SYLLABUS

(With effect from 2015-2016 Academic year)

ಪಠ್ಯಕ್ರಮ

(ಶೈಕ್ಷಣಿಕವರ್ಷ 2015–16)

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.

ಪಿ.ಇ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ

ಮಂಡ್ಯ–571 401, ಕರ್ನಾಟಕ

(ವಿ.ಟಿ.ಯು, ಬೆಳಗಾವಿ ಅಡಿಯಲ್ಲಿನ ಸ್ವಾಯತ್ತ ಸಂಸ್ಥೆ)

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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

Sri.B.Dinesh Prabhu
Deputy Dean (Academic)
Associate Professor,
Dept. of Automobile Engg

(Dr.P S Puttaswamy)
Dean (Academic)
Professor,
Dept. of Electrical & Electronics Engg.

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.

Program 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.

<table>
<tr><th colspan="7">EVALUATION SCHEME</th></tr>
<tr><th>Scheme</th><th>Weightage</th><th>Marks</th><th colspan="4">Event Break Up</th></tr>
<tr><td rowspan="2">CIE</td><td rowspan="2">50%</td><td rowspan="2">50</td><td>Test I</td><td>Test II</td><td>Quiz I</td><td>Quiz II</td><td>Assignment</td></tr>
<tr><td>35</td><td>35</td><td>5</td><td>5</td><td>10</td></tr>
<tr><td>SEE</td><td>50%</td><td>100</td><td colspan="2">Questions to Set: 10</td><td colspan="3">Questions to Answer: 5</td></tr>
<tr><td colspan="7">Scheme of SEE Question Paper (100 Marks)</td></tr>
<tr><td colspan="2">Duration: 3Hrs</td><td colspan="2">Marks: 100</td><td colspan="3">Weightage: 50%</td></tr>
<tr><td colspan="7">• 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</td></tr>
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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 L:T:P:H	Total Credit	Examination Marks		
						CIE	SEE	Total
1.	P15ME51	Dynamics of Machinery	Mechanical	3:2:0:5	4	50	50	100
2.	P15ME52	Design of Machine Elements I	Mechanical	3:2:0:5	4	50	50	100
3.	P15ME53	Turbomachines	Mechanical	4:0:0:4	4	50	50	100
4.	P15ME54	Manufacturing Process- III	Mechanical	4:0:0:4	4	50	50	100
5.	P15ME55x	Foundation Elective-I	Mechanical	4:0:0:4	3	50	50	100
6.	P15ME56x	Elective-I	Mechanical	4:0:0:4	3	50	50	100
7.	P15MEL57	Machine shop	Mechanical	0:0:3:3	1.5	50	50	100
8.	P15MEL58	I C Engine and Fluid Machinery Lab	Mechanical	0:0:3:3	1.5	50	50	100
9.	P15ME59	Industry Visit & Interaction	Mechanical	0:0:2:2	1	50	--	50
10.	P15HU510	Aptitude and Reasoning Development –Advanced. (ARDA)	HS&M	2:0:0:2	1	50	50	100
Total					27	500	450	950

List of Electives					
Foundation Elective-I			Elective - I		
Sl.. No	Course Code	Course title	Sl.No.	Course Code	Course title
1.	P15ME551	Engineering Economics	1.	P15ME561	Mechatronics & Microprocessor
2.	P15ME552	CAD/CAM	2.	P15ME562	Automotive Engineering
3.	P15ME553	Optimization Techniques	3.	P15ME563	Advanced material Science
4.	P15ME554	Mechanism Design: Analysis and Synthesis	4.	P15ME564	Numerical Analysis & Algorithms

VI Semester B.E. (ME)			Scheme of Teaching and Examination					
Sl. No	Course Code	Course Title	Teaching Dept.	Hrs/Week L:T:P:H	Total Credit	Examination Marks		
						CIE	SEE	Total
1.	P15ME61	Design of Machine Elements II	Mechanical	4:0:0:4	4	50	50	100
2.	P15ME62	Mechanical Vibrations	Mechanical	3:2:0:5	4	50	50	100
3.	P15ME63	Heat and Mass Transfer	Mechanical	3:2:0:5	4	50	50	100
4.	P15ME64	Finite Element Method	Mechanical	4:0:0:4	4	50	50	100
5.	P15ME65	Elective-II	Mechanical	4:0:0:4	3	50	50	100
6.	P15MEL66	Elective-III	Mechanical	4:0:0:4	3	50	50	100
7.	P15MEL67	Computer Aided Modeling & Analysis Lab	Mechanical	0:0:3:3	1.5	50	50	100
8.	P15MEL68	Heat & Mass Transfer Lab	Mechanical	0:0:3:3	1.5	50	50	100
9.	P15ME69	Mini Project	Mechanical	0:0:2:2	1	50	--	50
10.	P15HU610	Aptitude and Reasoning Development – EXPERT (ARDE)	HS&M	2:0:0:2	1	50	50	100
Total					27	500	450	950

