics Systems- Principles and Maintenance", Tata Mc Graw Hill, 2001	
2.	Majumdar, S.R., "Pneumatic Systems – Principles and Maintenance", Tata Mc Graw Hill, 2007.	
3.	Dudelyt, A Pease and John J Pippenger, "Basic Fluid Power", Prentice Hall, 1987.	
4.	Srinivasan.R, "Hydraulic and Pneumatic Controls", Vijay Nicole Imprints, 2008.	
5.	Joji.P, "Pneumatic Controls", John Wiley & Sons India, 2008	

Course Title	PRODUCT DESIGN AND DEVELOPMENT	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-I		

COURSE OBJECTIVES

- To teach the students about the basic concepts of Product Design and Process Development.
- To expose the students about concept generation, selection and its testing for product development.
- To literate various parts of product architecture and its importance in product design and development.
- To explain the needs of various tools in industrial design process.
- To teach the students about the design for manufacturing and prototyping techniques used for product development.

UNIT – I INTRODUCTION **9**

Strategic importance of Product development - integration of customer, designer, material supplier and process planner, Competitor and customer - behavior analysis. Understanding customer – promoting customer understanding – involve customer in development and managing requirements - Organization process management and improvement.

UNIT – II CONCEPT GENERATION, SELECTIONAND TESTING **9**

Plan and establish product specifications. Task - Structured approaches – clarification – search - externally and internally - Explore systematically - reflect on the solutions and processes – concept selection – methodology - benefits. Implications – Product change - variety - component standardization - product performance – manufacturability.

UNIT – III PRODUCT ARCHITECTURE **9**

Product development management - establishing the architecture - creation- clustering- geometric layout development – Fundamental and incidental interactions – related system level design issues - secondary systems -architecture of the chunks - creating detailed interface specifications-Portfolio Architecture.

UNIT – IV INDUSTRIAL DESIGN **9**

Integrate process design - Managing costs - Robust design - Integrating CAE, CAD, CAM tools–Simulating product performance and manufacturing processes electronically – Need for industrial design - impact – design process – investigation of customer needs–conceptualization - refinement - management of the industrial design process.

UNIT – V DESIGN FOR MANUFACTURINGAND PRODUCT DEVELOPMENT **9**

Definition - Estimation of Manufacturing cost - reducing the component costs and assembly costs – Minimize system complexity - Prototype basics - Principles of prototyping - Planning for prototypes – Economic Analysis.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Get familiarized about the basic concepts of Product Design and Process Development.	**PO7, PO10, PO11, PO12**
2.	Know about the importance of concept generation, selection and its testing.	**PO7, PO10, PO11, PO12**
3.	Get a clear vision on product architecture.	**PO7, PO10, PO11, PO12**
4.	Understand about various tools in industrial design process.	**PO7, PO10, PO11, PO12**
5.	Know about the prototyping techniques used for product development.	**PO7, PO10, PO11, PO12**
TEXT BOOK		
1.	Ulrich K.T. and Eppinger S.D., "Product Design and Development" Tata McGraw –Hill International Editions,1999.	
REFERENCES		
1.	BelzA., 36-Hour Course: "Product Development" Tata McGraw-Hill, 2010.	
2.	Rosenthal S., "Effective Product Design and Development", Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.	
3.	Pugh S.," Total Design –Integrated Methods for successful Product Engineering", Addison Wesley Publishing, 1991, ISBN 0-202-41639-5.	

Course Title	3D PRINTING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-I		

COURSE OBJECTIVES

- To develop CAD models for 3D printing.
- To import and export CAD data and generate. STL file.
- To select a specific material for the given application.
- To select a 3D printing process for an application.
- To produce a product using 3D printing or Additive Manufacturing (AM).

UNIT – I: 3D PRINTING (ADDITIVE MANUFACTURING) 9

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

UNIT – II: CAD FOR ADDITIVE MANUFACTURING 9

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

UNIT – III: ADDITIVE MANUFACTURING TECHNIQUES 9

Stereo- Lithography, LOM, FDM, SLS, SLM, Binder Jet technology. Process, Process parameter, Process Selection for various applications. Additive Manufacturing Application Domains: Aerospace, Electronics, HealthCare, Defence, Automotive, Construction, Food Processing, Machine Tools.

UNIT – IV: MATERIALS 9

Polymers, Metals, Non-Metals, Ceramics. Various forms of raw material – Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties. Support Materials

UNIT – V: ADDITIVE MANUFACTURING EQUIPMENT AND POST PROCESSING 9

Process equipment- design and process parameters
Governing bonding mechanism
Common faults and troubleshooting
Process design
Post processing: requirement and techniques
Product quality
Inspection and testing
Defects and their causes

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Develop CAD models for 3D printing.	**PO3, PO5**
2.	Import and Export CAD data and generate . STL file.	**PO3, PO5**
3.	Select a specific material for the given application.	**PO3, PO5**
4.	Select a 3D printing process for an application.	**PO3, PO5**
5.	Produce a product using 3D Printing or Additive Manufacturing (AM).	**PO3, PO5**

TEXT BOOK	
1.	Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2015, ISBN: 978-1-56990-582-1.
2.	Ian Gibson, David W. Rosen and Brent Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", 2nd edition, Springer., United States, 2015, ISBN-13: 978-1493921126.
REFERENCES	
1.	Khanna Editorial, "3D Printing and Design", Khanna Publishing House, Delhi.
2.	CK Chua, Kah Fai Leong, "3D Printing and Rapid Prototyping- Principles and Applications", World Scientific, 2017.
3.	J.D. Majumdar and I. Manna, "Laser-Assisted Fabrication of Materials", Springer Series inMaterial Science, 2013.
4.	L. Lu, J. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Kulwer Academic Press, 2001.
5.	Zhiqiang Fan And Frank Liou, "Numerical Modelling of the Additive Manufacturing (AM)Processes of Titanium Alloy", InTech, 2012.

Course Title	TRIBOLOGY	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-I		

OBJECTIVES

1.To understand the concept and different types of friction

2. To understand the concept and different types of wear

3. To understand the mechanism of hydro static lubrication

4 To understand the mechanism of hydro static lubrication

5. To understand the concept and testing of lubricants

UNIT – I **9**

DRY FRICTION - Dry friction – topography of surfaces – contact between surfaces – sliding friction – energy dissipation. Theory of molecular attraction – fretting corrosion and prevention – variables in dry friction – present concept of friction – boundary friction – oiliness – variables of boundary friction – friction characteristics of metals and non-metals– rolling friction – sources of measurement of friction.

UNIT – II **9**

Wear – types – mechanism – factors affecting wear. Adhesive wear – abrasive wear, fatigue wear – corrosive wear – brittle fracture wear. Delamination – wear measurement.

UNIT – III **9**

Fundamentals of viscosity and flow – Petroff's equation – friction torque – viscosity measurement – factors affecting viscosity. Principle of hydrostatic lubrication – hydrostatic step bearing – multi recess bearing – design problems – different types of compensation and their effect on bearing, parameters – hydrostatic lift, simple problems – hydrostatic journal bearing, simple problems – hydrostatic squeeze films.

