SYLLABUS

(With effect from 2018-2019 Academic year)

V & VI Semester

Bachelor Degree

In

MECHANICAL ENGINEERING

Out Come Based Education

with

Choice Based Credit System

P.E.S. College of Engineering

Mandya - 571 401, Karnataka

(An Autonomous Institution Affiliated to VTU, Belagavi)

Grant -in- Aid Institution

(Government of Karnataka)

Accredited by NBA, New Delhi

Approved by AICTE, New Delhi.

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Preface

PES College of Engineering, Mandya, started in the year 1962, has become autonomous in the academic year 2008-09. Since, then it has been doing the academic and examination activities successfully. The college is running Eight undergraduate and Eight Postgraduate programs. It consists of Six M.Tech programs, which are affiliated to VTU. Other postgraduate programs are MBA and MCA.

India has recently become a Permanent Member by signing the Washington Accord. The accord was signed by the National Board of Accreditation (NBA) on behalf of India on 13th June 2014. It enables not only the mobility of our degree globally but also establishes equivalence to our degrees with that of the member nations such as Taiwan, Hong Kong, Ireland, Korea, Malaysia, New Zealand, Russia, Singapore, South Africa, Turkey, Australia, Canada and Japan. Among other signatories to the international agreement are the US and the UK. Implementation of Outcome Based Education (OBE) has been the core issue for enabling the equivalence and of Indian degrees and their mobility across the countries.

Our Higher Educational Institution has adopted the CBCS based semester structure with OBE scheme and grading system.

The credit based OBE semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching.

The OBE, emphasize setting clear standards for observable, measurable outcomes of programs in stages. There lies a shift in thinking, teaching and learning processes moving towards Students Centric from Teacher Centric education. OBE standards focus on mathematics, language, science, attitudes, social skills & moral values.

The key features which may be used to judge, if a system has implemented an outcome based education system is mainly Standard based assessments that determines whether students have achieved the stated standard. Assessments may take any form, so long as the process actually measure whether the student knows the required information or can perform the required task. Outcome based education is a commitment that all students of all groups will ultimately reach the same minimum standards. Outcome Based Education is a method or means which begins with the end in mind and constantly emphasizes continuous improvement.

Choice Based Credit System (CBCS) provides choice for students to select from the prescribed courses (core, Foundation, Foundation Elective, elective, open elective and minor or soft skill courses). The CBCS provides a 'cafeteria' type approach in which the students can Choose electives from a wide range of courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, adopt an interdisciplinary approach to learning which enables integration of concepts, theories, techniques, and, perspectives from two or more disciplines to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline. These greatly enhance the skill/employability of students.

In order to increase the Industry/Corporate readiness, many Soft Skills and Personality Development modules have been added to the existing curriculum of the academic year 2015-16. Industry Interactions have been made compulsory to enhance the field experience. In order to enhance creativity and innovation Mini Project and Industrial visit & Interaction are included in all undergraduate programs

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Dr. Nagarathna
Dean (Academic)
Professor
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PES College of Engineering

Vision

"*A* leading institution imparting quality engineering and management education developing creative and socially responsible professionals"

Mission

Mission of P E S College of Engineering is to,

- Provide state of the art infrastructure, motivate the faculty to be proficient in their field of specialization and adopt best teaching-learning practices.
- Impart engineering and managerial skills through competent and committed faculty using outcome based educational curriculum.
- Inculcate professional ethics, leadership qualities and entrepreneurial skills to meet the societal needs.
- Promote research, product development and industry-institution interaction.

Department of Mechanical Engineering

ABOUT THE DEPARTMENT

The department of Mechanical Engineering was established in the year 1962 during the origination of the institute. The department was granted academic autonomy in the year 2009. The department presently offers B.E in Mechanical Engineering, M Tech in Computer Integrated Manufacturing (CIM), M Tech in Machine Design, M.Sc., (Engg.) by research and research leading to Ph.D. The present intake capacity of the department is 120 for BE, 18 for M Tech CIM and 24 for M Tech Machine Design. The department has a faculty-student ratio of 1:15 for UG courses and 1:12 for PG courses. The department has well established laboratories to meet the academic requirements of UG and PG programmes and a skilled technical faculty to train the students. The department has its own library which has a collection of about 3160 reference books.

The department regularly organizes industrial visits, technical lectures by experts from industries and institutes in contemporary areas to bridge the gap between syllabi and current developments. The students are encouraged to undergo industrial training as well as to take up industry oriented projects during their academic course. Mechanical Engineering Association, formed by the students and faculty of the department regularly organizes co-curricular and extracurricular activities for the students.

Vision

Be a department well recognized for its ability to develop competent mechanical engineers capable of working in global environment"

Mission

The Mission of the Department of Mechanical Engineering is to:

- Provide quality education by competent faculty.
- Provide adequate infrastructure and learning ambience for the development of essential technical skills.
- Inculcate a sense of higher education and research orientation.
- Foster industry interaction.

Programme Educational Objectives (PEOs)

The Department of Mechanical Engineering, PES College of Engineering, is dedicated to graduating mechanical engineers who:
PEO1: Use the fundamentals of basic science, mathematics and mechanical engineering, to pursue their career as engineers as well as to lead and manage teams in public and private sector organizations.
PEO2: Pursue advanced education, research and development and engage in the process of life-long learning.
PEO3: Develop their career as entrepreneurs in a responsible, professional and ethical manner to serve the society.

Programme Outcomes (POs)

	By the time of graduation, students will have:
1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)

1	**Apply** computer simulation and experimental methods in the design and development of sustainable products/mechanical systems.
2	**Utilize** the knowledge of advanced manufacturing and condition monitoring techniques in industrial/practical applications.

EVALUATION SCHEME							
Scheme	**Weightage**	**Marks**	**Event Break Up**				
CIE	50%	50	**Test I**	**Test II**	**Quiz I**	**Quiz II**	**Assignment**
			35	35	5	5	10
SEE	50%	100	**Questions to Set: 10**		**Questions to Answer: 5**		
Scheme of SEE Question Paper (100 Marks)							
Duration: 3Hrs			**Marks: 100**		**Weightage: 50%**		

- Each of the two questions set shall be so comprehensive as to cover the entire contents of the unit.
- There will be direct choice between the two questions within each Unit
- Total questions to be set are 10. All carry equal marks of 20
- The number of subdivisions in each main question shall be limited to three only
- Number of questions to be answered by students is 5

P.E.S. COLLEGE OF ENGINEERING, MANDYA
(An Autonomous Institution)
Department of Mechanical Engineering

V Semester B.E. (ME)			Scheme of Teaching and Examination							
Sl. No.	Course Code	Course Title	Teaching Dept.	Hrs/Week			Total Credit	Examination Marks		
				L	T	P		CIE	SEE	Total
1	P18ME51	Management and Entrepreneurship	Mechanical	4	-	-	4	50	50	100
2	P18ME52	Dynamics of Machinery	Mechanical	4	-	-	4	50	50	100
3	P18ME53	Design of Machine Elements-I	Mechanical	4	-	-	4	50	50	100
4	P18ME54	Turbo machines	Mechanical	4	-	-	4	50	50	100
5	P18ME55X	Professional Elective-I	Mechanical	2	2	-	3	50	50	100
6	P18MEL56	Machine shop	Mechanical	-	-	3	1.5	50	50	100
7	P18MEL57	I C Engine & Fluid Machinery Lab	Mechanical	-	-	3	1.5	50	50	100
8	P18MEL58	Material Processing Lab (Skill Oriented Laboratory-I)	Mechanical	-	-	2	1	50	50	100
9	P18ME59	Problem Solving Skill for Competitive Examinations	Mechanical	-	2	-	1	50	50	100
10	P18HU510	Aptitude and Reasoning Development-Advanced. (ARDA)	HS&M	-	2	-	1	50	50	100
Total							25	500	500	1000

Professional Elective-I		
Sl.No	Course Code	Course title
1.	P18ME551	CAD/CAM
2.	P18ME552	Engineering Economics
3.	P18ME553	Mechatronics & Microprocessor
4.	P18ME554	Industrial Automation

VI Semester B.E. (ME)			Scheme of Teaching and Examination							
Sl. No.	Course Code	Course Title	Teaching Dept.	Hrs/Week			Total Credit	Examination Marks		
				L	T	P		CIE	SEE	Total
1	P18ME61	Design of Machine Elements-II	Mechanical	4	-	-	4	50	50	100
2	P18ME62	Finite Element Method	Mechanical	4	-	-	4	50	50	100
3	P18ME63	Heat and Mass Transfer	Mechanical	4	-	-	4	50	50	100
4	P18ME64X	Professional Elective-II	Mechanical	2	2	-	3	50	50	100
5	P18MEO65X	Open Elective-I	Mechanical	3	-	-	3	50	50	100
6	P18MEL66	Computer Aided Modeling & Analysis Lab	Mechanical	-	-	3	1.5	50	50	100
7	P18MEL67	Heat & Mass Transfer Lab	Mechanical	-	-	3	1.5	50	50	100
8	P18MEL68	Digital Manufacturing Lab (Skill Oriented Laboratory-II)	Mechanical	-	-	2	1	50	50	100
9	P18HU69	Technical Training Program	Placement	2	-	-	1	50	50	100
Total							23	450	450	900

Professional Elective-II			Open Elective-I		
Sl.No	Course Code	Course title	Sl.No.	Course Code	Course title
1.	P18ME641	Total Quality Management	1.	P18MEO651	Foundry &Welding Technology
2.	P18ME642	Non-Traditional Machining	2.	P18MEO652	Non-Destructive Testing
3.	P18ME643	I. C. Engines	3.	P18MEO653	Industrial Robotics and Automation
4.	P18ME644	Maintenance Engineering	4.	P18MEO654	Emerging Cooling Technology

Course Title: **MANAGEMENT AND ENTREPRENEURSHIP**			
Course Code: **P18ME51**	Semester: 05	L-T-P: 4-0-0	Credits: 04
Contact Period - Lecture: 52 Hrs	Exam: 3Hrs	Weightage %: CIE:50,SEE: 50	

Course Objectives: The course aims at enabling the students to understand the basic concepts of Management, Principles of organization, organization theories, evolution of entrepreneur concept, Types and functions of entrepreneur, characteristics, importance of motivation and its kinds, project identification, preparation, selection and reporting.

Course Content

Unit-1

Management: Introduction, meaning, nature and characteristics of management, scope and functional area of management, management as a science, art or profession, management & administration, role of management, levels of management, development of management thought, early and modern management approaches. **10 Hrs**

Self Study Component: Functions of Management

Unit-2

Organization Structure: Principles of organization, organization theories, departmentation, authority, power, organizing, organizational effectiveness, structuring the organization, organizational change, organization charts, types of organizations, Span of control, forms and functions of committees. **10 Hrs**

Self Study Component: Staffing, Stages in Recruitment

Unit-3

Entrepreneurship: meaning of entrepreneur, evolution of concept, functions of entrepreneur, types of entrepreneur, development of entrepreneurship, stages in entrepreneurial process, role of entrepreneurs in economic development, entrepreneurship in India, entrepreneurship and its barriers. **10 Hrs**

Self Study Component: Difference between manager and entrepreneurs.

Unit-4

Motivation, Job Analysis, Job Evaluation, Wages & Incentives: Introduction, characteristics, importance, kinds of motivation. Thoughts of motivation philosophy: Maslow's theory of needs, Gouglass Mc Gregore – 'X' & ' Y' theory, Herzberg's theory, Incentives as motivators, managing dissatisfaction and frustration. Job analysis, job description, job specification, job design: job evaluation, time recording, wage and incentives. Wages, methods of wage payment, incentives. Bonus system. Non financial incentives. Time rate v/s piece rate, fringe benefits, numericals. **12 Hrs**

Self Study Component: Differences between Job analysis and job evaluation, essentials of time recording in industry, time recording tools.

Unit-5

Projectology And Small Scale Industries (SSI): Meaning of a project, project identification, project preparation, project selection, project report, need and significance of a project report, contents, project planning, project monitoring and control, project evaluation, errors of a project report, project appraisal, project cycle and project phases. Identification of business opportunities: market, technical, financial and social feasibility study. Steps to start SSI, Government support to SSI. **10 Hrs**

Self Study Component: Effect of GATT, Liberalization/Privatization/Globalization (LPG) GST on industrial sector in India.

Text Books

1. **"Principles of management"**, P C Tripathi, P N Reddy, Tata McGraw Hill.
2. **"Dynamics of Entrepreneurial Development & Management"**, Vasanth, Desai, Himalaya Publishing House.
3. **"Entrepreneurship Development, Small business enterprise",** Poornima M, Charanthi math, Pearson Education 2005(2&4).

Reference Books

1. **"Management Fundamentals Concepts, Application& skill development",** By Robert lusier, Thomson.

2. **"Management By Stephen Robbins**", Pearson Education/PHI 17th Edition, 2003
Entrepreneurship Development, By SS Khanka, S Chand & Co.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** the functions of management in industries at various levels.	III
CO2	**Apply** the organization principles in understanding the departmentation, authority, power, organizing, organizational effectiveness and span of control.	III
CO3	**Analyse** the stages in entrepreneurial process, role of entrepreneurs in economic development, entrepreneurship in India, entrepreneurship and its barriers.	IV
CO4	**Analyse** the job in order to select recruit right person for the right job and performance with **ethics**.	IV
CO5	**Identify** the different project ideas and organize the different tasks of the project.	III

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the functions of management in industries at various levels.	3													
CO2	**Apply** the organization principles in understanding the departmentation, authority, power, organizing, organizational effectiveness and span of control.	3													
CO3	**Analyse** the stages in entrepreneurial process, role of entrepreneurs in economic development, entrepreneurship in India, entrepreneurship and its barriers.		3												
CO4	**Analyse** the job in order to select recruit right person for the right job and performance with **ethics**.		3						2						
CO5	**Identify** the different project ideas and organize the different tasks of the project.	3					1					2			

Course Title: **DYNAMICS OF MACHINERY**			
Course Code: **P18ME52**	Sem: 05	L-T-P : 4:0:0	Credit: 04
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at enabling the students to understand the basic concepts of static and dynamic force analysis of simple mechanisms, flywheel analysis, balancing of rotating and reciprocating masses under the application of external load and analysis of gyroscopic couple.

Course Content

Unit-1

Static force analysis: Introduction, Static equilibrium, Equilibrium of two force, three force and four force members, Members with two forces and torque, Free body diagrams, Static force analysis (graphical) of four bar mechanism and slider-crank mechanism without friction.**10 Hrs**

Self study component: Principle of Virtual work

Unit-2

Inertia force analysis: Introduction, D'Alembert's principle, Inertia force, inertia torque, dynamically equivalent systems, Correction couple, line of action of inertia force in a link, inertia force analysis of (i) four bar mechanism (ii) slider crank mechanism with known details of accelerations. **10 Hrs**

Self study component: Equivalent Dynamic System

Unit-3

Flywheels: Introduction, Turning moment diagrams, Fluctuation of Energy and speed, energy stored in a flywheel, determination of size of flywheels. **Governors:** Introduction, Types, working principle and application [without numericals]. **10 Hrs**

Self study component: Comparison between flywheels and Governors, and application of fly wheels

Unit-4

Balancing of rotating & reciprocating masses: Introduction, Static and dynamic balancing, Balancing of several masses revolving in the same plane, balancing of several masses revolving in different planes. Inertia force of the reciprocating mass of a slider crank mechanism, primary balancing, secondary balancing, balancing of single cylinder engine, balancing of multi cylinder-inline engine, balancing of radial engines. **12 Hrs**

Self study component: Comparison between inline and radial engine

Unit-5

Gyroscopes: Introduction, vectorial representation of angular motion, basic definitions, gyroscopic couple, Effect of gyroscopic couple on plane disc, aeroplane, ship, stability of two wheelers and four wheelers. **10 Hrs**

Self study component: Effect of gyroscopic couple on bearings (with numericals)

Text Books

1. S.S. Rattan **"Theory of Machines"** Tata McGraw-Hill, New Delhi, 4th edition, 2015, ISBN: 9789351343479.
2. Thomas Bevan" Theory of Machines" Dorling Kindersley (India)Pvt Ltd.,18th edition, ISBN: 978-81-317-2965-6.