List of Electives					
Elective-II			Elective - III		
Sl. No	Course Code	Course title	Sl. No.	Course Code	Course title
1.	P15ME651	Theory of Elasticity	1.	P15ME661	Experimental Stress Analysis
2.	P15ME652	Refrigeration & Air Conditioning	2.	P15ME662	I. C. Engines
3.	P15ME653	Statistical Quality Control	3.	P15ME663	Maintenance Engineering
4.	P15ME654	Non-Traditional Machining	4.	P15ME664	Computer Integrated Manufacturing

Course Title: Dynamics of Machinery			
Course Code: P15ME51	**Sem: 05**	**L-T-P-H : 3:2:0:5**	**Credit: 04**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Knowledge of Engineering Mathematics-I (P15MA11), Engineering Mechanics (P15CV13), Mechanics of Materials (P15ME33) and Kinematics of Machines (P15ME51).

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**

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**

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**

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**

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**

Text books

1. John J. Uicker, Jr., Gordon R. Pennock and Joseph E. Shigley, "**Theory of Machines and Mechanisms,"** Oxford University Press, 4th Edition, 2014, ISBN: 9780199454167.
2. S.S. Rattan **"Theory of Machines"** Tata McGraw-Hill, New Delhi, 4th edition, 2015, ISBN: 9789351343479.

References

1. V.P. Singh, "Theory of Machines," Dhanpat Rai & Co., 3rd Edition, 2013, ISBN: 9788177000528.
2. P. L. Ballaney, "Theory of Machines and Mechanisms," Khanna Publishers., 25th Edition, 2003, ISBN: 978-8174091222.
3. Robert L. Norton, "Kinematics & Dynamics of Machinery," Tata Mc Graw Hill., 1st Edition, 2009, ISBN: 9780071278522.

Course Outcomes

At the end of the course the students should be able to:

1. **Analyse** graphically the static forces acting in different links of simple planar mechanisms.
2. **Determine** inertia forces acting on different links of simple planar mechanisms using graphical method.
3. **Design** suitable flywheel for simple mechanical.
4. **Determine** the magnitude and location of balancing masses for the rotating and reciprocating machines.
5. **Explain** working principle of Gyroscopes and **analyze** the gyroscopic stability of mechanical systems.

Lesson Plan

Unit-1

1 Introduction to static force analysis and Static equilibrium of mechanisms
2 Configuration diagram and free body diagram
3 Analysis of two, three, four force members
4 Analysis of Members with two forces and torque
5 Analysis of four bar mechanism without friction
6 Analysis of slider-crank mechanism without friction
7 Numerical Problems.
8 Numerical Problems.
9 Numerical Problems.
10 Numerical Problems.

Unit-2

1 Introduction to inertia force analysis, D'Alemberts principle
2 Inertia force, inertia torque
3 Dynamically equivalent systems
4 Line of action of inertia force
5 Inertia force analysis of four bar mechanism
6 Inertia force analysis of slider crank mechanism
7 Numerical Problems.
8 Numerical Problems.
9 Numerical Problems.
10 Numerical Problems.

Unit-3

1 Introduction to flywheels, turning moment diagrams
2 Derivation of expression for fluctuation of energy, velocity of flywheel
3 Derivation of expression for size of flywheels
4 Problems on Fluctuation of Energy and speed determination
5 Problems on energy produced at variable rate and consumed at constant rate
6 Problems on energy produced at constant rate and consumed at variable rate
7 Problems on stored in a flywheel
8 Problems on size of flywheels
9 Numerical Problems.
10 Numerical Problems.

Unit-4

1 Introduction to static and dynamic balancing of rotating systems
2 Balancing of single revolving mass by balancing masses in same plane and in different planes
3 Balancing of several masses revolving in the same plane, problems solving
4 Balancing of several masses revolving in different planes
5 Numerical Problems.
6 Numerical Problems.