UNIT – IV **9**

HYDRODYNAMIC LUBRICATION - Solution of Reynold's equation – application to tilting pad thrust bearing – design of hydrodynamic journal bearings – force feed of oil flow with various types of grooves – dynamic bearings and rotor systems – brief discussion, lubrication systems, bearing materials – gas bearings – brief discussion – elasto hydrodynamic lubrication – brief discussion.

UNIT – V **9**

LUBRICANTS AND MAINTENANCE - Lubricants – types-solids ,and liquid-properties-additives-testing-reclamation of lubricants, surface treatment-phospating of metal surface, Teflon coating. Predictive maintenance-signature analysis and condition monitoring-basic principles-instrumentation.

(APPROVED HAND BOOK MAY BE USED IN THE EXAMINATION)

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to know		
1.	The mechanism and types of friction	**PO1, PO4**
2.	The mechanism and types of wear	**PO1, PO4**
3.	The mechanism of hydrostatic lubrication	**PO2, PO4**
4.	The mechanism of hydrodynamic lubrication	**PO2, PO4**
5.	The concept and testing of lubricants	**PO1, PO2, PO5**

TEXT BOOK	
1.	HUTCHINGS. M, Tribology, Friction and Wear of Engg. Materials, Edward Arnold, London, 1992.
2.	MAJUMDAR, Introduction of Tribology of Bearings, A.H.Wheeler & Co., 1986.
REFERENCES	
1.	NCALC, NEWNCS, Tribology Handbook, Butterworths, 1975.
2.	DUDLEY D.FULLER, Theory and Practice of Lubrication for Engineers, John Wiley & Sons, 1984.
3.	CAMERON.A, Basic Lubrication Theory, Wiley Eastern Ltd., 1987.
4.	BHARAT BHUSAN & B.K.GUPTA, Handbook of Tribology, Tata McGraw Hill Inc., 1991.

PROFESSIONAL ELECTIVE COURSES – II

Course Title	REFRIGERATION AND AIR CONDITIONING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-II		

COURSE OBJECTIVES

- To learn the concepts of refrigeration & its related cycles.
- To learn the concepts of refrigeration systems and the mechanisms of refrigeration equipments.
- To analyze the principles of other refrigeration systems.
- To apply the concepts of thermodynamics to air conditioning.
- To analyze the principles of air conditioning equipments.

UNIT – I INTRODUCTION **9**

Introduction to Refrigeration - Unit of Refrigeration and C.O.P.– Ideal cycles- Refrigerants Desirable properties – Classification - Nomenclature - ODP & GWP.

UNIT – II VAPOUR COMPRESSION REFRIGERATION SYSTEM **9**

Vapor compression cycle: p-h and T-s diagrams - deviations from theoretical cycle – subcooling and super heating- effects of condenser and evaporator pressure on COP- multi pressure system - low temperature refrigeration - Cascade systems – problems. Equipments: Type of Compressors, Condensers, Expansion devices, Evaporators (Elementary treatment).

UNIT – III OTHER REFRIGERATION SYSTEMS **9**

Working principles of Vapour absorption systems and adsorption cooling systems – Steam jet refrigeration- Thermoelectric refrigeration- Air refrigeration - Magnetic - Vortex and Pulse tube refrigeration systems.

UNIT – IV PSYCHROMETRIC PROPERTIES AND PROCESSES **9**

Fundamental properties of psychrometry - Use of psychometric chart, psychometric processes, grand and room sensible heat factor, by pass factor, requirements of comfort air conditioning, comfort and comfort chart, factor governing optimum effective temperature recommended design conditions, ventilation standards.

UNIT – V AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION **9**

Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load; Apparatus selection; fresh air load, human comfort & IAQ principles, effective temperature & chart, calculation of summer & winter air conditioning load; Classifications, Layout of plants; Air distribution system; Filters; Air Conditioning Systems with Controls: Temperature, Pressure and Humidity sensors, Actuators & Safety controls.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Explain the basic concepts of refrigeration.	**PO1, PO2, PO3, PO6, PO10, P12**
2.	Explain the vapor compression refrigeration systems and to solve problems	**PO1, PO2, PO3, PO6, PO10, P12**
3.	Discuss the various types of refrigeration systems	**PO1, PO2, PO3, PO6, PO10, P12**
4.	Calculate the psychrometric properties and its use in psychrometric processes	**PO1, PO2, PO3, PO6, PO10, P12**
5.	Explain the concepts of air conditioning and to solve problems	**PO1, PO2, PO3, PO6, PO10, P12**

TEXT BOOK	
1.	Arora, C.P., "Refrigeration and Air Conditioning", 3rd edition, McGraw Hill, New Delhi, 2017.
2.	P.L BALLANY, "Refrigeration and Air conditioning" Khanna Publishers, 1972
REFERENCES	
1.	ARORA S.C AND DOMKUNDWAR S, Refrigeration & Air Conditioning, Dhanpat Rai and Sons Publishers, 2007.
2.	MANOHAR PRASAD, Refrigeration and Air Conditioning, Wiley Eastern Ltd, 2015
3.	Jones W.P., "Air conditioning engineering", 5th edition, Elsevier Butterworth-Heinemann, 2007.
4.	Roy J. Dossat, "Principles of Refrigeration", 4th edition, Pearson Education Asia, 2011.
5.	Stoecker, W.F. and Jones J. W., "Refrigeration and Air Conditioning", Tata McGraw Hill, 2nd Edition, New Delhi, 2014.

Course Title	INTERNAL COMBUSTION ENGINES	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-II		

COURSE OBJECTIVES

- To understand fuel supply system and combustion phenomena with different combustion chambers of SI engines
- To understand the fuel spray structure and air movements and super charging, turbo charging principles of CI engines
- To understand the pollutant formation and emission controlling methods in IC engines
- To understand the functions of different sensors and Engine management systems
- To know the recent trends in the development of fuel supply and ignition methods in IC engines

UNIT - I SPARK IGNITION ENGINES **9**

Air-fuel mixture requirements – feedback control in carburetors – petrol injection systems – normal and abnormal combustion – factors affecting knock – shape of combustion chambers in SI engines.

UNIT - II COMPRESSION IGNITION ENGINES **9**

Normal and abnormal combustion in CI engines, direct and indirect ignition systems, combustion chambers – air movements in CI engines – fuel spray structure, spray generation and evaporation – turbo charging – Supercharging in IC engines.

UNIT - III POLLUTANT FORMATION AND CONTROL **9**

Pollutants from IC engines – formation of NO_X, CO and hydrocarbon, emission mechanism, particulate emission – method of controlling emissions Catalytic convertors and particulate traps – methods of measurements of emission and driving cycles.

UNIT- IV ENGINE ELECTRONICS **9**

Introduction – Engine management systems – position displacement and speed sensor – pressure sensor – Temperature sensor –Air flow sensor – O_2 sensor – types.