Reference Books

1. V.P. Singh, "Theory of Machines," Dhanpat Rai & Co., 3rd Edition, 2013, ISBN: 9788177000528.
2. John J. Uicker, Jr., Gordon R. Pennock and Joseph E. Shigley, "**Theory of Machines and Mechanisms,"** Oxford University Press, 4th Edition, 2014, ISBN: 9780199454167.
3. P. L. Ballaney, "Theory of Machines and Mechanisms," Khanna Publishers., 25th Edition, 2003, ISBN: 978-8174091222.
4. Robert L. Norton, "Kinematics & Dynamics of Machinery," Tata Mc Graw Hill., 1st Edition, 2009, ISBN: 9780071278522.
5. Khurmi R S and Gupta J K , "Theory of Machines," S Chand & Company Pvt.Ltd Edition Re print 2015,ISBN978-81-219-2524-X

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

	Course Outcomes	Bloom's Level
CO1	**Apply** the concept of static forces acting on links and **analyze** simple planar mechanism using graphical method.	III, IV
CO2	**Apply** the concept of inertia forces acting on links and **analyze** simple planar mechanism with known value of acceleration.	III, IV
CO3	**Apply** the concept of turning moment diagram to **analyze** the performance of flywheel.	III, IV
CO4	**Analyze** the revolving and reciprocating masses in engines with the **applications** of the concepts of static and dynamic balancing.	III, IV
CO5	**Apply** the principle of gyroscopic effect to **analyze** the stability of mechanical systems (aeroplane, ship, two and four wheeler).	III, IV

Course Articulation Matrix

	Course Outcomes	Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the concept of static forces acting on links and **analyze** simple planar mechanism using graphical method.	3	2												
CO2	**Apply** the concept of inertia forces acting on links and **analyze** simple planar mechanism with known value of acceleration.	3	3												
CO3	**Apply** the concept of turning moment diagram to **analyze** the performance of flywheel.	2	3												
CO4	**Analyze** the revolving and reciprocating masses in engines with the **applications** of the concepts of static and dynamic balancing.	3	3												
CO5	**Apply** the principle of gyroscopic effect to **analyze** the stability of mechanical systems (aeroplane, ship, two and four wheeler).	2	3												

Course Title: **DESIGN OF MACHINE ELEMENTS-I**			
Course Code: **P18ME53**	Sem: 05	L-T-P3 : 4:0:0	Credit: 04
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at enabling the students to understand the basic concepts of Machine element design and to design some of the commonly used machine elements.

Course Content

Unit-1

Basic design concept: Introduction, designation of Engineering Materials, design considerations, Basic procedure of design of machine elements, Mechanical properties of Engineering materials, Failure of brittle materials, Failure of ductile materials, Design criteria based on strength and rigidity, factor of safety, criteria for selection of factor of safety, design of simple machine members subjected to static loading (including eccentric load) [limited to biaxial stresses].

Theories of failure: Maximum normal stress theory, Maximum shear stress theory, Distortion energy theory. **Stress concentration:** Stress concentration factor, design of simple elements with stress raisers Design of Cotter and Knuckle joints. **12 Hrs**

Self study component: Maximum strain theory [St. Venant's theory] of failure

Unit-2

Design against fatigue load: Introduction, types of fluctuating stresses, Low cycle fatigue, High cycle fatigue, Rotating beam bending test, S-N Diagram, endurance limit, endurance limit modifying factors: load, size and surface factors, Stress concentration effects; notch sensitivity, design for infinite life, combined steady and variable stress, Soderberg and Goodman relationship, stresses due to combined loading. Finite life design under completely reversed load. **Impact loading:** Impact stresses due to axial, bending and torsional loads, effect of inertia. **10 Hrs**

Self study component: Axial load fatigue test

Unit-3

Design of shafts: Introduction, shafts and axles, transmission shafts subjected to combined bending and twisting (including hollow shafts) based on strength and torsional rigidity, ASME code for shaft design. Design of Muff coupling and rigid flange coupling. **10 Hrs**

Self study component: Design against lateral rigidity

Unit-4

Threaded joints: Introduction, Stresses in threaded fasteners due to static loading, elastic analysis of bolted joints, initial tension in bolts, eccentrically loaded threaded joints. **Power screws** - Introduction, Types of screw threads, Design of Power Screws, efficiency, self-locking and over hauling. **10 Hrs**

Self study component: Differential and compound screws

Unit-5

Riveted joints – Introduction, methods of riveting, Types of rivets, rivet materials, types of riveted joints, failures of riveted joints, joint efficiency, design of boiler Joints.

Welded joints - Introduction, types of welded joints, design of welded joints (butt joints, fillet welds, axially loaded unsymmetrical welded joints, eccentrically loaded welded joints). **10 Hrs**

Self study component: Diamond or Lozenge joint

Design data hand book:

1 K. Mahadevan and Balaveera Reddy, "**Design Data Hand Book,"** CBS Publication, 4th Edition, 2013, ISBN: 978-8123923154.

Text Books

1 V. B. Bhandari, "**Design of Machine Elements,"** Tata McGraw Hill Publishing Company Ltd., New Delhi, 4th Edition 2017, ISBN: 9789339221126.

2 Maleev, V. L., & Hartman, J. B. . "***Machine design***". International Textbook Co.. CBS; 5 edition (1 December 2011) **ISBN-13:** 978-8123906379

Reference Books

1 Alfred S. Hall, A. R. Holowenko and H. G. Laughlin, "Schaum's Outlines of Machine

Design," Tata McGraw Hill Publishing Company Ltd., New Delhi., 2007, ISBN: 9780070634589.
2 Robert L Norton, "Machine design," Pearson, 5th Edition, 2013, ISBN: 978-0133356717.
3 Richard G Budynas and Keith J Nisbett, "**Shigley's Mechanical Engineering Design,"** McGraw Hill Education, 9th Edition, 2011, ISBN: 9780071077835.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** the basic design concept to **analyse** the failure theories and stresses induced in machine elements subjected to static load.	III, IV
CO2	**Apply** the basic design concept to **analyse** the failure theories and stresses induced in machine elements subjected to impact and fatigue loading.	III, IV
CO3	**Design** transmission shafts and couplings and **analyzing** it for safe design.	III, IV
CO4	**Apply** the concepts of threaded joints and power screws and **analyse** the same for safe design.	III, IV
CO5	**Apply** the concepts of riveted and welded joints and **analyse** the same for safe design for structural applications.	III, IV

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the basic design concept to **analyse** the failure theories and stresses induced in machine elements subjected to static load.	3	3												
CO2	**Apply** the basic design concept to **analyse** the failure theories and stresses induced in machine elements subjected to impact and fatigue loading.	3	3												
CO3	**Design** transmission shafts and couplings and **analyzing** it for safe design.		3	3											
CO4	**Apply** the concepts of threaded joints and power screws and **analyse** the same for safe design.	3	3	2											
CO5	**Apply** the concepts of riveted and welded joints and **analyse** the same for safe design for structural applications.	3	3	2											

Course Title: **TURBOMACHINES**			
Course Code: **P18ME54**	Sem: 05	L-T-P4 : 4:0:04	Credit: 04
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at to cover the basic principles, governing equations and applications of turbomachines and present an overall framework for the thermo – fluid dynamic design and performance analysis of turbomachines.

Course Content

Unit-1

Energy Transfer in Turbo Machine: Definition of a turbo machine. Parts of a Turbo machine. Comparison with positive displacement machines, Classification of turbomachines, Euler Turbine equation, Alternate form of Euler turbine equation and components of energy transfer. Degree of reaction, general expression for degree of reaction. Utilization factor, relation between utilization factor and degree of reaction. Condition for maximum utilization in Impulse, reaction and 50% reaction turbines .Velocity triangles for different values of degree of reaction. Comparison of impulse and reaction turbines. **11 Hrs**

Self study component: Classification of Aero-Foil section Blade terminology

Unit-2

Impulse Hydraulic Turbines (Axial flow type): Classification of hydraulic turbines. Unit quantities and their significance. Pelton wheel and its Components. Velocity triangles and power. Effect of friction and condition for maximum efficiency. Design parameters and design of Pelton turbines. Turbine efficiencies and performance curves of Pelton wheel. **10 Hrs**

Self study component: Basis for selection of Hydraulic turbine.

Unit-3

Reaction Hydraulic Turbines (Radial flow Type): Francis turbine, types of reaction turbines, components of reaction turbine, velocity triangles, power and efficiency. Runner shapes for different blade speeds, design parameters and design of Francis turbine. Draft tube, types of draft tube, design of draft tube and functions of draft tube. Kaplan turbine, components, velocity triangles and design parameters. **10 Hrs**

Self study component: Places of installation of hydraulic turbines in India

Unit-4

Steam Turbines (Both Axial and radial flow type): Classification of steam turbines with examples. Impulse staging and need for compounding; Velocity compounding, Pressure compounding and Pressure-velocity compounding. Velocity triangles, power and efficiency for impulse turbine, condition for maximum utilization factor. Effect of friction and blade angles on blade efficiency. Impulse reaction and reaction turbines and condition for maximum efficiency. Reheat factor and stage efficiency. **11 Hrs**

Self study component: Internal losses in steam turbine.

Unit-5

Centrifugal Pumps: Centrifugal pumps, introduction and main part of the centrifugal pump. Work done and velocity triangles. Head developed, manometric head, suction head, delivery head and static head. Pump losses and efficiency. Minimum starting speed, net positive suction head, priming. Multistage centrifugal pumps and Cavitation in centrifugal pumps. Axial flow pumps, description, velocity triangles, work done on the fluid and energy transfer or head. Miscellaneous pumps like Jet pump, air lift pump and submersible pump. **10 Hrs**

Self study component: Effects of Cavitation and Prevention of Cavitation.

Text Books

1. B K Venkanna**, "Fundamentals of Turbomachinary,"** PHI Learning Pvt Limited, 2009, ISBN: 978-8120337756.
2. A Valan Arasu**, "Turbomachines,"** Vikas Publishing House Pvt Ltd, 2009, ISBN: 9788125908401.
3. D. G. Shepherd, "**Principles of Turbo Machinery,"** Macmillan Company, 1964

Reference Books

1. V. Ganesan, **"Gas Turbines,"** Tata McGraw Hill Education Limited 3rd Edition, 2010,

ISBN: 978-0070681927.
2 S. M. Yahya**,** "**Turbines Compressors and Fans**," Tata McGraw Hill Education, 4th Edition, 2010, ISBN: 978-0070707023.
3 G. Gopalakrishnan, "**A Treatise on Turbo machines,"** Scitech Publications (India) Pvt Ltd, 1st Edition, 2008, ISBN: 9788187328988.
4 V. Kadambi and Monohar Prasad, **"An introduction to energy conversion: Volume III –Turbomachinery**," New Age International Private Limited, 2011, ISBN: 978-8122431896.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** the principles and operations of Turbo-machines with the use of velocity triangles.	III
CO2	**Apply** basics of fluid machines for **analyzing** the **design** parameters of axial flow hydraulic turbines.	III, IV
CO3	**Apply** basics of fluid machines for **analyzing** the **design** parameters of radial flow hydraulic turbines.	III, IV
CO4	**Apply** basics of fluid machines for **analyzing** the **design** parameters of steam turbines.	III, IV
CO5	**Analyse** the performance parameters of pumps with the use of velocity triangles.	IV

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the principles and operations of Turbo-machines with the use of velocity triangles.	3													2
CO2	**Apply** basics of fluid machines for **analyzing** the **design** parameters of axial flow hydraulic turbines.	3	3	2										1	2
CO3	**Apply** basics of fluid machines for **analyzing** the **design** parameters of radial flow hydraulic turbines.	3	3	2										1	
CO4	**Apply** basics of fluid machines for **analyzing** the **design** parameters of steam turbines.	3	3	2										1	
CO5	**Analyse** the performance parameters of pumps with the use of velocity triangles.	2	3											1	

Course Title: **CAD/CAM**			
Course Code: **P18ME551**	Sem: 05	L-T-P: 4:0:0	Credit: 03
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at enabling the students to understand the hardware and basics of CAD, also programming of CNC machines.

Course Content

Unit-1

Introduction: Role of computers in design and manufacturing, Product cycle in conventional and computerized manufacturing environment, introduction to CAD and CAM, advantages and limitations of CAD/CAM. Latest display systems, Types of input devices, output devices.**10 Hrs**

Self Study Component: Storage devices used in CAD

Unit-2

Computer Graphics and Geometric Modeling Techniques: Software configuration of a graphics system, functions of graphics software, 2-D transformation, homogeneous transformation, concatenation, problems on transformations, Geometric modeling: wire frame model, surface model, Types of curves: Cubic splines, Bezier curves, B-splines and NURBS. Types of Surfaces: Analytic surfaces and Synthetic surfaces. Solid modeling: Types of Solid Modeling Techniques: Constructive Solid Geometry (CSG), Sweeping, Boundary Representation (B-Rep), Feature-Based Modeling, Primitive Instancing, Cell Decomposition. **10 Hrs**

Self Study Component: Standardization of Graphics.

Unit-3

Numerical Control and CNC Machine Tools: Basic components of NC Systems, NC procedure, co-ordinate system, open loop & closed loop system, NC motion control system, Advantage & limitations of NC, application of NC. Classification of CNC machines, Features of CNC machining centers and CNC turning centers. Machine control unit of CNC. **10 Hrs**

Self Study Component: High Speed Machining

Unit-4

CNC Hardware Basics and Tooling: Structure of CNC machine tools, spindles, drives, actuation systems, feedback devices, Axes-standards. Cutting tool materials, Turning tool representation, Milling tooling system, Tool presetting, ATC. Cutting process parameter selection. **10 Hrs**

Self Study Component: Work/Job Holding Devices

Unit-5

CNC Programming: Part program fundamentals, ISO Codes for different functions, Tool length compensation, Cutter radius compensation, Canned cycles. Simple programming exercises in ISO codes for drilling using canned cycles, milling and turning centre programming. **12 Hrs**

Self Study Component: Axes system for Milling and Turning centres

Text Books

1. P.N. Rao, **"Principles and application of CAD/CAM,"** Tata McGraw Hill, 3rd edition, 26th May 2010, ISBN: 978-0070681934.
2. Groover, **"CAD/CAM",** Tata McGraw Hill, 1st edition 2003, ISBN: 978-8177584165

Reference Books

1. Newman and Sproull, **"Principles of interactive Computer Graphics",** Tata McGraw Hill, 28th Nov 2007, ISBN: 9780070463387.
2. Chno-Hwachang, Michel.A.Melkanoff, **"NC Machine programming and software Design",** Prentice Hall, 1988, ISBN: 9780136108092.
3. Pressman RS and Williams JE, **"Numerical Control and CAM",** Johnwiley Publication, 2000.
4. Steven Harrington, **"Computer Graphics",** McGraw Hill Book Co., 1st July 2014 ISBN: 978-9339204808.