7 Introduction, acceleration and inertia force of the reciprocating mass of a slider crank mechanism
8 Primary balancing and secondary balancing
9 Balancing of single cylinder engine and problems solving
10 Balancing of multi cylinder-inline engines and problems solving
11 Balancing of radial engines and problems solving
12 Numerical Problems.

Unit-5

1 Introduction, types, working principle and application of Governors
2 Introduction, vector representation of angular motion
3 Derivation of expression for gyroscopic couple
4 Effect of gyroscopic couple on shafts mounted in bearings
5 Problem solving
6 Effect of gyroscopic couple on stability of ships and problem solving
7 Effect of gyroscopic couple on stability of Aero plane and problem solving
8 Effect of gyroscopic couple on two wheelers and problem solving
9 Effect of gyroscopic couple on four wheelers and problem solving
10 Numerical Problems.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Analyse graphically the static forces acting in different links of simple planar mechanisms.	3	3	2	1						2				
Determine inertia forces acting on different links of simple planar mechanisms using graphical method.	3	2	2	2						2			2	
Design suitable flywheel for simple mechanical systems.	3	2	2	2						1				
Determine the magnitude and location of balancing masses for the rotating and reciprocating machines.	3	2	2	2						2				
Explain working principle of Gyroscopes and **analyze** the gyroscopic stability of mechanical systems.	3	2	3	2						1			1	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15MA11	Engineering Mathematics-I	P15ME51	Dynamics of Machines	P13ME51	Dynamics of Machines
2	P15CV13	Engineering Mechanics				
3	P15ME33	Mechanics of Materials				
4	P15ME51	Kinematics of Machines				

Course Title: Design of Machine Elements-I			
Course Code: P15ME52	**Sem: 05**	**L-T-P-H : 3:2:0:5**	**Credit: 04**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Material Science and Metallurgy (P15ME32) and Mechanics of Materials (P15ME44).

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, Failure of brittle materials, Failure of ductile materials, 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. Design of Cotter and Knuckle joints. **12 hrs**

Unit-2

Stress concentration, Stress concentration factor, design of simple elements with stress raisers. **Design under fatigue** - Introduction, types of fluctuating stresses, fatigue and endurance limit, S-N Diagram, Low cycle fatigue, High cycle fatigue, 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. **Impact loading:** Impact stresses due to axial, bending and torsional loads, effect of inertia. **10 hrs**

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**

Unit-4

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

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

Design data hand book:

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

Text books

1. Richard G Budynas and Keith J Nisbett, "**Shigley's Mechanical Engineering Design,"** McGraw Hill Education, 9th Edition, 2011, ISBN: 9780071077835.
2. V. B. Bhandari, "**Design of Machine Elements,"** Tata McGraw Hill Publishing Company Ltd., New Delhi, 4th Edition 2016, ISBN: 9789339221126.

References

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 Dr. Rajendra Karwa, "A text book of Machine Design," Laxmi Publications, 2nd Edition, 2006, ISBN: 9788170088332.

Course Outcomes

At the end of the course the students should be able to:

1. **Explain** basic design concept and **design** simple machine elements subjected to static loads.
2. **Apply** theories of failure and **design** simple machine elements under fatigue loading conditions.
3. **Determine** the stresses in simple machine elements due to impact loads; **Design** simple power transmission shafts.
4. **Design** threaded joints and power screws.
5. **Design** typical welded joints and riveted joints for boiler and structural applications.

Lesson Plan

Unit-1

1 Introduction, basic design concepts.
2 Mechanical properties of Engineering Materials
3 Material designation and identification of properties
4 Failure mechanism of brittle and ductile materials
5 Factor of safety, criteria for selection of factor of safety
6 Biaxial loading and determination of principal stresses
7 Numerical problems
8 Theories of failure- failure concepts, Maximum normal stress theory, design equation, design space
9 Maximum shear stress theory, design equation, design space.
10 Distortion energy theory, design equation, design space.
11 Design of Cotter joint, Numerical problems
12 Design of Knuckle joint; Numerical problems

Unit-2

1 Stress concentration factor, design of simple elements with stress raisers
2 Introduction to fluctuating load, types of fluctuating loads, fatigue and endurance limit, S-N Diagram
3 Endurance limit modifying factors: load, size and surface factors, Stress concentration effects; notch sensitivity, design for infinite life
4 Soderberg and Goodman relationship, derivation of equation
5 Numerical problems
6 Numerical problems
7 Stresses due to combined loading, Numerical problems
8 Introduction to impact loading, types of impact, impact stress due to axial load
9 Impact stress due to bending and torsional loads
10 Numerical problems