UNIT - V RECENT TRENDS IN IC ENGINES **9**

Stratified charge spark ignition engine – lean burn engines, dual fuel engine – multi point fuel injection gasoline engine – homogeneous charge compression ignition engines – plasma ignition, electric /hybrid vehicles.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Explain the principles of fuel supply system and combustion mechanism in SI engines	**PO1**
2.	Examine the air flow movements in various combustion chambers of CI engines	**PO1, PO2**
3.	Analyze the emission mechanism and controlling methods of pollutants in IC engines	**PO2, PO7**
4.	Understand the role of engine management systems and sensors.	**PO1**
5.	Gain knowledge about the recent trends in the engine development.	**PO1, PO5**
TEXT BOOK		
1.	GANESAN. V. Internal Combustion Engines, Tata McGraw Hill, 2012, 4th Edition.	
2.	GILL SMITH & ZURICH, Fundamentals of IC Engines. Oxford and IBH publication Co,1999.	
3.	JOHN B. HEYWOOD, Internal Combustion Engine Fundamentals, McGraw Hill, Ist edition, 1999	
REFERENCES		
1.	DOMKUNDWAR V.M, Internal Combustion Engines, Dhanpat Rai & Sons, 2018	
2.	P. L. Ballaney, Internal Combustion Engines, Khanna Publishers, 2006, 6th Edition.	
3.	MATHUR R.B AND SHARMA. R.B, Internal Combustion Engines, Dhanpat Rai & Sons, 2016	

Course Title	TURBO MACHINES	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-II		

OBJECTIVES

- To understand the fundamental concepts of turbo machines.
- To learn the velocity triangle & design concept of centrifugal fan & blower.
- To learn the velocity triangle & design concept of centrifugal compressor.
- To learn the velocity triangle & design concept of axial compressor.
- To learn the velocity triangle & design concept of axial & radial turbines.

UNIT - I BASIC CONCEPT OF TURBO MACHINES **9**

Definition and classification of turbo machines, specific work, T-S and H-S diagram, equation of energy transfer. Losses – Total-to-total efficiency, total to static efficiency, infinitesimal stage efficiency, effect of reheat, preheat. Aero-foil section, cascading of compressor and turbine blades, energy transfer in terms of lift and drag coefficient for compressor and turbine blades, variation of lift, deflection and stagnation pressure loss with incidence.

UNIT – II CENTRIFUGAL FANS AND BLOWERS **9**

Types, stage and design parameters, flow analysis in impeller blades, volute and diffusers, losses, characteristics curves and selection, fan drives and fan noise.

UNIT - III CENTRIFUGAL COMPRESSOR **9**

Construction details, types, impeller flow losses, slip factor, diffuser analysis, losses and performance curves.

UNIT - IV AXIAL FLOW COMPRESSOR **9**

Stage velocity triangle, enthalpy-entropy diagram, stage losses and efficiency, workdone factor, simple stage design problems and performance characteristics.

UNIT -V AXIAL AND RADIAL FLOW TURBINES **9**

Stage velocity diagrams, reaction stages, losses and coefficients blade design principles, testing and performance characteristics.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Compute the energy transfer and energy transformation in turbomachines	**PO1, PO2**
2.	Analyse the design of centrifugal fans & blowers	**PO2**
3.	Analyse the design of centrifugal compressor	**PO2**
4.	Analyse the design of axial compressor	**PO2**
5.	Analyse the design of centrifugal & axial flow turbines.	**PO2**
TEXT BOOK		
1.	S.M YAHYA, Fundamentals of Compressible flow with Aircraft and Rocket Propulsion, New Age International, 6th Edition, 2018.	
2.	GANESAN. V, Gas Turbines, Tata McGraw Hill, 3rd edition, 2017	
3.	SHEPERD DG. Theory of Turbo machines, McMillan, 1969	
REFERENCES		
1.	JOHN D.ANDERSON Jr. Introduction to Flight, 7th Edition, Tata McGraw Hill ISE 2011.	
2.	ALAN J. CHAPMAN, WILLIAM.F.WALKER, HOLT, Introduction to gas dynamics, Rineharl and winston, 1971	
3.	Dr.SL. SOMASUNDRAM, Gas dynamics and jet propulsion. New Age International (P) Limited, Publishers; First edition (2008).	
4.	A.H.CHURCH ND.JAGDISH LAL, Centrifugal Pumps and Blower, Metropolitan Book Co. PVT Ltd. ND 1973.	
5.	COHEN H. REC ROGERS & SRAVANAMUTOO, Gas Turbine Theory, Addison Wiley, 6th Edition, 2008.	
6.	KADAMBHI V. MANOHAR PRASAD, Introduction to Energy Conversions, Vol – III, Turbo machines, Wiley Eastern, 2011.	
7.	JAGDISHLAL, Centrifugal Pumps and Blowers, Metropolitan Press (P) Ltd., 1973	

Course Title	ENERGY CONSERVATION IN INDUSTRIES	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-II		

OBJECTIVES

- To understand the concepts of thermodynamic limitations and energy conservation in domestic, transportation, agricultural and industrial sectors.
- To understand the methodology of improving the boiler performance and energy conservation in turbines.
- To learn the heat exchanger systems, heat exchange networking, waste heat recovery and cogeneration schemes.
- To learn the concepts of energy conservation in various industries and their case studies.
- To learn the concepts of economic analysis of energy and energy auditing.

UNIT - I CONCEPT OF ENERGY CONSERVATION **9**

Sankey diagram – thermodynamic limitations: first and second laws of thermodynamics of energy transfer – availability analysis of various thermodynamics processes/devices/cycles. Need for energy conservation in domestic, transportation, agricultural and industrial sectors – Lighting and HVAC systems – simple case studies.

UNIT - II THERMAL ENERGY CONSERVATION **9**

Combustion systems and processes – combustion efficiency – boiler performance – methodology of improving the boiler performance – steam turbine and distribution systems: energy conservation in turbines – necessity for maintenance of correct pressure, temperature and quality of steam – condensate recovery – recovery of flash steam – air and gas removal – thermal insulation.

UNIT - III HEAT EXCHANGER SYSTEMS **9**

Recuperative and regenerative heat exchangers – compact heat exchangers – fluidized bed heat exchange systems – heat pumps – heat pipes – heat recovery from industrial processes. heat exchange networking – pinch analysis – target setting, problem table approach, composite curves – waste heat recovery and cogeneration schemes.

UNIT - IV ENERGY CONSERVATION IN INDUSTRIES **9**

Energy conservation in pumps, fans, compressed air systems, refrigeration & air conditioning systems, emergency DG sets, illumination, electrical motors – energy efficient motors and variable speed motors. Case studies for energy conservation in various industries such as cement, iron and steel, glass, fertilizer, food processing, refinery etc.

UNIT - V CONCEPT OF ENERGY MANAGEMENT **9**

Energy demand and supply – Economic analysis of energy options – Duties of energy managers. Energy auditing: definition, necessity and types. Understanding energy costs – bench marking – energy performance – matching energy use to requirement – maximizing system efficiencies – optimizing the input energy requirements. Fuels and energy: supplementing and substitution – energy audit instruments – energy economics: discount rate, pay back period, internal rate of return, life cycle costing – energy conservation systems analysis for safety, health and pollution.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Apply availability analysis of various thermodynamics processes, devices and cycles and explain the energy conservation in domestic, transportation, agricultural and industrial sectors.	**PO1, PO2**
2.	Apply the methodology of improving the boiler performance, steam turbine and distribution systems: explain the energy conservation in turbines.	**PO1, PO2**
3.	Explain the concepts of heat exchanger systems, heat pumps, heat pipes and heat recovery from industrial processes and apply the heat exchange networking, waste heat recovery and cogeneration schemes.	**PO2, PO3**
4.	Explain the energy conservation in pumps, fans, compressed air systems, refrigeration & air conditioning systems, emergency DG sets, illumination, electrical motors, energy efficient motors and variable speed motors.	**PO2, PO3**
5.	Apply economic analysis of energy, energy auditing, explain the energy conservation systems analysis for safety, health and pollution.	**PO2, PO3**
TEXT BOOK		
1.	Patrick, D. and Fardo, S. W., Energy conservation and Management, Prentice-Hall Inc., 1990	
2.	Witte, Larry C., Industrial energy management and utilization, Hemisphere publishers, Washington, 1988	
3.	Tyagi, A. K., Handbook of energy audits and management, TERI PCRA Booklets.	
REFERENCES		
1.	Thipse, S.S., Energy conservation and management, Alpha Science International Ltd., 2014	
2.	Frank Kreith and Yogi Goswami, D., Energy Management and Conservation Hand Book, CRC Press, 2008.	