5 Ibrahim Zeid, **"CAD-CAM,"** Tat McGraw Hill, 2nd edition, 25th June 2009, ISBN: 978-0070151345.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** basic concepts of computers and its hardware in design and manufacturing	III
CO2	**Apply** different modeling techniques to solve problems on 2D-3D transformations.	III
CO3	**Identify** basic components of NC and CNC machines.	III
CO4	**Identify** different hardware and tooling systems used in CNC machines.	III
CO5	**Develop** CNC part program for different operations.	IV

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** basic concepts of computers and its hardware in design and manufacturing	3													
CO2	**Apply** different modeling techniques to solve problems on 2D-3D transformations.	3													
CO3	**Identify** basic components of NC and CNC machines.	3													
CO4	**Identify** different hardware and tooling systems used in CNC machines.	3													
CO5	**Develop** CNC part program for different operations.			3										1	

Course Title: **ENGINEERING ECONOMICS**			
Course Code: **P18ME552**	Sem: 05	L-T-P : 4:0:0	Credit: 03
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at enabling students to analyze cost/revenue data and carry out economic analysis in the decision making process to justify or reject alternatives/projects on economic basis.

Course Content

Unit-1

Introduction: Definition and Meaning of Economic Terms, Goods, Classification of Goods, Wants, Characteristics and Classification of Wants, Wealth, Classification of Wealth, Demand, Equilibrium Demand Theory, Law of Demand, Price Elasticity of Demand, Supply, Law of Supply, Utility, Total and Marginal Utility, Types of Wages, Taxation, Principle of Taxation, Characteristics of a good Taxation System, Kind of Taxes and their Merits and Demerits. **10 Hrs**

Self study component: Direct and Indirect Taxes

Unit-2

Interest: Simple and Compound interest. Interest Formulae and Numericals. COMPARISON OF ALTERNATIVES: Present worth method, Equivalent Annual cost method and Rate of Return method, Numerical Problems. **10 Hrs**

Self study component: Conditions for present worth comparison, future worth comparison.

Unit-3

Depreciation: Causes of Depreciation, Methods of Calculating Depreciation, Straight Line Method, Sinking Funds Method, Sum of the Year Digits Methods, Declining Balance, Numerical Problems. REPLACEMENT ANALYSIS: Basic reasons of Replacement, Present Asset and its Replacement, Consideration Leading to Replacement, Installation and Removal Cost, Numerical Problems. **12 Hrs**

Self study component: Importance of accounting for Engineer

Unit-4

Estimation Of Material Cost: Definition of Estimating, Importance of Estimating, Aims of Estimating, Qualities of an Estimator, Functions of an Estimator, Errors in Estimating, Mensuration Procedure for Estimation, Estimating the Weight of Raw Materials & Material Cost, Numerical Problems. **10 Hrs**

Self study component: Constituents of Estimation and costing procedure.

Unit-5

Costs and Cost Accounting: First Cost, Fixed Cost, Variable Cost, Incremental Cost, Sunk Cost and Marginal Cost, Break Even Analysis & Minimum Cost Analysis, Material Cost, Labour cost, Allocation of Overheads by Different Methods, Man Hour Rate, Machine Hour Rate, Numerical Problems. **10 Hrs**

Self study component: Advantage of efficient costing.

Text Books

1 Tarachand, **"Engineering Economics**," Nem Chand & Brothers, 2012, ISBN: 978-8185240824.

2 T R Banga and S C Sharma, **"Industrial Organisation and Engineering Economics,"** Khanna Publishers, 2003, ISBN: 9788174090782.

Reference Books

1 Thuesen and Thuesen **"Engineering Economics**," Prentice Hall, 1992, ISBN: 978-0132799287.
2 Grant, Eugene L.; Ireson, W. Grant; Leavenworth, Richard S**, "Principles of Engineering Economics,"** Published by Wiley, 8th edition, ISBN: 9780471635260
3 Kannapan Augutine & Paranthaman, "**Mechanical Estimating & Costing,"** Tata McGraw Hill Publishing Co. Ltd., 1st Oct 1986 ISBN: 9780074519578.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** the basic concepts and terminologies used in engineering economics and taxation system.	III
CO2	**Identify** different types of interest rates and **Analyze** different alternatives for the purpose of investment.	III, IV
CO3	**Identify** different methods and causes of depreciation to perform replacement **analysis**.	III, IV
CO4	**Estimate** the material cost of different mechanical components.	V
CO5	**Estimate** different types of cost and perform break even **analysis.**	V

Course Articulation Matrix

	Course Outcomes	**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the basic concepts and terminologies used in engineering economics and taxation system.	3													
CO2	**Identify** different types of interest rates and **Analyze** different alternatives for the purpose of investment.	3	2												
CO3	**Identify** different methods and causes of depreciation to perform replacement **analysis**.	3	2												
CO4	**Estimate** the material cost of different mechanical components.		3												
CO5	**Estimate** different types of cost and perform break even **analysis.**	2	3												

Course Title: **MECHATRONICS AND MICROPROCESSOR**			
Course Code: **P18ME553**	Sem: 05	L-T-P: 4:0:0	Credit: 03
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at enabling the students to understand the basic concepts of Mechatronics, Mechatronics products and their applications, Different Electrical and Mechanical actuation systems, Signal condition process, Basic concepts of Microprocessor and data representation using different number systems.

Course Content

Unit-1

Introduction: Introduction to Mechatronics systems, measurement systems, control systems, Open & Closed loop control systems, basic elements of closed loop control system, Microprocessor based controllers such as automatic camera and engine management system, classification of sensors, light sensors, Tactile sensors, inputting data by switches, their merits and demerits, Hall – effect sensors, eddy-current Proximity sensors, selection of sensors. **10 Hrs**

Self study component: Velocity & motion sensor , Displacement & position seniors

Unit-2

Electrical Actuation Systems: Electrical systems, Mechanical switches, relays, solid state switches, diodes, thyristors and triacs, bipolar transistors, MOSFETS, solenoids, DC motors, permanent magnet DC motors with field coils, brushless permanent magnet DC motors, AC motors, stepper motors and their merits and demerits. **10 Hrs**

Self study component: Bipolar transistor MOSFETS

Unit-3

Signal Conditioning: Introduction to signal conditioning, signal conditioning process, operational amplifiers, inverting and non- inverting operational amplifiers, protection, filtering, wheat stone bridge, Digital signals, ADC, DAC, Multiplexers, Data Acquisition system, pulsed modulation. **10 Hrs**

Self study component: Digital signal processing, summing & Differential Amplifiers

Unit-4

Introduction to Microprocessor: Evolution of Microprocessor, Organization of Microcontroller, instructions, machine and mnemonics codes, machine and assembly language programming, High level language programming, organization of INTEL 8085 microprocessor, Data and Address busses, registers in the 8085, instruction set of 8085, instruction types, CPU of Microprocessors, the fetch operation, execute cycle, memory read / write cycle, timing diagram, HALT and HOLD states. **10 Hrs**

Self study component: Selecting a micro controller: Applications of Micro controlling

Unit-5

Microprocessor Data Representation: Positional number system, binary number system, octal number system, decimal number system, Hexadecimal number system, conversion from one number system to another, negative number representation, representation of floating point numbers, accuracy and range in floating point numbers, Binary Arithmetic: addition and subtraction of binary integers, overflow and underflow, logic gates, AND, OR, NOT, NAND, NOR and EXCLUSIVE – OR gate. **12 Hrs**

Self study component: Laws of Boolean Algebra & Numerical

Text Books

1 W. Bolton, **"Mechatronics,"** 2nd edition, Addison Wesely Longman, Inc.(Pearson Education, Essex, England), 1999, ISBN: 0-582-35705-5.
2 A P Mathur , **"Introduction to microprocessor,"** 3rd edition, Tata McGraw-Hill Publishing Co. Ltd., 1989 & reprint in 2006, ISBN: 0-07-460222-5.
3 R S Ganokar, **"Microprocessor Architecture, programming and applications with 8085/8085A,"** 6th edition, Wiley Eastern Publication, 1993, ISBN: 978-0852262979.

Reference Books

1 Malvino, **"Digital computer Electronics,"** McGraw Hill Education, 3rd edition, 2001, ISBN: 978-0074622353.
2 **Mechatronics & Microprocessors:** K P Ramachandran, G K Vijaya Raghava, M S Bala sundaram, Wiley precise India, 1st Edition, 18th May 2009, ISBN: 978-8126519859.

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

	Course Outcomes	Bloom's Level
CO1	**Identify** different types of control systems and sensors related to mechatronics and measurement systems.	III
CO2	**Identify** different types of mechanical and electrical components in mechatronics and measurement systems.	III
CO3	**Apply** the concepts of signal conditioning process to **analyse** data acquisition systems.	III, IV
CO4	**Apply** the concepts of different programming techniques in microprocessor and microcontroller.	III
CO5	**Make use of** different number systems and its conversion from one number system to another to **analyse** logic gates.	III, IV

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Identify** different types of control systems and sensors related to mechatronics and measurement systems.	3													
CO2	**Identify** different types of mechanical and electrical components in mechatronics and measurement systems.	3													
CO3	**Apply** the concepts of signal conditioning process to **analyse** data acquisition systems.	3	2												
CO4	**Apply** the concepts of different programming techniques in microprocessor and microcontroller.	3													
CO5	**Make use of** different number systems and its conversion from one number system to another to **analyse** logic gates.	3	1												

Course Title: **INDUSTRIAL AUTOMATION**			
Course Code: **P18ME554**	Semester: 05	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hrs.	Exam: 3Hrs.	Weightage: CIE: 50 %;SEE: 50%	

Course Objectives: The course aims at enabling the students to understand the Industrial automation and Quality control systems.

Course Content

Unit-1

Introduction: Production System – Facilities and Manufacturing Support systems, Automation in Production systems, Automation principles & Strategies**.**

Automation: Basic Elements of an Automated System, Advanced Automation Functions & Levels of Automation, Continuous versus Discrete control, Computer Process control. **10 Hrs**

Self Study Component: Forms of Computer Process Control.

Unit-2

Hardware Components For Automation And Process Control: Sensors, Actuators, Analog-to-Digital Converters, Digital-to-Analog Converters, Input/Output Devices for Discrete Data

Automated Manufacturing Systems: Components of Manufacturing systems, Classification of Manufacturing Systems, overview of Classification Scheme, Single Station Manned cells and Single Station Automated Cells. **12 Hrs**

Self Study Component: Applications of Single station cells.

Unit-3

Cellular Manufacturing: Part Families, Parts Classification and coding, Production Flow Analysis, Cellular Manufacturing, Application of group technology,

Flexible Manufacturing Systems: Introduction to FMS, FMS Components, FMS Applications & Benefits, and FMS Planning & Implementation Issues. **10 Hrs**

Self Study Component: Quantitative analysis of FMS.

Unit-4

Inspection Technologies: Automated Inspection, Coordinate Measuring Machines(CMM) Construction, operation & Programming, Software, Application & Benefits, Flexible Inspection System, Inspection Probes on Machine Tools, Machine Vision, optical Inspection Techniques, Non-contact Non optical Inspection Technologies. **10 Hrs**

***Self Study Component*:** Surface measurements.

Unit-5

Manufacturing Support System: Process Planning, Computer Aided Process Planning, Concurrent Engineering & Design for Manufacturing, Advanced Manufacturing Planning, lean production and waste in manufacturing, Just-in Time Production System, Autonomation, Worker involvement, Basic concepts of lean and Agile manufacturing. **10 Hrs**

Self Study Component: Applications of Lean & Agile Manufacturing

Text Books

1. M. P. Groover, "**Automation, Production Systems and Computer Integrated Manufacturing"**, Pearson education. 3rd Edition, 2008, ISBN: 9788120334182.
2. Vajpayee, and S. Kant, **Principle of Computer-Integrated Manufacturing,** PHI, 1st Edition, 1998, ISBN: 978-8120314764.

Reference Books

1. Amber G.H & P. S. Amber, "**Anatomy of Automation"**, Literary Licensing ,LLC 2012, ISBN: 9781258304256.
2. Viswanandham, "**Performance Modeling of Automated Manufacturing Systems"**,

PHI, 1st Edition, 2008, ISBN: 9788120308701.
3. Krishna Kant, "**Computer Based Industrial Control**", EEE-PHI **,** 1st Edition, 15 August 2004, ISBN: 9788120311237.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** concepts of automation in production and manufacturing support systems	III
CO2	**Identify** Hardware components for automation, process control and automated manufacturing systems.	III
CO3	**Apply** Cellular and Flexible mmanufacturing techniques in manufacturing organisations.	III
CO4	**Apply** Machine Vision and optical ttechniques for inspection of product quality in CMM.	III
CO5	**Make use of** Lean, Agile manufacturing and just in time manufacturing in modern automation systems.	III

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** concepts of automation in production and manufacturing support systems.	3													
CO2	**Identify** Hardware components for automation, process control and automated manufacturing systems.	3													
CO3	**Apply** Cellular and Flexible mmanufacturing techniques in manufacturing organisations.	3													
CO4	**Apply** Machine Vision and optical ttechniques for inspection of product quality in CMM.	3													
CO5	**Make use of** Lean, Agile manufacturing and just in time manufacturing in modern automation systems.	3													

Course Title: **MACHINE SHOP**			
Course Code: **P18MEL56**	Sem: 05	L-T-P: 0:0:3	Credit: 1.5
Contact Period: Practical: 36 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course Objective: The course aims at empowering the students with practical knowledge about manufacturing processes as well as skill enhancement.

Course Content

PART-A

Exp-1: Lathe operations on model-1 operations like plain turning, facing, knurling, taper turning and thread cutting. **6 Hrs**

Exp-2: Lathe operations on model-2. **6 Hrs**

Exp-3: Preparation of eccentric model by lathe machine using 4-jaw chuck. **6 Hrs**

PART-B

Exp-4: Gear teeth cutting on model1 using milling machine. **6 Hrs**

Exp-5: Performing grooving operation on model 2 using shaping machine. **3 Hrs**

Exp-6: Surfacing grinding operation on model 3 using grinding machine. **3 Hrs**

Seminar/viva **3 Hrs**

Test **3 Hrs**

Text Books

1 S. K. Hajra Choudhury, A. K. Hajra Choudhury and Nirjhar Roy, "**Elements of Workshop Technology- Vol II: Machine Tools,"** Media Promotors, 2010, ISBN: 978-8185099156.

2 HMT, "**Production Technology**", Tata McGraw Hill Educcation, 2001, ISBN: 9780070964433.

Evaluation Scheme

Scheme	Weightage %	Marks	Event Break Up		
			Test	Record	Seminar/viva
CIE	50	50	20	20	10
SEE	50	50			

Scheme for Examination

One Question from Part –A	20 Marks
One Question from Part -B	20 Marks
Viva – Voice	10 Marks
Total	**50 Marks**

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

	Course Outcomes	Bloom's Level
CO1	**Apply** the basic concepts of metal cutting process to understand the operations of machine tools.	III
CO2	**Analyse** the different parameters required for taper turning, thread cutting and gear cutting.	IV
CO3	**Develop** components using different machine tools and techniques	III
CO4	**Prepare** a report as an **individual** or as a team member to **communicate** effectively.	III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the basic concepts of metal cutting process to understand the operations of machine tools.	3													

CO2	**Analyse** the different parameters required for taper turning, thread cutting and gear cutting.		3												
CO3	**Develop** components using different machine tools and techniques.			3										2	
CO4	**Prepare** a report as an **individual** or as a team member to **communicate** effectively.								3	3					

Course Title: **I C ENGINE AND FLUID MACHINERY LAB**			
Course Code: **P18MEL57**	Sem: 05	L-T-P: 0:0:3	Credit: 1.5
Contact Period: Practical: 36 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at enabling the students with practical knowledge about performance measurement of IC Engines and Fluid machineries.