Unit-3

1 Introduction to transmission shafts, types of shafts, loads on shafts
2 Stresses induced in shafts due to different loads, ASME code for shaft design
3 Numerical problems
4 Numerical problems
5 Numerical problems
6 Numerical problems
7 Numerical problems
8 Design of muff coupling and numerical problems
9 Design of flange type of rigid coupling
10 Numerical problems

Unit-4

1 Introduction to threaded joints, types of threads, Stresses in threaded fasteners due to static loading
2 Numerical problems
3 Numerical problems
4 Initial tension in threaded joints, Effect of initial tension on bolt stress
5 Eccentrically loaded threaded joints, Numerical problems
6 Introduction to power screws, types of threads, applications
7 Stresses in power screws, efficiency, self-locking and over hauling
8 Numerical problems
9 Numerical problems
10 Numerical problems

Unit-5

1 Introduction, methods of riveting, types of rivets, rivet materials
2 Types of riveted joints, failures of riveted joints, joint efficiency
3 Numerical problems
4 Numerical problems
5 Design of boiler Joints.
6 Numerical problems
7 Introduction, types of welded joints, failure of welded joints
8 Design of welded joints
9 Numerical problems
10 Numerical problems

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Explain basic design concept and **design** simple machine elements subjected to static loads.	3	2	2	2									2	
Apply theories of failure and **design** simple machine elements under fatigue loading conditions.	3	3	3	2									2	
Determine the stresses in simple machine elements due to impact loads; **Design** simple power transmission shafts.	3	3	3	3									2	
Design threaded joints and power screws.	3	3	3	3									2	
Design typical welded joints and riveted joints for boiler and structural applications.	3	3	3	3									2	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME32	Material Science and Metallurgy	P15ME52	Design of Machine Elements-I	P13ME52	Design of Machine Elements-I
2	P15ME44	Mechanics of Materials				

Course Title: Turbomachines			
Course Code: P15ME53	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Basic Thermodynamics (P15ME35) and Fluid mechanics (P15ME33).

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**

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**

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**

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**

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

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.

References

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
5 D. G. Shepherd, "**Principles of Turbo Machinery,"** Macmillan Company, 1964.

Course Outcomes

At the end of the course the students should be able to:

1. **Understand** the principles and operations of Turbo-machines and the use of velocity triangles.
2. **Use** basics of fluid machines for axial flow hydraulic turbines.
3. **Apply** basics of fluid machines for radial flow hydraulic turbines.
4. **Apply** basics of fluid machines on steam turbines.
5. **Evaluate** the performance parameters of pumps with the use of velocity triangles.

Lesson Plan

Unit-1

1 Definition of turbo machine,
2 Parts of turbo machine, classification of turbo machines
3 Comparison with positive displacement machines
4 Euler turbine equation
5 Alternate form of Euler turbine equation – Components of energy transfer,
6 Degree of reaction , Relation between degree of reaction and utilization factor
7 Condition for maximum utilization in Impulse, reaction and 50% reaction turbines
8 Velocity triangles for different values of degree of reaction
9 Numerical Problems
10 Numerical Problems
11 Numerical Problems

Unit-2

1 Classification of hydraulic turbines
2 Unit quantities and their significance
3 Impulse hydraulic turbine (Pelton Wheel) Introduction
4 Work done and efficiency of Pelton wheel
5 Effect of friction and condition for maximum efficiency
6 Design parameter of Pelton wheel
7 performance curves of Pelton wheel
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-3

1 Reaction Hydraulic turbine – working of Francis turbine
2 Reaction Hydraulic turbine – working of Kaplan turbine
3 Velocity triangle ,Work done and efficiency of reaction turbine
4 Draft tubes – Different types Theory and efficiency of draft tube
5 Design Parameters of Francis turbine
6 Design Parameters of Kaplan turbine
7 Numerical Problems
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-4

1 Classification of steam turbines with examples
2 Need for compounding of turbine, velocity and pressure compounding
3 Velocity triangles, power and efficiency for impulse turbine
4 Condition for maximum utilization factor for multistage turbine
5 Effect of friction and blade angles on blade efficiency
6 Impulse reaction and reaction turbines and condition for maximum efficiency.