Course Title	GAS DYNAMICS & JET PROPULSION	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-II		

OBJECTIVES

- To understand the basic difference between incompressible flow and compressible flow and flow through variable area ducts.
- To understand the flow through constant area Ducts.
- To understand the phenomenon of shock waves and its effect on flow.
- To gain the basic knowledge about jet propulsion
- To gain the basic knowledge and rocket propulsion.

UNIT – I **9**

BASIC CONCEPTS AND ISENTROPIC FLOWS - Energy and momentum equations of compressible fluid flows - Stagnation states, Mach waves and Mach cone - Effect of Mach number on compressibility - Isentropic flow through variable area ducts - Nozzle and Diffusers - Use of Gas tables.

UNIT – II **9**

FLOW THROUGH DUCTS - Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) - Variation of flow properties - Use of tables and charts - Generalized gas dynamics.

UNIT – III **9**

NORMAL AND OBLIQUE SHOCKS **-** Governing equations - Variation of flow parameters across the normal and oblique shocks - Prandtl - Meyer relations - Use of table and charts - Applications.

UNIT – IV **9**

JET PROPULSION - Theory of jet propulsion - Thrust equation - Thrust power and propulsive efficiency - Operation principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan & turbo prop engines – Aircraft combustors

UNIT – V
9

SPACE PROPULSION - Types of rocket engines - Propellants - Ignition and combustion - Theory of rocket propulsion - Performance study - Staging - Terminal and characteristic velocity - Applications - Space flights.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Apply the concept of compressible flows in variable area ducts.	**PO1, PO2**
2.	Apply the concept of compressible flows in constant area ducts.	**PO1, PO2**
3.	Examine the effect of compression and expansion waves in compressible flow.	**PO2, PO3**
4.	Use the concept of gas dynamics in Jet Propulsion.	**PO3, PO4**
5.	Apply the concept of gas dynamics in Space Propulsion.	**PO3, PO4**

TEXT BOOK	
1.	S.M. Yahya, " Fundamentals of Compressible Flow ", New Age International (P)Limited, New Delhi, 2018.
2.	Anderson, J.D., "Modern Compressible flow", 3rd Edition, Tata McGraw Hill, 2017.
REFERENCES	
1.	Cohen. H., G.E.C. Rogers and Saravanamutto, "Gas Turbine Theory", Longman Group Ltd.,2001.
2.	Ganesan. V., "Gas Turbines", Tata McGraw Hill Publishing Co., New Delhi, 2017.
3.	Shapiro. A.H.," Dynamics and Thermodynamics of Compressible Fluid Flow", John wiley, New York, 1977.
4.	Sutton. G.P., "Rocket Propulsion Elements", John wiley, New York, 7thEdition. 2017
5.	Zucrow. N.J., "Principles of Jet Propulsion and Gas Turbines", John Wiley, New York.
6.	E. Radhakrishnan, Gas Dynamics, PHI, 6thEdition. 2017.

PROFESSIONAL ELECTIVE COURSES – III

Course Title	DESIGN FOR MANUFACTURING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-III		

OBJECTIVES

- To understand the principles of design such that the manufacturing of the product is possible.
- To educate students on various design aspects to be considered for manufacturing the products using different processes.
- To provide the students with knowledge to perform designing of components considering manufacture ability
- To develop the ability to design casting and weld structures.
- To develop the ability to use principles of design for assembly

UNIT – I MANUFACTURING METHODOLOGY AND PROCESSES **9**

Methodologies and tools, design axioms, design for assembly and evaluation, minimum part assessment, Taguchi method, robustness assessment, manufacturing process rules, designer's tool kit, Computer Aided group Technology, failure mode effect analysis, Value analysis, Design for minimum number of parts, development of modular design, minimizing part variations, design of parts to be multi-functional, multi-use, ease of fabrication, Poke Yoke principles.

UNIT – II GEOMETRIC ANALYSIS **9**

Surface finish, review of relationship between attainable tolerance grades and different machining processes, part features-feature of size-control from-placement material condition – MMC – LMC.

UNIT – III FORM DESIGN OF CASTINGS AND WELDMENTS **9**

Redesign of castings based on parting line considerations, minimizing core requirements, redesigning cast members by welded structure, use of welding symbols.

UNIT – IV MECHANICAL ASSEMBLY **9**

Selective assembly, deciding the number of groups, control of axial play, examples, Grouped datum systems , different types, geometric analysis and applications, design features to facilitate automated assembly, Assembly analysis worst case Arithmetic method, Monte -Carlo method.

UNIT – V TRUE POSITION THEORY **9**

Virtual size concept, floating and fixed fasteners, projected tolerance zone, assembly with gasket, zero true position tolerance, functional gauges, paper layout gauging, examples. Operation sequence for typical shaft type of components. Preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples.

O	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the concept of mass customization and product family design;	**PO1, PO2**
2.	Apply appropriate methods to achieve quality in product design;	**PO1, PO2**
3.	Analyze product design for assembly, manufacturing, and end-of-life issues;	**PO1, PO2**
4.	Understand how global environmental requirements affect product design;	**PO1, PO7**
5.	Analyze product design in terms of environmental impact and suggest improvements.	**PO1, PO7**
TEXT BOOK		
1.	Harry pack, "Designing for Manufacture", Pitman Publications, 1983.	
2.	Matousek, "Engineering Design, - A Systematic Approach" – Blackie & Son Ltd, London, 1974	
REFERENCES		
1.	Spotts M.F. "Dimensioning and Tolerance for Quantity Production, Prentice Hall Inc.1983.	
2.	Oliver R. Wade, "Tolerance Control in Design and Manufacturing ". Industrial Press Inc. New York Publications. 1967.	
3.	James G. Bralla. "Hand Book of Product Design for Manufacturing". Tata McGraw Hill Publications, 1983.	
4.	Trucks H.E. "Design for Economic Production". Society of Manufacturing Engineers, Michigan, 2nd edition, 1987.	

Course Title	THEORY OF METAL FORMING	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-III		

OBJECTIVES

- To understand the basic concepts of plasticity
- To educate students on various mechanical testing
- To provide the students with knowledge on metal forming
- To understand the sheet metal forming
- To develop the special forming process

UNIT- I THEORY OF PLASTICITY 9

Theory of plastic deformation – Engineering stress and strain relationship – Strain rate – Stress tensor – Strain tensor – Yield criteria – Plastic stress strain relationship – Plastic work – Plastic anisotropy.