Course Content

PART-A

Exp-1: Performance test on Four stroke Diesel Engine.	**3 Hrs**
Exp-2: Performance test on Four stroke Petrol Engine.	**3 Hrs**
Exp-3: Performance test on Two stroke Petrol Engine	**3 Hrs**
Exp-4: Morse test on Multi Cylinder Engine.	**3 Hrs**

PART-B

Exp-5: Performance test on Pelton wheel Turbine.	**3 Hrs**
Exp-6: Performance test on Centrifugal Pump.	**3 Hrs**
Exp-7: Performance test on Reciprocating Pump.	**3 Hrs**
Exp-8: Performance test on Two Stage Reciprocating Air Compressor.	**3 Hrs**
Exp-9: Performance test on an Air Blower.	**3 Hrs**
Seminar	**6 Hrs**
Test	**3 Hrs**

Text Books

1. P. K. Nag, **"Basic and Applied Thermodynamics"** Tata McGraw Hill, 3rd Edition, 2006, ISBN: 9780070260627.
2. Dr. Jagadish Lal **"Fluid Mechanics and Hydraulics"** Metropolitan Book Co. Pvt. Ltd, New Delhi, 2002, ISBN: 9788120002722.

References

1. M. L .Mathur and R. P. Sharma , "**Internal Combustion Engine**," Dhanpat Rai Publications, 22 July 2016, ISBN: 978-9383182428.
2. Dr. R. K. Bansal, "**Fluid mechanics and hydraulic machines"** Laxmi publications Ltd., New Delhi. 9th edition, 2015, ISBN: 9788131808153.

Evaluation Scheme

Scheme	Weightage %	Marks	Event Break Up		
			Test	**Record**	**Seminar/viva**
CIE	50	50	20	20	10
SEE	50	50			

Scheme for Examination

One Question from Part –A	20 Marks
One Question from Part -B	20 Marks
Viva – Voice	10 Marks
Total	**50 Marks**

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** the concepts of energy interaction in different thermal systems.	III
CO2	**Analyse** the performance of power developing machines.	IV
CO3	**Analyse** the performance of power absorbing machines.	IV
CO4	**Make** use of experimental data for writing a report as an **individual** or as a team member to communicate effectively.	III

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the concepts of energy interaction in	3												2	

	different thermal systems.													
CO2	**Analyse** the performance of power developing machines.		3											
CO3	**Analyse** the performance of power absorbing machines.		3											
CO4	**Make use of** experimental data for writing a report as an **individual** or as a team member to communicate effectively.								3	3				

Course Title: **MATERIAL PROCESSING LAB (SKILL ORIENTED LABORATORY-I)**			
Course Code: **P18MEL58**	Semester: 05	L-T-P: 0-0-2	Credit: 1
Contact Period: Practical: 26 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course Objectives: The course aims at enabling the students to understand the synthesis of different materials and study of their microstructure and mechanical property

Course Content

PART-A

Exp-1: Synthesis of low melting temperature alloys using Stir casting Techniques. **2 Hrs**

Exp-2: Synthesis of low melting temperature Metal Matrix Composites (MMC) using Stir casting Techniques **2 Hrs**

Exp-3: Sample preparation and Microstructure observation of synthesised alloys and MMC **2 Hrs**

Exp-4: Find Hardness of synthesized alloys and MMC **2 Hrs**

Exp-5: Find hardness of heat Treated synthesized alloys and MMC. **2 Hrs**

PART-B

Exp-6: Synthesis of fiber reinforced Polymer Matrix Composites (PMC) by Hand Layup method. **4 Hrs**

Exp-7: Sample preparation and Microstructure observation of synthesised fiber reinforced PMC. **2 Hrs**

Exp-8: Find hardness of synthesized fiber reinforced PMC. **2 Hrs**

Exp-9: Determination of Impact strength (Izod and Charpy) of synthesized fiber reinforced PMC **2 Hrs**

Seminar **3 Hrs**

Test **3 Hrs**

Reference Books

1. Ronald F Gibson, **"Principles of Composite Material Mechanics",** McGraw Hill Book Co, 1994.
2. Robert M Jones, **"Mechanics of Composite Materials",** McGraw Hill Book Co, 1970.
3. William D.Calister, **"Material sciences and Engineering",** 8th Edition John Wiley and sons,2010.
4. Philips V A**., "Modern Metallurgical Techniques and their applications",** Wiley inter science, NY, 2003.

Evaluation Scheme

Scheme	Weightage %	Marks	Event Break Up		
			Test	Record	Seminar/viva
CIE	50	50	20	20	10
SEE	50	50			

Scheme for Examination

One Question from Part –A	20 Marks
One Question from Part -B	20 Marks
Viva – Voice	10 Marks
Total	**50 Marks**

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

	Course Outcomes	Bloom's Level
CO1	**Apply** the concepts of manufacturing to understand the stir casting and hand lay-up processes.	III
CO2	**Analyze** microstructure of synthesised MMC and PMC.	IV
CO3	**Develop** the components using MMC and PMC materials.	III
CO4	**Make use of** experimental data for writing a report as an **individual** or as a team member to communicate effectively.	III

Course Articulation Matrix															
Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the concepts of manufacturing to understand the stir casting and hand lay-up processes.	3													
CO2	**Analyze** microstructure of synthesised MMC and PMC.		3												
CO3	**Develop** the components using MMC and PMC materials.			3										2	
CO4	**Make use of** experimental data for writing a report as an **individual** or as a team member to communicate effectively.									3	3				

Course Title: PROBLEM SOLVING SKILL FOR COMPETITIVE EXAMINATIONS			
Course Code: **P18ME591**	Semester:05	L-T-P: 0-2-0	Credit: 1
Contact Period - Tutorial: 26Hrs.	Exam: 1Hr.	Weightage: CIE: 50 %; SEE: 50%	

Course Objectives: This course enhances student's problem-solving skills in mechanical engineering courses and trains them for competitive exams.

Course Content

Applied Mechanics and Design

Engineering Mechanics: Free-body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations, collisions.

Mechanics of Materials: Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope **8 Hrs**

Fluid Mechanics and Thermal Sciences

Fluid Mechanics: Fluid properties; fluid statics, manometry, buoyancy, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings.

Thermodynamics: Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations. **8 Hrs**

Materials, Manufacturing and Industrial Engineering

Engineering Materials: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

Machining and Machine Tool Operations: Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, design of jigs and fixtures.

Metrology and Inspection**:** Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly. **10 Hrs**

Reference Books

1. R K Jain**, "Mechanical Engineers for Competitions",** Kanna publication, 2018. ISBN: 978-81-7409-282-3, 2015.
2. CL Educate, **"Gate 2020Mechanical Engineering",** Gk publication (P) Ltd. ISBN:978-81-93975-51-0, 2020.
3. Ajay KumarTamrakar and Dineshkumar Harusampath, **"Wiley Acing the Gate Mechanical Engineering",** 2nd Edition, Wiley publication, ISBN:9788126566563,2018.

Evaluation Scheme				
Section	**Question No.**	**No. of Questions**	**Marks Per Question**	**Total Marks**
General Aptitude	1 to 10	10	1	10
Technical	11 to 40	30	1	30
Engineering	41 to 70	30	2	60
Total Question: 70		Total Marks: 100	Total Duration: 3hrs	
Technical Section:70 Marks	General Aptitude:15 Marks	Engineering Mathematics:15 Marks		
25 to 40 marks will allotted to Numerical Answer Type Questions.				

Type of question	**Negative marking for wrong answer**
MCQs	1/3 for 1 mark questions 2/3 for 2 marks questions
Numerical Answer Type **(NAT)** Questions	No negative marking

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** the technical skill to attend all kind of competitive examinations.	III
CO2	**Analyse** the problems related to all streams of mechanical engineering.	IV
CO3	**Motivate** to take up all kinds of competitive examinations.	IV

Course Articulation Matrix

	Course Outcomes	**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the technical skill to attend all kind of competitive examinations.	3													
CO2	**Analyse** the problems related to all streams of mechanical engineering.		3												
CO3	**Motivate** to take up all kinds of competitive examinations.		3												

Course Title : **APTITUDE AND REASONING DEVELOPMENT - ADVANCED (ARDA)**			
Course Code : **P18HU510**	Semester : 05	L- T- P : 0 - 0 - 2	
Contact Period: Lecture: 32 Hr, Exam: 3 Hr		Weightage: CIE:50;% SEE:50%	
Prerequisites: Vocabulary builder, Concept of Percentage.			

Course Content

Unit-1

Reading Comprehension: Introduction: Read more and more, The process of writing and its relevance to the process of writing, how reading skills are important for aspects other than the reading comprehension questions, the daily reading scheme.

Seven dimension approach to better reading skills: Developing the ability of understanding vocabulary in context, Ability to identify and understand main ideas, Ability to predict and identify supporting details, Understanding the use of transition and idea organization patterns, Inferences, Identifying purpose and tone, Recognizing and evaluating arguments and their common structures.

Theory of reading comprehension : Solving RC passages is an exact science, tackling RC on the basis of evaluation of support, All passages have a topic, purpose and a plan, Other things to pick up while reading the passage– The tonality and other software related the author's viewpoint in the passage, specific details and their use in the passage, Types of questions asked in reading comprehension passage. **8 Hrs**

Unit-2

Averages and Alligations mixtures:

Average: relevance of average, meaning of average, properties of average, deviation method, concept of weighted average. **Alligation method:** situation where allegation technique, general representation of alligations, the straight line approach, application of weighted average and alligation method in problems involving mixtures. Application of alligation on situation other than mixtures problems. **6 Hrs**

Unit-3

Permutation and Combination: Understanding the difference between the permutation and combination, Rules of Counting-rule of addition, rule of multiplication, factorial function, Concept of step arrangement, Permutation of things when some of them are identical, Concept of 2^n, Arrangement in a circle.

Probability: Single event probability, multi event probability, independent events and dependent events, mutually exclusive events, non-mutually exclusive events, combination method for finding the outcomes**.** **6 Hrs**

Unit-4

Progression:

Arithmetic Progression: sum of given number of terms in an A.P., arithmetic mean, to insert a given number of arithmetic means between two given quantities, nth term of an A.P., finding common difference of an A.P. given 2 terms of an A.P., types of A.P.s– increasing A.P.s and decreasing A.P. s

Geometric: to find, the geometric mean between two given quantities, to insert a given number of geometric means between two given quantities, sum of a number of terms in a G.P. Types of G.P.s— increasing G. P. s type one and two , decreasing G. P. s type one and two.

Harmonic Progression: to find the harmonic mean between two given quantities , theorems related with progressions, solved examples sample company questions **4 Hrs**

Unit-5

Coding Decoding: Letter Coding, Number Coding, symbol coding

Crypt arithmetic: Basic concepts , addition **,** subtraction, multiplication of coded alphabets,Types of cryptarithm

Data Interpretation: Approach to interpretation - simple arithmetic, rules for comparing fractions, Calculating (approximation) fractions, short cut ways to find the percentages, Classification of data– Tables, Bar graph, line graph, Cumulative bar graph, Pie graph,

Combination of graphs. Combination of table and graphs	**8 Hrs**

Reference Books

1. The Trachtenberg speed system of basic mathematics, published by Rupa publications.
2. CAT Mathematics by Abhijith Guha. published by PHI learning private limited.
3. Quantitative aptitude by Dr. R. S Agarwal, published by S.Chand private limited.
4. Verbal reasoning by Dr. R. S Agarwal , published by S. Chand private limited.
5. Quantitative aptitude for CAT by Arun Sharma, published by McGraw Hill publication.

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

	Course Outcomes	**Bloom's Level**
CO1	Apply the approach of seven dimension to better reading skills.	II
CO2	Solve the questions under reading comprehension confidently with higher accuracy than random reading.	IV
CO3	Apply the technique of alligation for effective problem solving.	II
CO4	Interpret the requirement of different methods of calculating average and apply the right method at right scenario.	IV
CO5	Formulate the equations for summation and other functions for all the kinds of progressions– AP<GP and HP.	V
CO6	Effective solve the problems of coding decoding and crypt arithmetic and Interpret the data given in the graphical format and infer the results.	I

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	Apply the approach of seven dimension to better reading skills.														
CO2	Solve the questions under reading comprehension confidently with higher accuracy than random reading.														
CO3	Apply the technique of alligation for effective problem solving.														
CO4	Interpret the requirement of different methods of calculating average and apply the right method at right scenario.														
CO5	Formulate the equations for summation and other functions for all the kinds of progressions– AP<GP and HP.														
CO6	Effective solve the problems of coding decoding and crypt arithmetic and Interpret the data given in the graphical format and infer the results.														

Course Title: **DESIGN OF MACHINE ELEMENTS-II**			
Course Code: **P18ME61**	Sem: 06	L-T-P: 4:0:0	Credit: 04
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at strengthening the design capabilities of the students by exposing them to the design of different mechanical elements that are commonly used in engineering applications.

Course Content

Unit-1

Curved Beams: Introduction, stresses in curved beams, design of curved beams.

Springs: Introduction, types of springs, terminology, stresses and deflection in helical coil springs of circular and non-circular cross sections, springs under fluctuating loads, concentric springs. Leaf Springs, stresses in leaf springs, equalized stresses, length of spring leaves. Safety issues in leaf spring design. **10 Hrs**

Self study component: Surge in springs, buckling in compression spring.

Unit-2

Cylinders & cylinder heads: Introduction, thick cylindrical shells subjected to internal and external pressure, Lame's Equations, Clavarino's equations, Birnie's equations, compound cylinders, stresses due to different types of fits, autofrettage, circular and rectangular cover plates. Safety aspects in pressure vessel design. **10 Hrs**

Self study component: Study of Barlow's equation, Dish head cylinder with uniformly distributed load.

Unit-3

Spur, helical and bevel gears: Introduction, spur gears- terminology, standard proportions of gear systems, stresses in gear tooth, Lewis equation and form factor, design for strength, dynamic load and wear load. Helical Gears- definitions, formative number of teeth, design based on strength, dynamic and wear loads. Bevel Gears- terminology, formative number of teeth, design based on strength, dynamic and wear loads. **12 Hrs**

Self study component: Causes of Gear tooth failure, Effect of material defects on gear functioning.

Unit-4

Worm Gears- Terminology, design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Clutches & brakes: Introduction, types of clutches, design of Clutches (single plate, multi plate and cone clutches). Brakes- Types, energy absorbed, heat dissipated. Design of single block brakes and simple band brakes. Safety issues in brakes. **10 Hrs**

Self study component: Thermal rating of worm Gearing, Working of Centrifugal clutch.

Unit-5

Lubrication and Bearings: Introduction, principle of hydrodynamic lubrication, assumptions in hydrodynamic lubrication, bearing characteristic number and modulus, Sommerfeld number, coefficient of friction, power loss, heat generated and heat dissipated, Design of journal bearings. Rolling contact bearings- types of bearings, static equivalent load, selection of ball and roller bearings. **10 Hrs**

Self study component: Properties of sliding contact bearing materials

Design data hand book:

1 K. Mahadevan and Balaveera Reddy, "**Design Data Hand Book,"** CBS Publication, 4th Edition, 2013, ISBN: 978-8123923154.

Text Books

1 R S Khurmi & J K Gupta, Publisher: **" Design of Machine Elements"** , 34th Revised edition , S Chand Publications, ISBN:9788121925372.

2 V. B. Bhandari, "**Design of Machine Elements"** Tata McGraw Hill Publishing Company Ltd., New Delhi, 4th Edition 2016, ISBN: 9789339221126.