7 Reaction staging , Reheat factor in turbine
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems
11 Numerical Problems

Unit-5

1 Manometric head, suction head, delivery head, different types of efficiencies
2 Working of centrifugal pump
3 General analysis of design of centrifugal pump
4 General analysis of design of axial flow pump
5 Pump losses and efficiency. Minimum starting speed, net positive suction head,
6 Jet pump, air lift pump and submersible pump.
7 Jet pump, air lift pump and submersible pump.
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Course Articulation Matrix

Course Outcomes	**Program Outcomes (POs)**												**PSOs**	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Understand the principles and operations of Turbo-machines and the use of velocity triangles.	3	2	2	1						1		2	2	
Use basics of fluid machines for axial flow hydraulic turbines.	3	2	2	1						1		2	2	
Apply basics of fluid machines for radial flow hydraulic turbines.	3	2	2	1						1		2	2	
Apply basics of fluid machines on steam turbines.	3	2	2	1						1		2	2	
Evaluate the performance parameters of pumps with the use of velocity triangles	3	2	2	1						1		2	2	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME35	Basic Thermodynamics	P15ME53	Turbomachines	P13ME53	Turbomachines
2	P15ME33	Fluid mechanics				

Course Title: Manufacturing Process - III			
Course Code: P15ME54	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Manufacturing Process -I and II (P15ME34 & P15ME46) and Material Science and Metallurgy (P15ME32).

Course objective: This course enables the student to understand basic manufacturing processes and powder metallurgy.

Course Content

Unit-1

INTRODUCTION TO METAL WORKING: Classification of metal working processes, characteristics of wrought products, advantages and limitations of metal working processes. Concepts of true stress, true strain, biaxial & triaxial stresses. Determination of flow stress. Principal stresses, Tresca & von-Mises yield criteria, concepts of plane stress & plane strain. Temperature, strain rate, friction and lubrication, hydrostatic pressure in metalworking, Deformation zone geometry, workability of materials, Residual stresses in wrought products. **10 hrs**

Unit-2

FORGING & ROLLING: classification of forging processes. Forging machines & equipment. Expressions for forging pressures & load in open die forging and closed die forging by slab analysis, concepts of friction hill and factors affecting it, Die-design parameters. Material flow lines in forging. Forging defects, Residual stresses in forging. Simple problems. Classification of Rolling processes. Types of rolling mills, expression for Rolling load. Roll separating force. Frictional losses in bearing, power required rolling, Effects of front & back tensions, frictions, friction hill. Defects in rolled products. Numericals. Safety issues in forging and rolling operations. **12 hrs**

Unit-3

EXTRUSION & WIRE DRAWING: Types, Application, Variables in extrusion, Extrusion dies. Relationship between speed of extrusion and extrusion pressure. Special extrusion processes: Impact extrusion, hydrostatic extrusion, extrusion of brittle metals, Seamless Tube extrusion, Closed cavity extrusion, Powder extrusion. Metal flow pattern in extrusion with and without lubrication. Defects in extruded products. Analysis for extrusion force problems. Introduction to wire drawing, Drawing ratio, Steps in drawing operation Work done in homogenous deformation. Work formula for wire drawing. Max. Possible reduction of area per pass. Drawing equipment & dies, Drawing speed Vs wire diameter. Drawing stress Vs strain. Expression for drawing load by slab analysis. Power requirement. Redundant work and its estimation, optimal cone angle & dead zone formation, drawing variables, Tube drawing process and classification of tube drawing. Numericals.` **12 hrs**

Unit-4

SHEET & METAL FORMING: Forming methods dies & punches, progressive die, compound die, combination die. Rubber forming. Open back inclinable press (OBI press), piercing, blanking, bending, deep drawing, LDR in drawing, Forming limit criterion, defects of drawn products, stretch forming. Roll bending & contouring, Sheet metal drawing process, types. Deep drawing, stresses in deep drawing, Numericals. Safety aspects in forming operations. **8 hrs**

Unit-5

POWDER METALLURGY: Basic steps in Powder metallurgy brief description of methods of production of metal powders, Characteristics of powder. Conditioning and blending powders, Compaction and sintering. Sintering types, Mechanism of Sintering, Effect of sintering on structure and dimensional changes. Sintering furnaces, post sintering operations. Application of powder metallurgy components, advantages and limitations.