UNIT - II CONSTITUTIVE RELATIONSHIPS AND INSTABILITY 9

Uniaxial tension test – Mechanical properties – Work hardening, Compression test, bulge test, plane strain compression, plastic instability in uniaxial tension stress, plastic instability in biaxial tension stress – Material models – Elasto plasticity, Rigid plasticity, visco plasticity.

UNIT - III ANALYSIS OF METAL FORMING 9

Slab analysis – Slip line method, upper bound solutions, numerical methods, contact problems, effect of friction, thermo elastic- analysis of forging, rolling, extrusion and wire drawing processes – forming load – Net and near net shape forming – Cold and hot forging.

UNIT- IV SHEET METAL FORMING 9

Sheet Metal Forming methods – Bending – Drawing – Deep Drawing – Stretch forming – Formability and workability – Forming limit diagram – Analysis of Sheet metal forming – HERF Techniques – Principles and process parameters – Superplastic forming.

UNIT - V SPECIAL METAL FORMING PROCESSES 9

Orbital forging, Isothermal forging, Warm forging, Hot and Cold isotrophical pressing, high speed extrusion, rubber pad forming, micro blanking – Overview of Powder Metal Techniques – Powder rolling.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the concept of plasticity	**PO1, PO2**
2.	Develop ideas on various mechanical testing	**PO1, PO2**
3.	Understand the concept of metal forming	**PO1, PO2**
4.	Understand the sheet metal forming process	**PO1, PO2**
5.	Understand the recent trends in special metal forming	**PO1, PO2**

TEXT BOOK	
1.	Dieter G.E, "Mechanical Metallurgy" Mc Graw – Hill Co. S1. Edition 1995
2.	Surender Kumar, "Technology of Metal Forming Processes", PHI, New Delhi, 2008.
REFERENCES	
1.	Nagpal G.R "Metal Forming Process", Kanna Pub, New Delhi – 2000.
2.	Wagoner, R.H and Chenot, JJ Metal Forming Analysis, Cambridge University Press,2002.
3.	Slater, R.A.C., Engineering Plasticity – Theory and Applications to Metal Forming, John Wiely and Sons, 1987.
4.	Shiro Kobayshi, Altan. T, Metal Forming and Finite Element Method, Oxford University Press, 1989.
5.	Hosford, W.F and Caddell, R.M., Metal Forming Mechanics and Metallurgy, Prentice Hall Eaglewood Cliffs, 1993.
6.	Narayanaswamy. R, Theory of Metal Forming and Plasticity Narosa Publishers, 1999.
7.	Kurt Lange, "Handbook of Metal Forming", Society of Manufacturing Engineers, Michigan, USA, 1988.
8.	Avitzur, "Metal Forming – Process and Analysis", Tata McGraw-Hill Co., New Delhi,

Course Title	DIGITAL MANUFACTURING	Credits	L T P C
Course Code			3 0 0 3
Course Category	Pec-III		

OBJECTIVES

- To develop ideas on digital manufacturing.
- To import and export CAD data and generate .stl file.
- To gain knowledge on reverse engineering for the given application.
- To gain knowledge on virtual manufacturing.
- To develop knowledge on IoT.

UNIT – I INTRODUCTION TO DIGITAL MANUFACTURING **9**

Definition of digital manufacturing, Operation Mode and Architecture of Digital Manufacturing System.

UNIT – II CAD / CAM **9**

Design process and role of CAD, Types and applications of design models, Three dimensional modeling schemes, Wire frames and surface representation schemes, Solid modeling - Parametric modeling, Assembly modeling. Component modeling, Machine and tool selection, Defining process and parameters, Tool path generation, Simulation, Post processing.

UNIT – III REVERSE ENGINEERING AND CONCEPT MODELERS **9**

Need, Reverse engineering process, Reverse engineering hardware and software, Geometric model development.
Introduction to concept modelers, Principle, Thermo jet printer, Sander's model market, 3-D printer, GenisysXs printer, JP system 5, object quadra system-Rapid proto typing.

UNIT – IV DIGITAL FACTORY, VIRTUAL MANUFACTURING AND PLM **9**

Introduction, Scope, Methods and tools used in virtual manufacturing, benefits. virtual factory simulation.
Introduction to Product Life Cycle Management, Types of Product Data, PLM systems, Features of PLM System, System architecture, Product information models, Functionality of the PLM Systems.

UNIT – V INTERNET OF THINGS **9**

Introduction to Internet of Things, Applications, IOT data management requirements, Architecture of IOT, Technological challenges, RFID and the Electronic Product Code (EPC) network, the web of things, Issues in implementing IOT.

TUTORIALSESSION: 3D Modeling of Engineering components and assemblies in CAD software, Machining simulation using CAM software, Reverse Engineering using microscribe.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Develop ideas on digital manufacturing.	**PO1, PO5**
2.	Import and export CAD data and generate .stl file.	**PO1, PO5**
3.	Gain knowledge on reverse engineering for the given application.	**PO1, PO5**
4.	Gain knowledge on virtual manufacturing.	**PO1, PO5**
5.	Develop knowledge on IoT.	**PO1, PO5**
TEXT BOOK		
1.	Ibrahim Zeid and Sivasubramanian R, "CAD/CAM - Theory and Practice", Tata McGraw Hill Education, 2011.	
2.	Vinesh Raja and Kiran J Fernandes, "Reverse Engineering- An Industrial Perspective", Springer-Verlag, 2008	
3.	Pham D T and Dimov S S, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping", Springer-Verlag, 2001.	
4.	Adrian McEwan and Hakim Cassimally, "Designing the internet of things", Wiley, 2013.	
REFERENCES		
1.	Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", Springer, 2005.	
2.	Antti Saaksvuori and AnselmiImmonen, "Product Lifecycle Management", Springer, 2004.	

Course Title	COMPOSITE MATERIALS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-III		

OBJECTIVES

- To learn about the fundamentals, classifications and need for composite materials.
- To know about the various manufacturing methods of polymer matrix composites.
- To learn about the properties and various processing techniques of metal matrix composites.
- To learn about the properties, classifications and production methods of ceramic composites.
- To know about the advances in composite materials and testing procedures.

UNIT – I **9**

INTRODUCTION TO COMPOSITES - need for composites – Enhancement of properties - classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Reinforcement – Particle reinforced composites, Fibre reinforced plastics (FRP). Applications and advantages of various types of composites.

UNIT – II **9**

POLYMER MATRIX COMPOSITES - Polymer matrix resins – Thermosetting resins, thermoplastic resins – Reinforcement fibres – Rovings – Woven fabrics – Non woven random mats – various types of fibres. PMC processes - Hand layup, Spray layup processes – Vacuum bagging – Compression moulding – Reinforced Reaction injection moulding - Resin transfer moulding – Pultrusion – Filament winding – Injection moulding.

UNIT – III **9**

METAL MATRIX COMPOSITES - Characteristics of MMC, Various types of Metal matrix composites, Alloy vs. MMC, Advantages of MMC, Limitations of MMC, Metal Matrix, Reinforcements – particles – fibres. Effect of reinforcem ent - Volume fraction – Rule of mixtures. Processing of MMC – Powder metallurgy process - diffusion bonding – stir casting – squeeze casting.