3 K Raghavendra, **"Design of Machine Elements II"**, CBS publishers and distributors pvt Ltd., ASIN: B07DL1ZKND

Reference Books

1. Alfred S. Hall, A. R. Holowenko and H. G. Laughlin, **"Schaum's Outlines of Machine Design,"** Tata McGraw Hill Publishing Company Ltd., New Delhi., 2007, **ISBN:** 9780070634589.
2. Robert L Norton, "**Machine design,"** Pearson, 5th Edition, 2013, ISBN: 978-0133356717.
3. Richard G Budynas and Keith J Nisbett, "**Shigley's Mechanical Engineering Design,"** McGraw Hill Education, 9th Edition, 2011, ISBN: 9780071077835.

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

	Course Outcomes	Bloom's Level
CO1	**Apply** the engineering mathematics and basics of mechanical engineering to **design** the curved beams and springs.	III, IV
CO2	**Apply** the Lame's equation, Clavarino's equations and Birnie's equations to **design** the cylinder and their cover plates.	III, IV
CO3	**Apply** the gear design procedure to **analyse** the power transmission in spur gear, helical gear, bevel gear and worm gear.	III, IV
CO4	**Design** the brakes and clutches to understand their effects during power transmission.	IV
CO5	**Apply** the basics of tribology to **design** the sliding and rolling contact bearings.	III, IV

Course Articulation Matrix

	Course Outcomes	Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the engineering mathematics and basics of mechanical engineering to **design** the curved beams and springs.	3		2											1
CO2	**Apply** the Lame's equation, Clavarino's equations and Birnie's equations to **design** the cylinder and their cover plates.	3		3											1
CO3	**Apply** the gear design procedure to **analyse** the power transmission in spur gear, helical gear, bevel gear and worm gear.	3	3											2	1
CO4	**Design** the brakes and clutches to understand their effects during power transmission.			3										1	1
CO5	**Apply** the basics of tribology to **design** the sliding and rolling contact bearings.	2		3											1

Course Title: **FINITE ELEMENT METHODS**			
Course Code: **P18ME62**	Sem: 06	L-T-P: 4:0:0	Credit: 04
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims to provide an introductory approach to finite element method as a basic numerical tool for solving mechanical engineering problems.

Course Content

Unit-1

Introduction to FEM: Need for use of FEM, Advantages and disadvantages of FEM, Engineering Applications of FEM, Steps involved in FEM, Discretization process - types of elements (1D,2D,3D), size of the elements, location of nodes, node numbering scheme, Method of solution of linear algebraic equations - Gauss elimination method. Numerical integration by Gaussian quadrature (one point and two point formula). Basic elastic equations – body force and traction force, strain-displacement relations. Principle of minimum potential energy and derivation of potential energy functional for a 3D elastic body, concept of plane stress and plane strain and their stress-strain relations. **10 Hrs**

Self study component: Methods for FEM formulation

Unit-2

Interpolation Models: Displacement function, selection of the order of displacement function, convergence criteria, geometric isotropy, Pascal's triangle for 2D polynomial, Different co-ordinate systems used in FEM, Interpolation or shape functions for 1D linear and quadratic bar elements and 2D linear triangular (CST) element in cartesian and natural co-ordinate systems. Lagrangian polynomial – Shape functions for linear quadrilateral element (QUAD 4) and quadratic quadrilateral element (9-noded), Iso-parametric, sub-parametric and super-parametric elements, Concept of Jacobian matrix, Jacobian matrix for CST. **10 Hrs**

Self study component: Simplex, complex and multiplex Elements. Pascal's pyramid for 3D Polynomial

Unit-3

Element Stiffness Matrix and Load Vectors: Strain displacement matrix, Stiffness matrix and load vector for linear and quadratic bar element and CST element. Assembly of elements by direct stiffness method, Treatment of boundary conditions- elimination and penalty methods. Analysis of axially loaded uniformly tapered and stepped bars. **12 Hrs**

Self study component: special characteristics of stiffness matrix. Stress vector for CST Element under plane stress and plane strain condition.

Unit-4

Analysis Of Plane Trusses and Beams: stiffness matrix for plane truss element, analysis of truss members. Hermite shape function for beam element in Cartesian coordinates, Stiffness matrix and load vector for beam element, element shear force and bending moment, analysis of beams. **10 Hrs**

Self study component: comparison of beams and trusses, Differences between Hermite shape function and Lagrange interpolation function.

Unit-5

Analysis of Heat Transfer Problems: Steady state heat transfer, 1D heat conduction- governing equation, boundary conditions, one-dimensional element, Galerkin's approach to heat conduction, heat flux boundary condition. 1D heat transfer in thin fins- Formulation of equations. Simple numerical of 1D heat transfer problems on composite walls and fins with conduction and convection. **10 Hrs**

Self study component: Different types of boundary conditions in heat transfer problem.

Text Books

1. Chandrakanth S Desai and J.F. Abel, **"Introduction to the Finite Element Method,"** CBS, 1st edition, 2005, ISBN: 978-8123908953.
2. T R Chandrupatla and A D Belegundu, **"Introduction to Finite Elements in engineering,"** Pearson, 4th edition, 19th October 2011, ISBN: 978-0132162746.

3 Singiresu S Rao, **"The Finite Element Method in engineering,"** Elsevier Publisher, 5th edition, 2008 ISBN: 978-9380931555.

Reference Books

1 O.C.Zienkiewicz, **"The FEM its basics and fundamentals,"** Elsevier Publisher, 6th edition, 2007, ISBN: 978-8131211182.
2 J.N.Reddy, **"Finite Element Method,"** McGraw Hill International Edition, 2005, ISBN: 9780072466850.
3 Daryl. L. Logon, **"Finite Element Methods,"** Thomson Learning 5th edition, 1st Jan 2011, ISBN: 978-0495668251.
4 David V. Hutton, **"Fundamentals of Finite Element Analysis,"** Tata McGraw Hill Publishing Co. Ltd, New Delhi, 10th June 2005, ISBN: 978-0070601222.

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

	Course Outcomes	Bloom's Level
CO1	**Apply** the basic concepts and mathematical preliminaries of FEM required to **solve** basic field problems.	III, IV
CO2	**Develop** interpolation models for 1D and 2D elements that satisfy convergence criteria and geometric isotropy and use isoparametric concept in the finite element analysis.	IV
CO3	**Formulate** element stiffness matrices and load vectors for different elements using variational principle and **analyze** axially loaded bars.	IV
CO4	**Make use of** finite element formulations in **analysing the** stresses, strains and reactions of trusses and transversely loaded beams.	III, IV
CO5	**Formulate** finite element equations for heat transfer problems using Variational and Galerkin techniques to **analyze** conduction and convection heat transfer problems.	III, IV

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the basic concepts and mathematical preliminaries of FEM required to **solve** basic field problems.	3	2												
CO2	**Develop** interpolation models for 1D and 2D elements that satisfy convergence criteria and geometric isotropy and use isoparametric concept in the finite element analysis.	1		3											
CO3	**Formulate** element stiffness matrices and load vectors for different elements using variational principle and **analyze** axially loaded bars.	1	3												
CO4	**Make use of** finite element formulations in **analysing the** stresses, strains and reactions of trusses and transversely loaded beams.	3	2												
CO5	**Formulate** finite element equations for heat transfer problems using Variational and Galerkin techniques to **analyze** conduction and convection heat transfer problems.	1	3												

Course Title: **HEAT AND MASS TRANSFER**			
Course Code: **P18ME63**	Sem: 06	L-T-P: 4:0:0	Credit: 04
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims to cover the basic principles of heat transfer, to present a wealth of real-world engineering examples to give students a feel for how heat transfer is applied in engineering practice and to develop an intuitive understanding of the subject matter by emphasizing the physics and physical arguments.

Course Content

Unit-1

General introduction: Modes and basic laws of heat transfer- general heat conduction equation in Cartesian coordinates, heat conduction equation in cylinder and spherical co-ordinates (no derivation). Boundary conditions of conduction problems. Numerical Problems.

One Dimensional steady state heat conduction: slab, hollow cylinder, hollow sphere and their composites. Critical thickness of insulations, Numerical Problems. **Theory of fins** governing partial differential equation – One Dimensional fin of uniform cross-section – Numerical problems. **12 Hrs**

Self study component: Combined Heat Transfer Mechanism, Thermal Resistances also in Series and Parallel, Applications of Fins

Unit-2

Steady State Conduction with Heat Generation: Introduction, One Dimensional heat conduction with heat sources in slab, temperature effect on thermal conductivity. **Transient Heat Conduction:** Systems with negligible internal resistance, Transient heat conduction in plane walls, cylinders, spheres with convective boundary conditions, Chart solution, Numerical problems. **10 Hrs**

Self study component: Numerical methods for ID & Two Dimensional steady state Heat Generation

Unit-3

Convection: Concept of boundary layers (hydro dynamic and thermal) - critical Reynolds number. Drag-co-efficient and heat transfer coefficient, Reynold's – Colburn analogy. Application of dimensional analysis for free & forced convection problems, significance of Reynolds, Prandtl and Nusselt and Grashoff numbers. **Free convection:** free convection from or to vertical, horizontal and inclined flat plates, vertical and horizontal cylinder. Numerical Problems. **Forced convection**: Flow over a flat plate, over a cylinder and across a tube bundle, flow through tubes and ducts. Numerical Problems. **10 Hrs**

Self study component: Forced Convection flow over spheres, Forced Convection cooling of electronic devices.

Unit-4

Radiation: Introduction- absorption, reflection and transmission of radiation, black and grey body concept , Kirchoff's Law, Planck's law,Wein's displacement law, Lamberts cosine law, radiation intensity- total emissive power, radiation between two parallel black surfaces, gray surfaces, radiation shield, Hottel's cross string formula. Numerical Problems. **10 Hrs**

Self study component: Fundamental principles of white, Opaque and transparent body concept, Radiation Shield.

Unit-5

Heat exchangers: Classification of heat exchangers overall heat transfer coefficient, fouling and fouling factor; LMTD, effectiveness- NTU methods of analysis of heat exchangers. Numerical Problems. **Heat transfer with phase change (boiling and condensation**). Types of condensation, Nusselt's theory for laminar condensation on a vertical flat surface, regimes of pool boiling, Numerical Problems. **Mass transfer**: Mass transfer concept and Fick's law of diffusion (no numericals) **10 Hrs**

Self study component: Shell & tube, compact& multipass heat exchangers Mechanism of Nucleate Boiling

Text Books

1. A Basic approach by M Necati, Ozisik, **"Heat Transfer,"** Mc-Graw Hill International edition, 1988, ISBN: 978-0070479821
2. Frank Kreith, Mark Bohn, **"Principles of Heat Transfer,"** Cengage Learning, 6th edition, 2006, ISBN: 978-8131500385.

Reference Books

1. Yunus A Cengel, **"Heat transfers a practical approaches,"** Tata Mc-Graw Hill, Mc-graw Hill, 2nd edition 1st October, 2002, ISBN: 978-0072458930.
2. James Sucec, **"Heat Transfer,"** Jaico Book house, 2002, ISBN: 978-8172247799.
3. Er. R K Rajput **"Heat & Mass Transfer,"** S Chand Publications, 2008, ISBN: 978-8121926171.
4. P.K. Nag, **"Heat & Mass Transfer,"** Tata Mc-Graw Hill, 3rd edition, 2011, ISBN: 978-0070702530.
5. R.C.Sachdeva, **"Fundamentals of Engg. Heat & Mass Transfer,"** New Age, 4th edition, 2010, ISBN: 978-8122427851.
6. J.P. Holman, Souvik Bhattacharyya **"Heat Transfer,"** Tata Mc-Graw Hill, 10th edition, 2011, ISBN**:** 978-0071069670.

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

Course Outcomes		Bloom's Level
CO1	**Apply** fundamentals of heat transfer modes to **formulate** governing differential equation to solve problems of one-dimensional steady state conduction heat transfer problems with focus on fin **design**.	III, IV
CO2	**Apply** the concepts of steady state and transient heat conduction, heat generation and variable thermal conductivity to **analyse** heat transfer problems.	III, IV
CO3	**Apply** the concepts of convection heat transfer to **analyse** the problems using both analytical and empirical approaches.	III, IV
CO4	**Apply** the fundamentals of radiation heat transfer to **analyse** mechanical systems.	III, IV
CO5	**Apply** the heat transfer basics to **design** heat exchanger and understand the concepts of condensation and boiling of liquids.	III, IV

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** fundamentals of heat transfer modes to **formulate** governing differential equation to solve problems of one-dimensional steady state conduction heat transfer problems with focus on fin **design**.	3	2	1											
CO2	**Apply** the concepts of steady state and transient heat conduction, heat generation and variable thermal conductivity to **analyse** heat transfer problems.	3	3												
CO3	**Apply** the concepts of convection heat transfer to **analyse** the problems using both analytical and empirical approaches.	3	3												
CO4	**Apply** the fundamentals of radiation heat transfer to **analyse** mechanical systems.	3	2												
CO5	**Apply** the heat transfer basics to **design** heat exchanger and understand the concepts of condensation and boiling of liquids.	3		3											

Course Title: TOTAL QUALITY MANAGEMENT			
Course Code: **P18ME641**	Semester: 06	L-T-P-3-2-0	Credits: 03
Contact Period - Lecture: 52 Hrs.;	Exam:3Hrs.	Weightage%: CIE: 50,SEE: 50	

Course Objectives: The course aims at enabling the students to understand the basic concepts of TQM. Identify and develop appropriate tools solving of real life problems.

Course Content

Unit-1

Introduction: Introduction, Definition, Basic approach, Gurus of TQM, Awareness, Defining Quality, Historical Review, Obstacles, Benefits of TQM, TQM Exemplary Organization, Exercises.

Leadership: Definitions, Characteristics of Quality Leaders, Leadership Concepts, The 7 Habits of Highly Effective People, Ethics, The Deming Philosophy, Role of TQM Leaders, Implementation, Quality Council, Core Values, Concepts and Framework, Quality Statements, Strategic Planning, Communications, Decision Making, TQM Exemplary Organization, Exercises. **12 Hrs**

Self Study Component: Characteristics of successful teams.

Unit-2

Customer Satisfaction: Introduction, Who is the Customer?, Customer Perception of Quality, Feedback, Using Customer Complaints, Service Quality, Translating Needs into Requirements, Customer Retention, Additional Comments, TQM Exemplary Organization, Exercises.

Continuous Process Improvement: Introduction, Process, The Juran Trilogy, Improvement Strategies, Types of Problems, The PDSA Cycle, Problem-Solving Method, Kaizen, Reengineering, Six-Sigma, TQM Exemplary Organization, Exercises. **10 Hrs**

Self Study Component: Objectives of Performance measures.

Unit-3

Benchmarking: Introduction, Benchmarking Defined, Reasons to Benchmark, Process, Deciding What to Benchmark, Understanding Current Performance, Planning, Studying Others, Learning from the Data, Using The Findings, Pitfalls and Criticisms of Benchmarking, TQM Exemplary Organization, Exercises.

Quality Management Systems: Introduction, Benefits of ISO Registration, ISO9000 Series of standards, Sector-Specific Standards, ISO 9001 Requirements, Implementation, Documentation, Writing the Documents Internal Audits, Registration, Closing Comments, TQM Exemplary Organization, Exercises. **10 Hrs**

Self Study Component: Limitations of Quality of Cost**.**

Unit-4

Environmental Management System: Introduction, ISO14000 Series Standards, Concepts of ISO 14001, Requirements of ISO 14001, Benefits of EMS, Integrating ISO 14000with ISO9000, Relationship to Health and safety Additional Comments, TQM Exemplary Organization, Exercises.