PROCESSING OF PLASTICS AND CERAMICS: Introduction, types of plastics, Processing of rubber, elastomers and ceramics. Health and safety issues. **10 hrs**

Text books

1. George E. Dieter, "**Mechanical Metallurgy,"** Tata Mc Graw Hill Education, 3rd Edition, 2013, ISBN**:** 9781259064791.
2. Serope Kalpakjian & Stevan R. Schmid, **"Manufacturing Engineering and Technology,"** Pearson Education; 4th Edition, 2014, ISBN: 978-9332535800.

References

1 J.T. Black, Ronald A. Kohser, "**Materials and Processes in manufacturing,"** Wiley, 11th Edition, 2011, ISBN: 978-0470924679.
2 G. W. Rowe, "**Principles of Industrial metal working process,"** CBS Publisher, 1st Edition, 2005, ISBN: 978-8123904283.
3 Amitabha Ghosh and Asok Kumar Mallik, "**Manufacturing Science,"** East-West press Pvt. Ltd., 2010, ISBN: 978-8176710633.
4 Sadhu Singh, **Theory of Plasticity & Metal Forming Processes,"** Khanna Publishers, 2003, ISBN: 978-8174090508.

Course Outcomes

At the end of the course the students should be able to:

1. **Describe** different metal working processes and its applications.
2. **Illustrate** metal working processes.
3. **Analyse** stresses and strain rate in metal working processes.
4. **Explain** powder metallurgy process.
5. **Discuss** processing of plastics and ceramics.

Lesson Plan

Unit-1

1 Introduction to metal working & effects of parameters.
2 Classification of metal working processes, characteristics of wrought products.
3 Advantages and limitations of metal working processes, Concepts of true stress, true strain
4 Triaxial & biaxial stresses. Determination of flow stress.
5 Principal stresses, Tresca & von-Mises yield criteria
6 Concepts of plane stress & plane strain.
7 Temperature, strain rate, friction and lubrication.
8 Hydrostatic pressure in metalworking.
9 Deformation zone geometry, workability of materials
10 Residual stresses in wrought products.

Unit-2

1 Introduction to forging processes and classification, forging machines & equipment.
2 Expressions for forging pressures & load in open die forging and closed die forging by slab analysis.
3 Concepts of friction hill and factors affecting it, Die-design parameters.
4 Material flow lines in forging and its defects.
5 Residual stresses in forging, Simple problems.
6 Introduction to rolling and classification of Rolling processes.
7 Types of rolling mills, expression for Rolling load.
8 Roll separating force, Frictional losses in bearing,
9 Power required rolling. Effects of front & back tensions,
10 Frictions, Friction hill, Defects in rolled products.
11 Problems on rolling variables.
12 Safety issues in Forging and Rolling operations.

Unit-3

1 Introduction to extrusion types, Application,
2 Variables in extrusion, Extrusion dies.
3 Relationship between speed of extrusion and extrusion pressure, Special extrusion processes: Impact extrusion, Hydrostatic extrusion.

4 Extrusion of brittle metals, Seamless Tube extrusion, Closed cavity extrusion, Powder extrusion.
5 Metal flow pattern in extrusion with and without lubrication, Defects in Extrusion products.
6 Analysis for extrusion force problems.
7 Introduction to wire drawing, Drawing ratio, Steps in drawing operation Work done in homogenous deformation.
8 Work formula for wire drawing. Max. Possible reduction of area per pass.
9 Drawing equipment & dies, Drawing speed Vs wire diameter. Drawing stress Vs strain,
10 Expression for drawing load by slab analysis. Power requirement.
11 Redundant work and its estimation, optimal cone angle & dead zone formation, drawing variables.
12 Tube drawing process and classification of tube drawing, Numerical.