UNIT – IV **9**

CERAMIC MATRIX COMPOSITES - Engineering ceramic materials – properties – advantages – limitations – Monolithic ceramics - Need for CMC – Ceramic matrix- Various types of Ceramic Matrix composites- oxide ceramics – non oxide ceramics – aluminium oxide – silicon nitride – reinforcements – particles- fibres-whiskers. Sintering - Hot pressing – Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing).

UNIT – V **9**

ADVANCES IN COMPOSITES **-** Carbon / Carbon composites – Advantages of carbon matrix – limitations of carbon matrix. Carbon fibre – chemical vapour deposition of carbon on carbon fibre preform, Sol gel technique. Composites for aerospace applications – Introduction to Nano composite. Various testing procedures for composite materials –Eco-friendly composite materials.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Learn about the fundamentals of composite materials.	**PO1**
2.	Know the manufacturing methods of polymer matrix composites.	**PO1, PO3**
3.	Understand about the processing techniques of metal matrix composites.	**PO1, PO3**
4.	Know production methods of ceramic composites.	**PO1, PO3**
5.	Understand about the advances in composite materials.	**PO1, PO5**
TEXT BOOK		
1.	Mathews F.L. and Rawlings R.D., "Composite materials: Engineering and Science", Chapman and Hall, London, England, 1st edition, 1994.	
2.	Chawla K.K., "Composite materials", Springer – Verlag, 1987	
REFERENCES		
1.	Clyne T.W. and Withers P.J., "Introduction to Metal Matrix Composites", Cambridge University Press, 1993.	
2.	Strong A.B., "Fundamentals of Composite Manufacturing", SME, 1989.	
3.	Sharma S.C., "Composite materials", Narosa Publications, 2000.	
4.	"Short Term Course on Advances in Composite Materials, Composite Technology Centre, Department of Metallurgy", IIT- Madras, December 2001.	
5.	Madhu Jit Mukho Padhyay, Mechanics of Composite Materials and Structures, University Press, 2004.	

PROFESSIONAL ELECTIVE COURSES – IV

Course Title	TOTAL QUALITY MANAGEMENT	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-IV		

OBJECTIVES

- To introduce the basic functions of Total Quality Management
- To learn the principles of TQM
- To impart knowledge on statistical process control techniques
- To study the usage of tools for problem solving
- To familiarize various system standards

UNIT – I INTRODUCTION **9**

Definition of quality, dimensions of quality, quality planning, quality costs - analysis Techniques for quality Costs, basic concepts of total quality management, historical review, principles of TQM, leadership – concepts, Role of senior management, quality council, quality statements, Strategic planning, deming philosophy, Barriers to TQM implementation.

UNIT – II TOTAL QUALITY MANAGEMENT PRINCIPLES **9**

Customer satisfaction – customer perception of quality, customer complaints, service quality, customer retention, employee involvement – motivation, empowerment, teams, recognition and reward, performance appraisal, benefits, continuous process improvement – Juran trilogy, pdsa cycle, 5s, kaizen, supplier partnership – partnering, sourcing, supplier selection, supplier rating, relationship development, performance measures – basic concepts, strategy, performance measure.

UNIT – III TOTAL QUALITY MANAGEMENT TOOLS **9**

Bench marking – reasons to benchmark, benchmarking process, quality function deployment (QFD) – house of quality, QFD process, benefits, taguchi quality loss function, total productive maintenance (TPM) – concept, improvement needs, FMEA – stages of FMEA.

UNIT – IV QUALITY SYSTEMS **9**

Quality Auditing - Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, TS 16949, ISO 14000 – Concept, Requirements and Benefits.

UNIT – V STATISTICAL PROCESS CONTROL (SPC) **9**

The seven tools of quality, statistical fundamentals – measures of central tendency and dispersion, population and sample, normal curve, control charts for variables and attributes, process capability, concept of six sigma, new seven management tools.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Understand the basics of TQM	**PO1**
2.	Explain the principles of TQM	**PO1**
3.	Solve problems on statistical process control	**PO1, PO4**
4.	Use the tools for finding solutions	**PO1, PO4**
5.	Gain knowledge on system standards	**PO1, PO4**
TEXT BOOK		
1.	DALE H.BESTERFILED, et al., "Total Quality Management", Pearson Education, Inc. 2003. (Indian reprint 2004). ISBN 81-297-0260-6.	
REFERENCES		
1.	JAMES R.EVANS & WILLIAM M.LIDSAY, "The Management and Control of Quality", (5th Edition), South-Western (Thomson Learning), 2002 (ISBN 0-324-06680-5).	
2.	OAKLAND.J.S. "Total Quality Management", Butterworth – Hcinemann Ltd., Oxford. 1989.	
3.	NARAYANA V. AND SREENIVASAN, N.S. "Quality Management – Concepts and Tasks", New Age International 1996.	
4.	ZEIRI. "Total Quality Management for Engineers", Wood Head Publishers, 1991.	

Course Title	ENTREPRENEURSHIP DEVELOPMENT	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-IV		

OBJECTIVES

- To gain knowledge on basics of Entrepreneurship
- To study on motivation of Entrepreneurship development
- To gain knowledge of business entity, source of capital
- To gain knowledge on financially evaluate the project
- To gain knowledge on manufacturing system

UNIT – I ENTREPRENEURSHIP **9**

Entrepreneur – types of entrepreneurs – Difference between entrepreneur and intrapreneur– entrepreneurship in economic growth, factors affecting entrepreneurial growth.

UNIT – II MOTIVATION **9**

Major motives influencing an entrepreneur – Achievement motivation training, self rating, business game, thematic apperception test – Stress management, entrepreneurship development programs – need, objectives.

UNIT – III BUSINESS **9**

Small enterprises – Definition, classification – Characteristics, ownership structures – Project formulation – Steps involved in setting up a business – Identifying, selecting a good business opportunity, market survey and research, techno economic feasibility assessment – Preparation of preliminary project reports – Project appraisal – Sources of information –Classification of needs and agencies.

UNIT – IV FINANCING AND ACCOUNTING **9**

Need – sources of finance, term loans, capital structure, financial institution, management of working capital, costing, break even analysis, network analysis techniques of PERT/ CPM – taxation – Income tax, excise duty – Sales tax.

UNIT – V SUPPORT TO ENTREPRENEURS **9**

Sickness in small Business – Concept, Magnitude, causes and consequences, Corrective Measures – Government Policy for Small Scale Enterprises – Growth Strategies in small industry – Expansion, Diversification, Joint Venture, Merger and Sub Contracting.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Acquire the knowledge on the types of entrepreneurship and the factors influencing entrepreneur.	**PO6, PO8, PO9, PO11, PO12**
2.	Explain about skills and motivation required to become an entrepreneur.	**PO6, PO8, PO9, PO11, PO12**
3.	Enhance the business concepts towards a start – up considering all factors.	**PO6, PO8, PO9, PO11, PO12**

4.	Explain the financial and accounting details required for starting and running a small enterprise.	**PO6, PO8, PO9, PO11, PO12**
5.	Review the various supports, resources available and skills required to establish an enterprise to establish a small enterprise	**PO6, PO8, PO9, PO11, PO12**
TEXT BOOK		
1.	S.S. Khanka "Entrepreneurial Development" S.Chand & Co. Ltd. Ram Nagar New Delhi, 1999.	
2.	Kuratko & Hodgetts, "Enterprenuership – Theory, process and practices", Thomson.	
REFERENCES		
1.	Robert Mellor., Entrepreneurship for Everyone: A Student textbook, Sage Publications Ltd., 2008.	
2.	Lee Swanson, Entrepreneurship and Innovation Toolkit, University of Saskatchewan, 2017.	