Statistical Process Control: Introduction, Pareto Diagram, Process Flow Diagram, Cause-and-Effect Diagram, Check Sheets, Histogram, Statistical Fundamentals, Introduction to Control Charts, State of Control, Out of Control Process, Process Capability, Different Control Charts for variables, Control Charts for Attributes, scatter Diagram, Summary, TQM Exemplary Organization Exercises. **10 Hrs**

Self Study Component: Applications and Importance of MSA.

Unit-5

Quality Function Deployment: Introduction, The QFD Team, Benefits of QFD, The Voice of the Customer, Organization of Information, House of quality, QFD Process, Examples, Conclusion, TQM Exemplary Organization, exercises.

Quality by Design: Introduction, Rationale for Implementation Benefits, Teams, Communication Models, Implementation, Tools, Misconceptions and Pitfalls, TQM

Exemplary Organization Exercises. **10 Hrs**

Self Study Component: Computers and Quality Function (Data Collection)

Text Books

1. **Total Quality Management**. Dale H. Besterfield et al. Pearson Publishers, New Delhi.
2. **TQM**. V K Khanna et al. New Age International Publishers, New Delhi.

Reference Books

1. **Total Quality Management**. Dr.S Kumar. Laxmi Publications, New Delhi.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** concepts of strategic planning, decision making and characteristics of leaders in organizations.	III
CO2	**Apply** the concepts of customer perception of quality and continuous process improvement.	III
CO3	**Apply** the concept of benchmarking process in quality control and quality management systems.	III
CO4	**Identify** different environmental management systems and statistical process control.	III
CO5	**Apply** the concepts of quality function deployment and quality by design in Exemplary Organizations.	III

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** concepts of strategic planning, decision making and characteristics of leaders in organizations.	3													
CO2	**Apply** the concepts of customer perception of quality and continuous process improvement.	3													
CO3	**Apply** the concept of benchmarking process in quality control and quality management systems.	3													
CO4	**Identify** different environmental management systems and statistical process control.	3						1							
CO5	**Apply** the concepts of quality function deployment and quality by design in Exemplary Organizations.	3													

Course Title: **NON TRADITIONAL MACHINING**			
Course Code: **P18ME642**	Sem: 06	L-T-P: 4:0:0	Credit: 03
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course enables to understand the need for nontraditional machining processes. It also highlights various Non-conventional machining processes.

Course Content

Unit-1

Introduction to Mechanical Process: Need for nontraditional machining processes, Process selection- classification on-comparative study of different processes, comparison between conventional and Non-conventional machining process selection. Ultrasonic Machining-Definition-Mechanism of metal removal- elements of the process-Tool feed mechanism, theories of mechanics of cutting, effect of parameter, applications. **10 Hrs**

Self study component: Advantages and disadvantages of Ultrasonic Machining

Unit-2

Abrasive Jet Machining and Thermal Metal Removal Processes: Principles - parameters of the process applications-advantages and disadvantages. Electric discharge machining-Principle of operation - mechanism of metal removal basic EDM circuitry-spark erosion generators-Analysis of relaxation type of circuit-material removal rate in relaxation circuits -critical resistance parameters in Ro Circuit-Die electric fluids-Electrodes for spark erosion- surface finish, applications, pollution and safety issues. **10 Hrs**

Self study component: Principle of water jet machining and Applications of water jet machining.

Unit-3

Chemical and Electrochemical Machining: Introduction, fundamental principle, types of chemical machining Maskants, Etchants, Advantages and disadvantages, applications, environmental issues, Electro Chemical machining (ECM), Classification of ECM, process, Principle of ECM, Chemistry of the ECM process, parameters of the process, determination of the metal removal rate, dynamics of ECM process-Hydrodynamics of ECM process-polarization-Tool Design-advantages and disadvantages-applications. Electro Chemical grinding-Electro Chemical honing. Electrochemical deburring. **11 Hrs**

Self study component: Process Characteristics of chemical machining.

Unit-4

Laser Beam Machining and Ion Beam Machining Introduction-principles of generation of lasers, Equipment and Machining Procedure-Types of Lasers-Process characteristics-advantages and limitations- applications. Introduction-Mechanism of metal removal and associated equipment-process characteristics applications, safety issues.

High Velocity forming processes: Introduction-development of specific process-selection-comparison of conventional and high velocity forming methods-Types of high velocity forming methods-explosion forming process-electro hydraulics forming-magnetic pulse forming. **11 Hrs**

Self study component: Advantages, disadvantages and applications of High Velocity forming processes.

Unit-5

Plasma arc machining and Electron beam machining: Introduction-Plasma-Generation of Plasma and equipment - Mechanism of metals removal, PAM parameters-process characteristics- type of torches, applications. **EBM:** Thermal & Non thermal type-Process characteristics -applications, safety issues. **10 Hrs**

Self study component: Safety Precautions of Plasma arc machining.

Text Books

1 P. C. Pandey and H. S. Shan**, "Modern Machining Process,"** TATA McGraw-Hill, 2000, ISBN: 9780070965539.

2 V K Jain, **" Advanced Machining Process",** Allied Publisers Pvt. Ltd. ISBN:9788177642940,8177642944

Reference Books

1 Hindustan Machine Tools, **"Production Technology,"** Tata McGraw Hill. 2001, ISBN: 978-0070964433.

2 P.K.Mishra, **"Non-Conventional Machining,"** The Institution of Engineers (India) Test book series, Narosa Publishing House, 2007, ISBN: 9788173191381.

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

	Course Outcomes	Bloom's Level
CO1	**Identify** different non-traditional machining processes and its applications.	III
CO2	**Apply** the concepts of machining process to understand the working principle and process parameters of EDM and AJM process with its **safety** issues.	III
CO3	**Apply** the concepts of machining process to understand the working principle, applications and process parameters of chemical and electrochemical machining process.	III
CO4	**Apply** the concepts of machining process to understand the working principle and process parameters of laser beam and ion beam machining process.	III
CO5	**Apply** the concepts of machining process to understand the working principle and process parameters of plasma arc and electron beam machining process with its **safety** issues.	III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Identify** different non-traditional machining processes and its applications.	3													
CO2	**Apply** the concepts of machining process to understand the working principle and process parameters of EDM and AJM process with its **safety** issues.	3					1								
CO3	**Apply** the concepts of machining process to understand the working principle, applications and process parameters of chemical and electrochemical machining process.	3													
CO4	**Apply** the concepts of machining process to understand the working principle and process parameters of laser beam and ion beam machining process.	3													
CO5	**Apply** the concepts of machining process to understand the working principle and process parameters of plasma arc and electron beam machining process with its **safety** issues.	3					1								

Course Title: **I C ENGINES**			
Course Code: **P18ME643**	Sem: 06	L-T-P-H : 4:0:0	Credit: 03
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: This course is helps the student to understand about IC engines and its combustion processes and recent technologies developed in IC engines.

Course Content

Unit-1

Thermodynamic Cycle Analysis: Fuel- Air cycle; Variation of specific heat; loss due to variation of specific heat; Dissociation. Effect of variables- compression ratio; effect of fuel –air ratio on efficiency; maximum temperature; maximum pressure; exhaust temperature; MEP Numerical problems.

Fuels: Hydro carbons; structure of petroleum – paraffin, olefin, napthene; aromatic series; requirements of an ideal gasoline; effect of volatility engine performance; knock rating on SI engine fuels- octane number; research & motor octane number; performance number. **12 Hrs**

Self study component: knock rating of diesel fuels - cetane number; diesel index; aniline point API gravity and specific gravity

Unit-2

Carburation and Combustion Process in S.I. Engines: Carburettor; types of carburettors and its limitations. Knock free and knocking combustion- stages of combustion process in S.I. engines. Features of different types of combustion chambers system for S.I. engine. I-head, F-head combustion chambers. Effect of engine variables on ignition lag; effect of variables on flame propagation. Detonation; effect of detonation; control of detonation. **10 Hrs**

Self study component: HUCR values. Anti Knock agents – Pre ignition – Post ignition.

Unit-3

C. I. Engines: Ricardo's three stages of combustion process in C.I. engines. Delay period & factors affecting delay period. Variables affecting delay period; Diesel knock- Methods of controlling diesel knock.

Combustion Chambers: C.I. engine combustion chambers; methods of generating air swirl; induction air swirl and open combustion chambers; turbulent swirl chambers; M. type combustion chamber. **10Hrs**

Self study component: Requirements of combustion chamber, features of different types of combustion chambers system for SI Engine

Unit-4

Fuel Injection Systems: Diesel injection systems; types of injection systems; fuel pump; Nozzles of different types; Petrol injection systems for S.I. engines; Electronic fuel injection system. MPFI system; spark advance mechanisms; Various factors affecting piston temperature in an engine. Cooling system-Water cooling, Air cooling; Radiators. **10 Hrs**

Self study component: Alternative fuels – alcohols; vegetable oils; bio gas as Diesel engine fuels.

Unit-5

Modern Developments: Turbo charging and super charging of I.C. engines, Stratified charge engines (Lean burned SI engine); Multi fuel engines. Two injector engines; Pilot ignition engine, all ceramic swirl chamber engines.

Emission Regulation and Control Systems: Mechanism of pollutant formation. Total emission control package thermal reactor package-catalytic converter package - control of NOx -Exhaust gas recirculation; chemical method. **10 Hrs**

Self study component: Emission standards

Text Books

1. M.L. Mathur and R.P. Sharma, **"A Course in I.C. Engines,"** Dhanpat Rai Publication 1st edition, 2010, ISBN: 9788189928469.
2. Ganeshan V, **"Internal Combustion Engine,"** Tata McGraw Hill Education, 4th edition, 2012, ISBN: 978-1259006197.
3. Colin R. Ferguson C, **"Internal Combustion Engines,"** John Wiley & sons, 1st edition,

1986, ISBN: 9780471837053.

Reference Books

1 Edward. F. Obert, **"I.C. Engines and Air Pollution,"** Intex Educational Publication, 3rd edition, 1973, ISBN: 9780700221837.
2 Willard W. Pulkrabek, **"Engineering Fundamentals of the I.C. Engine,"** PHI Publisher, 2nd edition, 2011, ISBN: 9788120330313.
3 Lester C Lichty, **"Combustion Engine Process,"** McGraw Hill Inc US, 7th revised edition, 1967, ISBN: 9780070377202.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** the concepts of ideal and actual thermodynamic cycles to **analyse** operation and performance of internal combustion engine.	III,IV
CO2	**Apply** thermal aspects to understand combustion process and its controlling factors in spark ignition engines.	III
CO3	**Apply** thermal aspects to understand combustion process and its controlling factors in compression ignition engines.	III
CO4	**Identify** different fuel injection systems, cooling systems and various factors affecting both systems.	III
CO5	**Identify** different modern developments in I C engines and understand the impact of emissions from IC engines from **environmental context**.	III

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the concepts of ideal and actual thermodynamic cycles to **analyse** operation and performance of internal combustion engine.	3	2												
CO2	**Apply** thermal aspects to understand combustion process and its controlling factors in spark ignition engines.	3													
CO3	**Apply** thermal aspects to understand combustion process and its controlling factors in compression ignition engines.	3													
CO4	**Identify** different fuel injection systems, cooling systems and various factors affecting both systems.	3													
CO5	**Identify** modern developments in I C engines and understand the impact of emissions from IC engines from **environmental context**.	3						1							

Course Title: **MAINTENANCE ENGINEERING**			
Course Code: **P18ME644**	Sem: 06	L-T-P: 4:0:0	Credit: 03
Contact Period: Lecture: 52 Hrs	Exam: 3 Hrs	Weightage % : CIE- 50, SEE-50	

Course objective: The course aims at strengthening the Maintenance and management capabilities of the students by exposing them to handling the different maintenance requirements and management that are commonly used in Machinery.

Course Content

Unit-1

Introduction to Maintenance System: Definition, Scope, Objective, Functions and Importance of maintenance system.

Types of Maintenance System: Break down maintenance system, Preventive maintenance, Predictive maintenance design out maintenance, corrective maintenance, Planned maintenance, total productive maintenance, condition monitoring. Problems on selection of methods like preventive or breakdown maintenance. **12 Hrs**

Self study component: Fundamental Requirements of Effective Preventive Maintenance

Unit-2

Economics in Maintenance: Repair, replacement, Repair complexity, Finding out most optimal preventive maintenance frequency. Numerical treatment required.

Machinery Maintenance: Causes of machine failure, performance evaluation, complete overhauling of Machines tools. **10 Hrs**

Self study component: Maintenance Equipment and Facilities

Unit-3

Maintenance Planning: Maintenance planning and scheduling. Repair order control manpower requirement, Maintenance job analysis spare parts control.

Maintenance Scheduling: Planning of maintenance junctures man power allocation, Long range planning, short range planning. Planning techniques and procedure. Estimation of maintenance work. Maintenance control. **10 Hrs**

Self study component: Motivation in Maintenance

Unit-4

Computers in Maintenance: Features and benefits of Computer aided maintenance. Application of computer to maintenance work.

Pollution Control in Industry: Dust control- Fiber collectors, mechanical dust collectors, wet type collectors, Electro static precipitators, Noise pollution Control –Noise measurement and control. Industrial vibration and its control. **10 Hrs**

Self study component: Classification of information system and decision support system**.**

Unit-5

Industrial Safety: Economic importance of accidents, types of safety organizations, analysis of accident records, accident investigations. Analysis of accident Safety standards for Mechanical equipment and Electrical system. Chemical hazards, material handling, exhaust system, welding, plant housekeeping-building, Aisles, Passages, floors, tool cribs, washrooms, canteens. **10 Hrs**

Self study component: OSHA'S hazard communication standard in Industries

Text Books

1. R. C. Mishra and K Pathak, **"Maintenance Engineering and Management,"** PHI Learing Pvt. Ltd., 2nd edition , 2012, ISBN: 9788120345737.
2. Morrow L C, **"Maintenance Engineering Hand book,"** McGraw-Hill Inc., US;2nd revised edition, 1967, ISBN: 9780070432017.

Reference Books

1. Frank Herbaty, **"Hand book of Maintenance Management,"** Noyes Publication, 2nd edition, 1990, ISBN: 9780815512042.
2. W.Grant Ireson, Eugene L. Grant, **"Hand book of Industrial Engg & Management,"** 2000.
3. Herbert F. Lund, **"Industrial Pollution Control Handbook,"** McGraw-Hill Publication, 1st edition, 1971, ISBN: 9780070390959.

4 H P Garg, **"Industrial Maintenance,"** S Chand & Co Ltd., 3rd edition, 1987, ISBN: 9788121901680.
5 Keith Mobley, Lindrey Higgins, Darrin Wikoff, "**Maintenance engineering Hand book,"** McGraw Hill, 7th edition, 2008, ISBN: 9780071546461.
6 William Staniar, **"Plant engineering hand book,"** McGraw-Hill Publication,1st **edition**,1950, Digitized 2007.

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

	Course Outcomes	**Bloom's Level**
CO1	**Apply** maintenance engineering functions in different organizations.	III
CO2	**Develop** preventive maintenance policy for maintenance systems.	IV
CO3	**Apply** planning and scheduling techniques in maintenance systems and **analyse** the maintenance job and spare parts control.	III, IV
CO4	**Make use of** computers in maintenance systems and **analyse** the noise and vibration control.	III
CO5	**Analysis** of accident **Safety** standards for Mechanical equipment and Electrical system, economic importance of accidents.	IV

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** maintenance engineering functions in different organizations.	3													
CO2	**Develop** preventive maintenance policy for maintenance systems.	1		3											
CO3	**Apply** planning and scheduling techniques in maintenance systems and **analyse** the maintenance job and spare parts control.	3	2												
CO4	**Make use of** computers in maintenance systems and **analyse** the noise and vibration control.	3	1												
CO5	**Analysis** of accident **Safety** standards for Mechanical equipment and Electrical system, economic importance of accidents.		3				2								

Course Title: FOUNDRY & WELDING TECHNOLOGY (Open Elective-II)			
Course Code**: P18MEO651**	Semester: VI	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hrs.	Exam: 3Hrs.	Weightage%: CIE: 50,SEE: 50	

Course Objectives: The course aims at understanding and strengthening knowledge of advancements in Foundry and welding technology to the students by exposing them to different Foundry and welding techniques that are commonly used in industries.