Unit-4

1 Introduction to sheet metal forming, Forming methods.
2 Dies & punches, progressive die, compound die, combination die. Rubber forming.
3 Open back inclinable press (OBI press), piercing, blanking, bending.
4 Deep drawing, LDR in drawing, Forming limit criterion.
5 Defects of drawn products, stretch forming.
6 Roll bending & contouring, Sheet metal drawing process, types.
7 Stresses in deep drawing, Numericals.
8 Numericals, Safety aspects in forming operations

Unit-5

1 Introduction to powder metallurgy and basic steps involved in it.
2 Brief description of methods of production of metal powders.
3 Characteristics of powder. Conditioning and blending powders,
4 Compaction and sintering. Sintering types, Mechanism of Sintering,
5 Effect of sintering on structure and dimensional changes.
6 Sintering furnaces, post sintering operations.
7 Application of powder metallurgy components, advantages and limitations.
8 Introduction to plastics and ceramics and types of plastics.
9 Processing of rubber & elastomers and ceramics.
10 Healthy and safety issues

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Describe different metal working processes and its applications.	3	2	1									1	1	
Illustrate metal working processes	3	2	1									1	1	
Analyse stresses and strain rate in metal working processes	3	2	1									1		
Explain powder metallurgy process.	3	2	1									1	1	
Discuss processing of plastics and ceramics.	3	2	1									1	1	

Prerequisites & Equivalents for Courses of 2015-16

Sl. No.	Prerequisites Course 2015-16		Course of Regulations 2015-16		Equivalent Course for 2013-14	
	Code	Title	Code	Title	Code	Title
1	P15ME34	Manufacturing Processes– I	P15ME54	Manufacturing Processes– III	P13ME54	Manufacturing Processes– III
2	P15ME46	Manufacturing Processes– II				
3	P15ME32	Material Science & Metallurgy				

Course Title: Engineering Economics			
Course Code: P15ME551	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Engineering Mathematics-IV (P15MAAC41).

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**

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**

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**

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**

Unit-5

COSTS & 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**

Text books

1. Tarachand, **"Engineering Economics**," Nem Chand & Brothers, 2012, ISBN: 978-8185240824.
2. Tr Banga and Sc Sharma, **"Industrial Organisation and Engineering Economics,"** Khanna Publishers, 2003, ISBN: 9788174090782.

References

1. 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.

Course Outcomes

At the end of the course the students should be able to:

1. **Understand** the basic concept and terminology used in engineering economics-goods, wants and wealth etc. and taxation system.
2. **Analyze** different types of interest rates, causes for charging interest, interest factors and **evaluate** different alternatives for the purpose of investment.

3. **Describe** depreciation, cause of depreciation, c**alculate** depreciation and **perform** replacement analysis.
4. **Calculate** the cost of given component.
5. **Estimate** different types of cost and **perform** break even analysis.

Lesson Plan

Unit-1

1 Definition and Meaning of Economic terms
2 Goods, Classification of Goods
3 Want, Characteristics and Classification of Wants
4 Wealth, Classification of Wealth
5 Demand, Equilibrium Demand Theory
6 Law of Demand, Price Elasticity of Demand, Supply, Law of Supply
7 Terms Utility, Total and Marginal Utility
8 Types of Wages
9 Taxation, Principle of Taxation, Characteristics of a good Taxation System,
10 Kind of Taxes and their Merits and Demerits.

Unit-2

1 Simple and Compound interest
2 Interest Formulae
3 Numerical Problems on Simple Interest
4 Numerical Problems on Compound Interest
5 Comparison of alternatives, Present worth method
6 Numerical Problems on Present worth method
7 Equivalent Annual cost method and Rate of Return method,
8 Numerical Problems on Equivalent Annual cost method
9 Numerical Problems on Rate of Return method
10 Numerical Problems on Rate of Return method

Unit-3

1 Depreciation, Causes of Depreciation
2 Methods of Calculating Depreciation
3 Straight Line Method
4 Sinking Funds Method
5 Sum of the Year Digits Methods
6 Declining Balance
7 Numerical Problems
8 Replacement Analysis, Basic reasons of Replacement
9 Present Asset and its Replacement
10 Consideration Leading to Replacement
11 Installation and Removal Cost
12 Numerical Problems

Unit-4

1 Estimation of Material Cost, Importance of Estimating
2 Aims of Estimating, Procedure for Estimation
3 Qualities of an Estimator, Functions of an Estimator,
4 Errors in Estimating, Mensuration Procedure for Estimation
5 Estimating the Weight of Raw Materials
6 Estimating Material Cost
7 Numerical Problems
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-5