Course Title	NON-TRADITIONAL MACHINING PROCESSES	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-IV		

OBJECTIVES

- To develop ideas on traditional machining
- To gain knowledge on mechanical process for the given application
- To impart knowledge on electrical discharge machining
- To gain knowledge on chemical machining
- To understand material removal by using high energy process

UNIT – I INTRODUCTION **9**

Need of non-Traditional machining processes – Classification based on energy, mechanism, source of energy, transfer media and process - Process selection-based on physical parameters, shapes to be machined, process capability and economics – Overview of all processes.

UNIT – II MECHANICAL PROCESS **9**

Ultrasonic machining: principle- Transducer types – Concentrators - Abrasive slurry - Process parameters – Tool feed mechanism – Advantages and limitations – Applications. abrasive jet machining: process- principle – Process variables – Material removal rate - advantages and limitations – Applications. Water jet machining: principle – Process variables - Advantages and limitations – Practical applications – Abrasive water jet machining process.

UNIT – III ELECTRICAL DISCHARGE MACHINING **9**

Electrical discharge machining: mechanism of metal removal – Dielectric fluid – Flushing methods - Electrode materials - Spark erosion generators – Electrode feed system – Material removal rate – Process parameters – Tool electrode design – Tool wear characteristics of spark eroded surfaces - Advantages and limitations – Practical applications. Electrical discharge wire cut and grinding: principle – wire feed system - advantages and limitations
– Practical applications

UNIT – IV CHEMICAL AND ELECTRO CHEMICAL MACHINING **9**

Chemical machining: fundamentals, principle – Classification and selection of etchant -chemical milling, engraving, blanking - advantages and limitations – Applications. electro chemical machining: electro-chemistry of the process- electrolytes - electrolyte and their properties – material removal rate – tool material – tool feed system – design for electrolyte flow – process variables - advantages and limitations – applications - electro chemical grinding: honing, cutting off, deburring and turning.

UNIT – V HIGH ENERGY MACHINING PROCESS **9**

Electron beam machining: principle – Generation and control of electron beam- Advantages and limitations – applications. laser beam machining: principle –solid and gas laser application – Thermal features of LBM - Advantages and limitations – Applications. Ion beam machining: equipment – process characteristics - advantages and limitations – applications. Plasma arc machining: principle – Gas mixture– Types of torches – Process parameters - advantages and limitations – applications. Ion beam machining – principle – MRR – advantages, limitation, applications.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Acquire the knowledge on the various types of non-traditional machining techniques	**PO1, PO2**
2.	Understand the basics of mechanical process	**PO1**
3.	Understand the basics of EDM	**PO5**
4.	Understand the various types of chemical machining	**PO5**
5.	Understand the basics of HIGH ENERGY PROCESS	**PO5**
TEXT BOOK		
1.	P.C Pandey And H.S. Shan, "Modern Machining Process", Tata Mc Graw – Hill Publishing Company Limited, New Delhi, 2007	
2.	V.K. Jain, " Advanced Machining Process", Allied Publishers Pvt Limited 2007	
REFERENCES		
3.	Amithaba Bhattacharyya , "New Technology", The Institution of Engineers , (India) "Production Technology", HMT Bangalore, Tata Mc Graw–Hill Publishing Company Limited, New Delhi, 2006.	
4.	Hassan El – Hofy "Advanced machining Processes" Tata MC Graw-Hill, 2005.	

Course Title	NON DESTRUCTIVE EVALUATION	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-IV		

OBJECTIVES

- To make the students understand about various Non Destructive testing methods including advanced techniques, with emphasis on basic principles, limitations and application areas.
- To provide knowledge on liquid penetrant and magnetic inspection methods.
- To provide knowledge on radiography testing methods
- To impart knowledge on ultrasonic testing method
- To study various special electrical and other non-destructive testing methods.

UNIT – I INTRODUCTION **9**

Visual methods: Optical aids, In-situ metallography, Optical holographic methods, Dynamic inspection.

UNIT – II LIQUID PENETRANT & MAGNETIC INSPECTION **9**

Penetrant systems: Principles-Process- Liquid penetrant materials-Emulsifiers-cleaners developers-sensitivity-Advantages, Limitations and Applications .Magnetic methods: Advantages, Limitations-Methods of generating fields: magnetic particles and suspending liquids Magnetography-field sensitive probes: applications. Measurement of metal properties.

UNIT – III RADIOGRAPHIC METHODS **9**

Principles of radiography- sources of radiation- Ionising radiation -sources-X-rays, Gama rays- Recording of radiation-Radiographic sensitivity-Fluoroscopic methods-special techniques- Radiation safety. Advantages ,Limitations and applications.

UNIT – IV ULTRASONIC TESTING OF MATERIALS **9**

Advantages, disadvantages, Applications, Generation of. Ultrasonic waves, general characteristics of ultrasonic waves: methods and instruments for ultrasonic materials testing: special techniques.

UNIT – V ELECTRICAL AND OTHER METHODS **9**

Electrical methods:Eddy current methods: potential-drop methods, applications-Other methods: Acoustic Emission methods, Acoustic methods: Leak detection: Thermal inspection.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Select appropriate surface inspection techniques for the components to be inspected	**PO1**
2.	Explain the non-destructive testing method to identify the sub surface defects in materials.	**PO1, PO5**
3.	Apply radiography testing methods for different suitable applications	**PO1, PO5**
4.	Select and explain the suitable testing method for testing internal defects	**PO1, PO5**
5.	Choose the suitable special non-destructive technique for various applications.	**PO1, PO5**

TEXT BOOK	
1.	Halmshaw R., "Non Destructive Testing", Edward Arnold Publication, London, 1987.
2.	Hull B. and John V., "Non-destructive testing", English Language Book Soc., 1989.
3.	Ravi Prakash, "Non destructive Testing Techniques", New Age Science, 2009.
4.	Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2009
REFERENCES	
1.	Metals Handbook, "Nondestructive Inspection and Quality Control", Vol. 17, 9th Edition, ASM International
2.	Hellier C., "Handbook of Non destructive Evaluation", Tata McGraw-Hill Professional, I edition, 2001.
3.	"Non destructive Testing Handbook", Vol. 1-10, 3rd Edition, American Society for Non Destructive Testing, 2010.
4.	Charles, J. Hellier," Handbook of Nondestructive evaluation", McGraw Hill, New York 2001.
5.	ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.