Course Content

Unit-1

Solidification of Castings: Introduction- concept of solidification of metals- solidification of pure metals- nucleation, homogeneous or self-nucleation, heterogeneous nucleation- growth- solidification of alloys, alloyed metal characteristics, main types of alloys, solid solution alloys, their characteristics, and solidification, phase diagram, coring or segregation, types of segregation, solute distribution, - solidification phenomenon and grain structure, mechanism of dendrite, formation and dendrite growth- solidification rate, directional solidification and control of solidification to obtain sound castings.

Metallurgy of Cast Steel: Composition, structure, control of properties, macrostructure, microstructure, inclusions, Heat- treatment, annealing, normalizing, stress relief anneal, liquid quench and temper. **10 Hrs**

Self study component: Alloy steels, measurement of hardenability and its significance, production heat treating.

Unit-2

Principles of Gating: Gating System- Requirements, purposes of functions of the gating system- pouring cups and basins- spruers- gates, their characteristics and different types- design of gating system, objectives achieved from good design, defects occurring due to improper design of gating system, turbulence in gating system, metal flow rate and velocity calculations, design criteria for pouring basin, design of sprue, pouring time, design of runner and gates, pressurized and unpressurized gating system, streamlining the gating system, practical rules for gating practice, elimination of slag and dross for copper, ferrous and light metal alloys.

Principles of Risering: Introduction- Functions of a riser- types of riser, open and blind risers- Riser and Directional solidification- increasing riser efficiency and promoting directional solidification, insulating materials, exothermic materials, chills, padding etc. –Feeder Head (or riser system) Design, general principles, riser shape, riser size, Chvorinove's rule, riser location and riser feeding distance. **10 Hrs**

Self study component: Risering practice for alloys- Heat loss from risers.

Unit-3

Casting Design Considerations: functional design, mechanical strength, dimensional design factors, simplification of foundry practice, molding and coring, elimination of coring, metallurgical design,

Shakeout/ Cleaning/ Finishing: shakeout- modern developments, punch out machines, shakeout tables and decks, high frequency shakeouts, vibrating shakeout conveyors, rotary separators, robots and manipulators, - fettling(cleaning) and finishing of castings- removal of cores- cleaning of castings surfaces, hand methods and mechanical methods,- blast cleaning- process control- blast cleaning abrasives- air blasting- mechanical blast cleaning (wheelabrator system)- hydro blasting- safety considerations when blast cleaning nonferrous casting, chemical cleaning, removal of gates and riser- removal of fins and other unwanted projections from castings- finishing of castings- grinding castings, robots for grinding, manipulators, trim dies. abrasive

10 Hrs

Self study component: products- surface treatment of castings.

Unit-4

Welding Processes: Classification of Welding and allied processes, cast weld processes: Thermit welding, Electroslag welding, Arc and Flame welding processes: Seam welding & Arc spot welding processes, Resistance welding processes: Spot welding, Seam welding, Zonal welding processes, Solid state welding processes: High heat input and Low heat input processes,

Allied processes: Material joining processes, Thermal cutting processes, Modes of Welding: manual welding, semiautomatic welding, automatic welding, automated welding(flexible welding system), positions in welding.

Cracks in Welding: introduction, classifications in weld cracks, Hot and Cold cracks, Nomenclature, Location & Orientation of weld cracks: Weld metal cracks, Base metal cracks, Factors contribution to weld Cracking. **11 Hrs**

Self study component: Specific weld cracks: Chevron cracks, lamellar cracks, reheat cracking, stress corrosion cracking

Unit-5

Defects in Welding: Classification of weld defects, General sources of weld defects, Arc welding defects: surface or visual defects, subsurface weld defects, Acceptance levels of arc welding defects, Weld defects in other arc welding processes: Resistance welding defects, defects in friction welding, defects in welds of other welding processes.

Weld Inspection and Quality Control: Introduction, visual inspection and measurement: equipment, visual inspection, Destructive tests, Non-Destructive tests(NDT): liquid penetrate testing, magnetic particle testing, eddy current testing, magneto graphic test, radiographic testing, ultrasonic testing, acoustic emission testing, comparison of NDT methods, Pressure and Leak testing: kerosene test, hydrostatic pressure testing, air pressure or pneumatic testing, vacuum testing, halide testing, helium test. **11 Hrs**

Self study component: Comparison of NDT methods, vacuum testing, halide testing, helium test.

Text Books

1. CARL R Loper & PHILIP C Rosenthal, Richard W Heine, **"Principle of metal casting" ,** TMH-2001, ISBN-13:9780070993488.
2. P.L.Jain, **"Principle at Foundry Technology",** MH education (India) ltd., 5th edition 2009, ISBN-13:9780070151291.
3. Dr R S Parmar, **"Welding Engineering and Technology"** , Khanna publications, 2nd edition, 2004, ISBN-13:9788174090287.

Reference Books

1. John Campbell, **"Casting",** Butterworth heinnmann, 2nd edition, 2004, ISBN-13:978075064791..
2. P.N.Rao, **"Manufacturing technology Foundry, forming and welding",** McGraw Hill , 4th edition volume 1, 2013,ISBN: 9789383286614.
3. Dr. K. Radha Krishna, **"Manufacturing process I",** Sapna Book House, Bangalore. 5th Edition.2006, ISBN:8128002074.

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

	Course Outcomes	Bloom's Level
CO1	**Apply** the concepts of solidification and nucleation of metals in casting process.	III
CO2	**Identify** the different gating and riser systems to obtain sound casting.	III
CO3	**Identify** the different modern equipments and factors affecting in casting design.	III
CO4	**Identify** different types of welding techniques and factors contributing to weld cracks.	III
CO5	**Identify** the different welding defects using different non destructive testing methods.	III

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the concepts of solidification and nucleation of metals in casting process.	3													

CO2	**Identify** the different gating and riser systems to obtain sound casting.	3													
CO3	**Identify** the different modern equipments and factors affecting in casting **design**.	3		1											
CO4	**Identify** different types of welding techniques and factors contributing to weld cracks.	3													
CO5	**Identify** the different welding defects using different non destructive testing methods.	3													

Course Title: **NON DESTRUCTIVE TESTING (Open Elective-II)**			
Course Code: **P18MEO652**	Sem: 06	L –T-P: 4:0:0	Credit: 03
Contact Period: Lecture: 52 Hrs	Exam: 3Hrs	Weightage %: CIE- 50, SEE-50	

Course objective: This course gives an insight into various non destructive testing techniques used in industry.

Course Content

Unit - 1

Introduction to NDT: Introduction, Types of flaw, Methods for the detection of Surface and Interior flaws, Visual inspection, Types of Boroscopes, Special features and Illumination. Liquid Penetrant Inspection- Principles, Penetrant methods, Procedure, Materials used and Applications. **12 Hrs**

Self study component: Leak detection and evaluation

Unit- 2

Magnetic Particle and Radiography Inspection: MPI-Principle, General procedure, Advantages, limitation, Applications, Magnetic field generation methods, Magnetic particles and Suspending liquids examples and Applications. RI- Principles, X-ray sources,Working procedure of X-ray radiography, Gamma - ray radiography, Gamma -ray sources, Real time radiography, Radiation hazard, Application examples. **10 Hrs**

Self study component: Principle and application of neutron radiography

Unit - 3

Optical Holography and Eddy Current Inspection: OH-Principles, Applications, Holographic recording, Reconstruction, Interferometric techniques of inspection. ECI- Principles of operation, Procedure, Advantages and Limitations, Operating variables-Coil impedance, Lift off factor,Edge effects, Skin effect and Inspection coils. Eddy current instruments, Application and examples. **10 Hrs**

Self study component: Working principle of acoustic holography

Unit -4

Ultrasonic Inspection and Computed Tomography: UT-Principles of ultrasonic inspection, Basic equipment, Advantages, Limitations, Applicability, Major variables in ultrasonic inspection,Transducers and Couplants, Basic inspection methods-Pulse echo method, Industrial applications. CT- Principle of working, Equipment, Capabilities, Industrial computed tomography, Applications. **10 Hrs**

Self study component: Challenges and characteristics of ultrasonic inspection

Unit -5

Acoustic Emission and Thermal Inspection: AE- Introduction, Acoustic emission waves and Propagation, Instrumentation, Principles, Application and Examples. Thermal inspection-Principles, Equipment, Inspection methods and Applications. Fundamentals of Image Processing Methods: Digital image enhancement system, Image capture and Acquisition system, Image processing and Image enhancement principles. **10 Hrs**

Self study component: Principle of machine vision technique

Text Books

1. Metals hand book, Vol-17, "**Non destructive evaluation & quality control"**, American society of metals, 9th Edition, 2001.
2. Handbooks of American Society for **Non destructive testing**, 2002.

Reference Books

1. Baldev Raj, Jayakumar, Thavasimuthu, **Practical Non-Destructive Testing ,** Narosa Publishing House, 3rd Edition, 2014, ISBN: 9788173197970.
2. Halmshaw R, **Non-Destructive Testing,** Butterworth-Heinemann Publisher, 2nd Edition, 1991, ISBN: 9780340545218.
3. Barry Hull & Vernon John, **Non Destructive Testing** ,Macmillian Education,1st Edition, 1988, ISBN: 9780333357880.
4. **Metals Handbook** Vol. II, Nondestructive inspection and quality control.

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

	Course Outcomes	Bloom's Level
CO1	**Identify** different NDT methods and its applications with special emphasis on liquid penetrant testing method.	III
CO2	**Apply** the concepts of testing methods to understand the working principle of magnetic particle inspection and radiographic inspection**.**	III
CO3	**Apply** the concepts of testing methods to understand the working principle of optical holography and eddy current inspection methods.	III
CO4	**Identify** the concepts of testing methods to understand the working principle of Ultrasonic Inspection and Computed Tomography.	III
CO5	**Apply** the concepts of testing methods to understand the working principle of thermal inspection and acoustic emission inspection methods.	III

Course Articulation Matrix

	Course Outcomes	Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Identify** different NDT methods and its applications with special emphasis on liquid penetrant testing method.	3													
CO2	**Apply** the concepts of testing methods to understand the working principle of magnetic particle inspection and radiographic inspection**.**	3													
CO3	**Apply** the concepts of testing methods to understand the working principle of optical holography and eddy current inspection methods.	3													
CO4	**Identify** the concepts of testing methods to understand the working principle of Ultrasonic Inspection and Computed Tomography.	3													
CO5	**Apply** the concepts of testing methods to understand the working principle of thermal inspection and acoustic emission inspection methods.	3													

Course Title: **INDUSTRIAL ROBOTICS AND AUTOMATION (Open Elective-II)**			
Course Code**: P18MEO653**	Semester: VI	L-T-P-H: 4-0-0-4	Credits: 03
Contact Period - Lecture: 52 Hrs	Exam:3Hrs	Weightage%: CIE: 50,SEE: 50	

Course Objectives:

- To familiarize students with brief history of robot and basic concepts of industrial robot.
- To expose the students to programming languages of robot
- To make the students familiar with various applications in robots in industry

Course Content

Unit-1

INTRODUCTION: Automation and robotics, brief history of robotics, Robot Anatomy, Joints and Links, wrist and its motions, Classifications of robots, Robot Control Systems, Geometrical configuration, Work Volume, Resolution, Accuracy and Repeatability. **10 Hrs**

Self Study Component: Pay load and Stability of robots

Unit-2

STRUCTURE OF ROBOTIC SYSTEM: End Effectors: types of grippers, tools. Robot drive system: Hydraulic, electric and pneumatic, Types of Actuators. Feedback components: position, velocity sensors, internal State sensors, tactile sensors, - proximity sensing, range sensing. **10 Hrs**

Self Study Component: Force-Torque Sensors

Unit-3

ROBOT PROGRAMMING: Introduction, manual teaching, lead through teaching, Robot programming languages: Robot language elements and functions, Motion commands, simple programs. **10 Hrs**

Self Study Component: Generations of robot programming Languages.

Unit-4

AUTOMATION: Basic elements of an automated system, advanced automation functions, levels of automation, computer process control and its capabilities. Forms of computer process control, Levels of Industrial Process Control. **10 Hrs**

Self Study Component: Direct Digital Control.

Unit-5

ROBOTS IN MANUFACTURING AUTOMATION: Material Transfer: general considerations in robot material handling: pick and place, palletizing operations. Machine loading and unloading: Die casting, Plastic moulding, Forging, machining and stamping press operations. Processing Operations: features of spot and arc welding robot spray coating and other processing applications. **12 Hrs**

Self Study Component: Recent developments in industrial applications of robot.

Text Books

1. Michell Grover, Mitchel weiss, Roger nagel **"Industrial Robots",** McGraw Hill 2012,India ,2nd edition, ISBN-13:9780070265097.
2. Yoramn Koren, **"Robotics for Engineers"** McGraw hill Intl. Book Co., New Delhi 1987 ISBN-13:9780070353992.

Reference Books

1. Robert J. Schilling, **"Fundamentals of Robotics"** PHI**, 1ST** edition-.2011, ISBN-13:9788120310476.
2. K.S. Fu, R.C. Gonzales and Lee, **"Robotics"**. McGraw Hill Intl. India, 1st edition, 2008 ISBN-13:9780070265103.
3. Richard D. Klafter,C Thomas A, "**Robotic Engineering"** PHI,1993, ISBN-13:9788120308428.
4. R.K. Mittal and J. Nagarath, **"Robotics and Control"** Tata McGraw Hill, DELHI,6th edition 2007, ISBN:0070482934.

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

	Course Outcomes	Bloom's Level
CO1	**Identify** robots based on geometrical configuration, joints and links.	III
CO2	**Identify** different types of drive system and sensors required for specific applications.	III
CO3	**Develop** robot task program using robot language.	IV
CO4	**Identify** various elements and levels of automated system.	III
CO5	**Apply** the concepts of working of robots in automating the manufacturing process.	III

Course Articulation Matrix

	Course Outcomes	Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Identify** robots based on geometrical configuration, joints and links.	3													
CO2	**Identify** different types of drive system and sensors required for specific applications.	3													
CO3	**Develop** robot task program using robot language.			3											
CO4	**Identify** various elements and levels of automated system.	3													
CO5	**Apply** the concepts of working of robots in automating the manufacturing process.	3													

Course Title: EMERGING COOLING TECHNOLOGY (Open Elective-II)			
Course Code**: P18MEO654**	Semester: VI	L-T-P: 4-0-0	Credits: 03
Contact Period - Lecture: 52 Hrs.	Exam: 3Hrs.	Weightage % : CIE: 50 ; SEE: 50	

Course objective: The course aims at understanding the concept of

- Operation, application and study of the basic refrigeration and air conditioning systems, refrigerant properties and RAC demand scenarios.
- Operation and applications of promising cooling systems.