Course Title	FLEXIBLE MANUFACTURING SYSTEMS	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-IV		

OBJECTIVES

- To understand the basic concepts of flexible manufacturing systems
- To gain basic knowledge on computer control and software associated with flexible manufacturing systems
- To educate students about simulation and database systems with respect to flexible manufacturing systems
- To know about group technology and justifications on implementing flexible manufacturing system
- To educate the applications of flexible manufacturing systems in various industrial sectors

UNIT – I PLANNING, SCHEDULING AND CONTROL **9**

Introduction to FMS– development of manufacturing systems – benefits – major elements – types of flexibility – FMS application and flexibility –single product, single batch, n – batch scheduling problem – knowledge based scheduling system.

UNIT – II COMPUTER CONTROL AND SOFTWARE **9**

Introduction – composition of FMS– hierarchy of computer control –computer control of work center and assembly lines – FMS supervisory computer control – types of software specification and selection – trends.

UNIT – III FMS SIMULATION AND DATA BASE **9**

Application of simulation – model of FMS– simulation software – limitation – manufacturing data systems – data flow – FMS database systems – planning for FMS database.

UNIT – IV GROUP TECHNOLOGY AND JUSTIFICATION OF FMS **9**

Introduction – matrix formulation – mathematical programming formulation –graph formulation – knowledge based system for group technology – economic justification of FMS- application of possibility distributions in FMS systems justification.

UNIT – V APPLICATIONS OF FMS AND FACTORY OF THE FUTURE **9**

FMS application in machining, sheet metal fabrication, prismatic component production – aerospace application – FMS development towards factories of the future – artificial intelligence and expert systems in FMS – design philosophy and characteristics for future.

CO	COURSE OUTCOMES	PO
Upon completion of this course, Students should be able to		
1.	Appreciate the fundamentals of flexible manufacturing systems	**PO5**
2.	Explain the use of software and computer control in flexible manufacturing systems	**PO5**
3.	Recognise the importance of simulation and database systems	**PO5**
4.	Explain the group technology and understand the justification of implementing flexible manufacturing systems	**PO5**
5.	Recognise the effectiveness of imparting flexible manufacturing systems in various industrial sectors	**PO5**
TEXT BOOK		
1.	Nand K. Jha., "Handbook of flexible manufacturing systems", Academic Press Inc., 1991	
2.	Shivanand. H. K., Benal. M. M., Koti. V., "Flexible manufacturing system" New Age International Publishers., 2006.	
REFERENCES		
1.	Radhakrishnan P. and Subramanyan S., "CAD/CAM/CIM", Wiley Eastern Ltd., New Age International Ltd., 1994.	
2.	Raouf A. and Daya B.M., "Flexible manufacturing systems: recent development", Elsevier Science, 1995.	
3.	Groover M.P., "Automation, production systems and computer integrated manufacturing", Prentice Hall of India Pvt., New Delhi, 1996.	
4.	Kalpakjian S.,"Manufacturing Engineering and Technology",Addison-Wesley Publishsing Co., 1995.	
5.	Ohno T., "Toyota production system: beyond large-scale production", Productivity Press (India) Pvt. Ltd., 1992.	

Course Title	INDUSTRY 4.0	Credits	L T P C
Course Code			3 0 0 3
Course Category	PEC-IV		

OBJECTIVES

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UNIT - II ADVANCED TECHNOLOGY AND ADVANCED MATERIALS **9**

Advanced electro-optical sensing technology-active, passive multi-spectral and hyper spectral imaging; electronic beam steering; vacuum technology, surface and coating technology, health care technology, Nanotechnology- Nanomechanics, Nano optoelectronics; energy storage technology-next generation Li-based Batteries, Hydrogen storage, solar photovoltaic's, Flexible electronics. Intellectual Property Rights - case studies governing/pertaining to Materials/Technology.

UNIT - II TRANSFORMING TECHNOLOGIES IN BIOENGINEERING **9**

Establishment of smart biotechnology factory, Artificial intelligence in Bioprocess technology, Omics – Big data analysis through automation, 3D bio printing for tissue engineering. Simulation tools, RSM and Box model. Cyber physical system-based telemedicine, diagnosis and therapeutics through real time biosensors. Bionanotechnology.

UNIT - III ADVANCEMENTS IN SUSTAINABLE BUILT ENVIRONMENT **9**

Introduction – Technological developments in Architectural, Engineering and Construction (AEC) - Building Information Modelling (BIM) using Cloud computing technology and Internet of things (IoT) – Unmanned Aerial Vehicles, sensors – Additive manufacturing in construction – Concrete 3D printing - Materials used - Lightweight and functionally graded structures - Net Zero Energy buildings, Bioswales, Biofiltration pond, Ecosan systems- Recent developments in Waste water Management, Air pollution control, waste disposal - Integration of energy, water and environmental systems for a sustainable development- Emerging Technologies: Robot Highway- Vertical farming.

UNIT - IV SMART MANUFACTURING **9**

Smart factories and interconnection, Smart Manufacturing – automation systems, Additive Manufacturing, Smart grids, Micro Electro Mechanical Systems (MEMS), Stealth technology, Metal Finishing, Self-propelled vehicles, e mobility, green fuels, drones – unmanned aerial vehicles (UAVs), aerodynamics. Robotic Automation and Collaborative Robots – Augmented reality and haptics, engineering cybernetics and artificial intelligence (AI), Disruptive Technologies – Frugal Innovations – Emerging Technologies - Autonomous Robots, Swam Robot, Modular Robotics, Space craft.

UNIT - V SMART WORLD		9
Smart Sensors and IIOT, Smart grid, Hybrid renewable energy systems, Electronics in Smart city, Integration of Sensors in Robots and Artificial Intelligence, 5G Technology, Communication protocols, Human-Machine Interaction, Virtual Reality, Quantum Computing: Changing trends in transistor technology: Processor, Emerging Trends: Deep Space, Swarm Robots, Cyborg, Geofencing, Pervasive Computing.		
CO	**COURSE OUTCOMES**	**PO**
On completion of the course, student will be able to		
1.	Apply the basic concepts for electro optical sensing technology and selection of materials.	
2.	Analyze the technology on AI and Big Data for biomedical applications.	
3.	Elaborate the various technologies for sustainable built environment.	
4.	Evaluate different smart technologies for industrial robotics-based automation.	
5.	Compare various advanced technologies for development of smart city.	
TEXT / REFERENCES BOOKS		
1.	William D. Callister,"Materials Science and Engineering, An Introduction, John Willey and Sons Inc. Singapore, 2001.	
2.	V. Raghavan, "Physical Metallurgy: Principle and Practice,. Prentice Hall India Pvt Ltd, 2006.	
3.	Flavio Craveiro, Jose Pinto Duarte, Helena Bartolo and Paulo Jorge Bartolo, "Additive manufacturing as an enabling technology for digital construction: A perspective on Construction 4.0", Automation in Construction, Vol. 103, pp. 251- 267, 2019.	
4.	Klaus Schwab, "Fourth Industrial Revolution", Random House USA Inc, New York, USA, 2017.	
5.	Oliver Grunow, "SMART FACTORY AND INDUSTRY 4.0. The current state of Application Technologies", Studylab Publications, 2016.	
6.	Alasdair Gilchrist, "INDUSTRY 4.0: Industrial Internet of Things", Apress, 2016.	
7.	Sang C. Suh, U. John Tanik, John N Carbone, Abdullah Eroglu, "Applied Cyber-Physical Systems", Springer Publications, New York, 2013.	