Course Content

Unit-1

Introduction: History of Refrigeration, Basic Definitions, classification of cooling systems. Refrigeration: Definition, Unit of refrigeration, Coefficient of Performance, Refrigeration cycles and concepts. Refrigerants: Definition, Environmental properties of emerging Refrigerants and Refrigerant mixtures (zeotropic and azeotropic mixtures) and their choice for different applications – Eco friendly refrigerant. Air conditioning: Introduction, Basic Definitions, Classification. **10 Hrs**

Self-Learning Components: Principle of refrigeration and thermodynamics, Necessity of Refrigeration and Air-conditioning in industries.

Unit-2

Refrigeration Systems: Engineering principles of Refrigeration system and components: Vapour Compression Refrigeration System (VCRS), Vapour Absorption Refrigeration System (VBRS) Refrigeration system as heat pump, Air Refrigeration, Introduction to Steam Jet Refrigeration and Solar refrigeration. Industrial Refrigeration: Chemical and process industries, Dairy plants, Petroleum refineries, Food processing and food chain, Miscellaneous. **10 Hrs**

Self-Learning Components: Differences between Vapour Compression System and Vapour Absorption system, Necessity of compressor in Vapour Compression System.

Unit-3

Air-Conditioning Systems: Engineering principles of air conditioning system and components: Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner. Components related to Air-Conditioning Systems. Transport air conditioning Systems: Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships. Energy efficient air conditioning system. **11 Hrs**

Self-Learning Components: Air conditioning demand scenarios for India and associated health, social justice, energy, Potential sustainable air conditioning scenarios for India.

Unit-4

Thermal Comfort and Climate Analysis: The "human thermal comfort" and its implications for cooling system design, Adaptive Comfort Model and Indian Model for Adaptive Comfort (IMAC) for addressing human thermal comfort needs. Factors affecting human comfort, Introduction to the cooling standards. Implications of IMAC on mitigating the climate change and Energy consumption, Principles and tools for climate analysis. Social and Environmental Issues related to conventional Refrigeration and Air conditioning. **11 Hrs**

Self-Learning Components: Tools for predicting thermal comfort in buildings.

Unit-5

Emerging Non convectional cooling technologies (Solar cooling technologies):

Principle of Solar Cooling Systems (absorption cycles, desiccant cycles and solar mechanical cycles). Solar powered air condition system, Photovoltaic (PV) solar cooling, Solar open-loop air conditioning, Solar closed-loop absorption cooling, Passive solar cooling, Solar sorption cooling, Evaporative cooling, Solar ejector cooling, Solar cooling systems utilizing concentrating collectors. Solar panels to power growing global demand for air-conditioners. **10 Hrs**

Self-Learning Components: Applications of solar cooling, Challenges of solar cooling.

Text Books

1. C. P. Arora, "**Refrigeration and Air-Conditioning**," Tata McGraw Hill

Publication,2001, ISBN: 978-0074630105.
2. Manohar Prasad, "**Refrigeration and Air-Conditioning**," new age publishers, 30th May 2009, ISBN: 978-8122414295.

Reference Books

1. Ballaney P.L, "**Refrigeration and Air-conditioning**," Khanna Publisher, New Delhi 13th edition, 2003, ISBN: 978-8174091369.
2. R. S Khurmi & J. K. Guptha, "**Refrigeration and Air-conditioning**," S. Chand & company ltd. New Delhi, 3rd edition, 1st December 2006, ISBN: 978-8121927819.
3. Arora S C & Domkundwar S, "**A Course in Refrigeration and Air-conditioning**," Dhanpat Rai & Sons, New Delhi, 1997.

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

	Course Outcomes	**Bloom's Level**
CO1	**Identify** the suitable **eco-friendly refrigerants for** refrigeration and air conditioning cooling technologies.	III
CO2	**Apply** the basic concepts of refrigeration to understand the principles of different refrigeration systems.	III
CO3	**Apply** the basic concepts of refrigeration to understand the principles of different air conditioning systems.	III
CO4	**Identify** and study the adaptive cooling system for analysing the consequences of Social and Environmental Issues.	III
CO5	**Apply** the Principles of Non-conventional Cooling Systems and its applications for global demand RAC.	III

Course Articulation Matrix

Course Outcomes		**Program Outcomes**												**PSO**	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Identify** the suitable **eco-friendly refrigerants for** refrigeration and air conditioning cooling technologies.	3						1							
CO2	**Apply** the basic concepts of refrigeration to understand the principles of different refrigeration systems.	3											1		
CO3	**Apply** the basic concepts of refrigeration to understand the principles of different air conditioning systems.	3											1		
CO4	**Identify** and study the adaptive cooling system for analysing the consequences of Social and Environmental Issues.	3						2							
CO5	**Apply** the Principles of Non-conventional Cooling Systems and its applications for global demand RAC.	3											1		

Course Title: **COMPUTER AIDED MODELING & ANALYSIS LAB**			
Course Code: **P18MEL66**	Sem: 06	L –T-P-H: 0:0:3:3	Credit: 1.5
Contact Period: Lecture: 36 Hrs,		Exam: 3Hrs	Weightage % : CIE- 50, SEE-50

Course Objective: The course aims at enabling the students to use FEM tools for solving structural and thermal problems as well enhancing their domain skills.

Course Content

PART-A

Exp-1: Study of ANSYS FEA package.Analysis of bars of constant cross section area, tapered cross section area and stepped bars using ANSYS. **3 Hrs**

Exp-2: Analysis of plane trusses and beams using ANSYS. **3 Hrs**

Exp-3: Plane stress analysis of plate with hole and 2D heat transfer analysis (conduction and convection). **3 Hrs**

Exp-4: Application of 2-D elements to Axisymmetric problems. **3 Hrs**

Exp-5: Vibration Analysis: Modal analysis of fixed - fixed beam Harmonic analysis of axially loaded bar, Fixed - fixed beam **3 Hrs**

PART-B

Exp-6: Thermal stress in simple structures (Coupled analysis). **3 Hrs**

Exp-7: Buckling analysis of columns. **3 Hrs**

Exp-8: Modelling of torsion problem. **3 Hrs**

Exp-9: Analysis of fluid flow over cylinder. **3 Hrs**

Exp-10: Analysis of mixing flow in an elbow. **3 Hrs**

Seminar **3 Hrs**

Test **3 Hrs**

Reference Books

1 Saeed Moaveni, **"Finite Element Analysis Theory and Application with ANSYS**," Pearson Education, 3rd edition, 2007, ISBN: 978-0131890800.

2 **ANSYS 15** documentation.

Evaluation Scheme

Scheme	Weightage %	Marks	Event Break Up		
			Test	Record	Seminar/Mini Project
CIE	50	50	20	20	10
SEE	50	50			

Scheme for Examination

One Question from Part –A	20 Marks
One Question from Part -B	20 Marks
Viva – Voice	10 Marks
Total	**50 Marks**

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

	Course Outcomes	Bloom's Level
CO1	**Apply** the basic concepts of FEM to commercially available FEA tool.	III
CO2	**Analysis** the mechanical elements and validate with FEA tool with the **Applications** of the numerical technique for structural members.	III, IV
CO3	**Apply** FEA tool for thermal **analysis** of mechanical elements.	III, IV
CO4	**Interpret** post processor results for writing a report as an **individual** to **communicate** effectively**.**	IV

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the basic concepts of FEM to commercially available FEA tool.	3				3								3	

CO2	**Analysis** the mechanical elements and validate with FEA tool with the **Applications** of the numerical technique for structural members.	3	3												
CO3	**Apply** FEA tool for thermal **analysis** of mechanical elements.	3	3												
CO4	**Interpret** post processor results for writing a report as an **individual** to **communicate** effectively**.**								3	3					

Course Title: **HEAT AND MASS TRANSFER LAB**			
Course Code: **P18MEL67**	Sem: 06	L –T-P-H: 0:0:3:3	Credit: 1.5
Contact Period: Lecture: 36 Hrs,	Exam: 3Hrs	Weightage % : CIE- 50, SEE-50	

Course Objective: The objective of this course is to provide an opportunity for mechanical engineering students to learn how to perform basic measurements of heat transfer and analyze the results.

Course Content

PART-A

Exp-1: Determination of thermal Conductivity of a Metal Rod. **3 Hrs**
Exp-2: Determination of Overall Heat Transfer Coefficient of a Composite wall **3 Hrs**
Exp-3: Determination of Effectiveness and Efficiency of a Metallic fin. **3 Hrs**
Exp-4: Determination of free Convective Heat Transfer Coefficient of a vertical Cylinder **3 Hrs**
Exp-5: Determination of Heat Transfer Coefficient in Forced Convection **3 Hrs**
Exp-6: Determination of Emissivity of a Surface. **3 Hrs**
Exp-7: Determination of thermal conductivity of liquid **3 Hrs**

PART-B

Exp 8: Determination of Stefan Boltzman Constant. **3 Hrs**
Exp 9: Determination of Effectiveness in Parallel Flow and Counter Flow Heat Exchangers. **3 Hrs**
Exp-10: Performance Test on Vapour Compression Refrigeration. **3 Hrs**

Seminar **3 Hrs**
Test **3 Hrs**

Reference Books

1 P.K. Nag, **"Heat & Mass Transfer,"** Tata Mc-Graw Hill, 3rd edition, 2011, ISBN: 978-0070702530.
2 Er. R K Rajput **"Heat & Mass Transfer,"** S Chand Publications, 2008, ISBN: 978-8121926171.

Evaluation Scheme

Scheme	Weightage %	Marks	Event Break Up		
			Test	Record	Seminar
CIE	50	50	20	20	10
SEE	50	50			

Scheme for Examination

One Question from Part - A	20 Marks
One Question from Part -B	20 Marks
Viva – Voice	10 Marks
Total	**50 Marks**

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

	Course Outcomes	Bloom's Level
CO1	**Identify** safe operating practices and requirements for laboratory experiments	III
CO2	**Apply** the concepts of heat transfer and fluid flow to **analyse** thermal and fluid systems.	III, IV
CO3	**Identify** different measurement techniques related to thermal and fluid system.	III
CO4	**Make use of** experimental data to prepare clear and concisely lab reports as an **individual** or as a **team member** to **communicate** effectively.	III

Course Articulation Matrix

Course Outcomes	Program Outcomes												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2

CO1	**Identify** safe operating practices and requirements for laboratory experiments	3												
CO2	**Apply** the concepts of heat transfer and fluid flow to **analyse** thermal and fluid systems.	3	3											
CO3	**Identify** different measurement techniques related to thermal and fluid system.	3												
CO4	**Make use of** experimental data to prepare clear and concisely lab reports as an **individual** or as a **team member** to **communicate** effectively.	3							3	3			2	

Course Title: **DIGITAL MANUFACTURING LAB (Skill Oriented Laboratory-II)**			
Course Code: **P18MEL68**	Sem: 06	L –T-P-: 0:0:2	Credit: 1
Contact Period: Lecture: 26 Hrs,		Exam: 3Hrs	Weightage % : CIE- 50, SEE-50

Course Objectives: The course facilitates the students to be familiar with digital manufacturing technologies like CNC machines, Robots, Additive Manufacturing, Reverse engineering etc.

Course Content

1. Experiments on hydraulic system	**2 Hrs**
2. Programming of CNC milling machine	**4 Hrs**
3. Programming of CNC turning centre	**2 Hrs**
4. Programming a robot for pick and place operation	**4 Hrs**
5. Creating part in software and producing the same using FDM machine	**4 Hrs**
6. Digitization of given part using 3D scanner and building the same part in FDM machine	**4 Hrs**
CIE	**3 Hrs**
SEE	**3 Hrs**

Reference Books

1. S.R Majumdar, **"Oil Hydraulic Systems, Principles and Maintenance",** Tata McGraw Hill publishing company Ltd. 2001, ISBN: 9780071406697.
2. P.N. Rao**, "Principles and application of CAD/CAM,"** Tata McGraw Hill, 3rd edition, May 2010, ISBN**:** 978-0070681934.
3. Michell Grover, Mitchel weiss, Roger nagel **"Industrial Robots",** McGraw Hill 2012, India, 2nd edition, ISBN-13:9780070265097.
4. Pham D.T & Dimov, S.S, **"Rapid Manufacturing"** Springer Verlog, London November 2011, ISBN-13:9781447111825.

Evaluation Scheme

Scheme	Weightage %	Marks	Event Break Up		
			Test	Record	Seminar
CIE	50	50	20	20	10
SEE	50	50			

Scheme for Examination

One Question from Part - A	20 Marks
One Question from Part -B	20 Marks
Viva -Voice	10 Marks
Total	**50 Marks**

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

	Course Outcomes	Bloom's Level
CO1	**Apply** the basic concepts of Hydraulic System using cascading method.	III
CO2	**Develop** CNC part program for turning and milling operations.	IV
CO3	**Develop** robot program for pick and place operation.	IV
CO4	**Make use of a** FDM machine to build a 3D model	III
CO5	**Construct** virtual model of a part using 3D scanner	IV

Course Articulation Matrix

Course Outcomes		Program Outcomes												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	**Apply** the basic concepts of Hydraulic System using cascading method.	3													
CO2	**Develop** CNC part program for turning and milling operations.			3											1
CO3	**Develop** robot program for pick and place operation.			3											
CO4	**Make use of a** FDM machine to build a 3D model	3												1	
CO5	**Construct** virtual model of a part using 3D			3										1	

	scanner													

P.E.S. College of Engineering: Training & Placement Centre

Program: Technical Training Program

Duration: 36 hours

Methodology: Blended (Classroom and lab)

Departments: Mech, Auto, IP & Civil.

COURSE OUTCOME:

To enable students to:

- Strengthen their understanding of **Introduction to Computer Science**, **C**, and **Data Structures**
- Write effective codes on **C** Programming

OVERALL SYLLABUS BREAKUP:

Sl. No.	Module name	Classroom (Hours)	Lab (Hours)	Total duration (Hours)
1.	**Introduction to Computer Science**	3	0	3
2.	**C Programming**	0	18	18
3.	**Introduction to Data Structures**	6	9	15
	Total Hours	**9**	**27**	**36**

LEARNING OUTCOMES

- After undergoing training in this course, the students will be in a position to –
- write complete program based on the requirements and to debug.
- Frame effective programs using C programming and Data Structures.

ASSESSMENTS

- Each of the modules (C and Data Structures) will have two types of assessments -
  - Multiple-choice assessment for programming logic, concepts and debugging
  - Coding

COURSE PLAN:

C Programming

Sl. No.	Topics covered	Learning outcome	Type of learning	Duration
1.	**Introduction to Computer Science:** **Basic Structure of Computers:** Basic Operational Concepts, Bus Structures, Performance– Processor Clock, Basic Performance Equation, Clock Rate, Performance Measurement. • **Operating System - An Introduction:** Definition and functions of operating systems. discussion on evolution of operating systems and different structures of operating systems.	● Understand the basics of computer structure and operation of computers and their peripherals and need of Operating System.	Class - 3	3
2.	**C Programming Language:** • **Basic level** of Snippets for o Understanding basic syntax o If - else statement o Switch case o Struct o For loop o While and do - while loop o Array o Strings o Pointers o Function o String o File handling o Preprocessing	● Understand the concepts of snippets in a programming term for a small region of re-usable source code, machinecode, or text. In C it could be part of the program - A Function, typedef or a part of the algorithm or code. ● Understand the concepts of programs as sequences or machine instructions.	Lab - 18	18
3.	**Introduction to Data Structures:** Data Structures Basics: Structure and Problem Solving, Data structures, Data structure Operations, Algorithm: complexity, Time- space tradeoff. o Linked List o Stack and Queue o Searching and Sorting Techniques	● Understand common data structures and the algorithms that build and manipulate them including various sorting and searchingalgorithms. Data structures include arrays, linked lists, stacks, queues, Features,properties, applications, enumerators, and performance issues.	Class –6 Lab - 9	15