1 Costs & Cost Accounting
2 First Cost, Fixed Cost, Variable Cost
3 Incremental Cost, Sunk Cost and Marginal Cost

4 Break Even Analysis
5 Minimum Cost Analysis
6 Material Cost, Labour cost
7 Allocation of Overheads by Different Methods
8 Man Hour Rate
9 Machine Hour Rate
10 Numerical Problems.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Understand the basic concept and terminology used in engineering economics- goods, wants and wealth etc. and taxation system.	3	2	1								2	2	1	
Analyze different types of interest rates, causes for charging interest, interest factors and **evaluate** different alternatives for the purpose of investment.	3	3	3								2	2	1	
Describe depreciation, cause of depreciation, c**alculate** depreciation and **perform** replacement analysis.	3	3	3								2	2	1	
Calculate the cost of given component.	3	3	3								2	2	1	
Estimate different types of cost and **perform** break even analysis.	3	3	3								2	2	1	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15MAAC41	Engineering Mathematics – IV	P15ME551	Engineering Economics	P13ME55	Engineering Economics

Course Title: CAD/CAM			
Course Code: P15ME552	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Computer Concept & C Programming (P15CS13/23) and Manufacturing Process-II (P15ME46)

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, Input devices and Output devices. **10 hrs**

Unit-2

Computer Graphics and Geometric Modeling Techniques: Software configuration of a graphics system, functions of graphics software. Graphic primitives, 2-D transformation, homogeneous transformation, concatenation, problems on transformations, Geometric modeling wire frame, surface & solid modeling. Drawing interchange files DXF, IGES and STEP, representation of curves and surfaces, cubic splines, Bezier curves, B-splines and Nurbs, Bicubic polynomial surface patches, Bezier bicubic surface patches, cubic B-spline surfaces. **11 hrs**

Unit-3

Numerical Control (NC) and CNC Machine Tools: Basic components of NC Systems , NC procedure, co-ordinate system, open loop & closed loop system (position controlled NC), NC motion control system, application of NC, Advantage & limitations of NC. Features of CNC, CNC machining centers, CNC turning centers, high speed machining. **10 hrs**

Unit-4

CNC Hardware Basics and CNC Tooling: Structure of CNC machine tools, spindles, drives, actuation systems, feedback devices, Axes-standards. Cutting tool materials, Tool representation, Milling tooling system, Tool presetting, ATC, work/job holding devices. **10 hrs**

Unit-5

CNC Programming: Part program fundamentals, ISO Codes, simple programming exercises in drilling including canned cycle, turning and milling using ISO codes. **11 hrs**

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

References

1 S.E. Goodman, S.T.Headetniemi "**Introduction to the Design and Analysis of Algorithms"**, McGraw Hill Book Company, 1977, ISBN: 0070237530

2 Newman and Sproull**, "Principles of interactive Computer Graphics"**, Tata McGraw Hill, 28th Nov 2007, ISBN: 9780070463387.

3 Chno-Hwachang, Michel.A.Melkanoff, "**NC Machine programming and software Design",** Prentice Hall, 1988, ISBN: 9780136108092.

4 Pressman RS and Williams JE, "**Numerical Control and CAM",** Johnwiley Publication, 2000.

5 Steven Harrington, "**Computer Graphics"**, McGraw Hill Book Co., 1st July 2014 ISBN: 978-9339204808.

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

Course Outcomes

At the end of the course the students should be able to:

1. **Describe** in-put and out-put devices used in CAD.
2. **Apply** modeling techniques to **solve** problems on transformations.
3. **Discuss** the basic components of NC system and the different NC motion control systems.
4. **Identify** CNC machine components.
5. **Develop** CNC part program for different operations and **use** it for the production of parts.

Lesson Plan

Unit-1

1 Introduction and hardware for cad
2 Role of computers in design and manufacturing,
3 Product cycle in conventional and computerized manufacturing environment,
4 Introduction to CAD and CAM
5 Advantages and limitations of CAD/CAM
6 Display Units CRT, DVST, DBR.
7 Raster scan their image generation techniques
8 Input devices Mouse, Joystick, Digitizer, Tablet, & Etc
9 Latest display system types.
10 Output devices pen plotters, laser printer, color laser printer, Electrostatic printer.

Unit-2

1 Computer graphics and geometric modeling techniques,
2 Software configuration of a graphics system, functions of graphics software
3 Graphic primitives, 2-D transformation,
4 Homogeneous transformation.
5 Geometric modeling wire frame, surface & solid modeling.
6 Introduction Drawing interchange files DXF, IGES and STEP.
7 Representation of curves and surfaces,
8 Cubic splines, Bezier curves,
9 B-splines and nurbs.
10 Bicubic polynomial surface patches, Bezier bicubic surface patches
11 Cubic B-spline surfaces.

Unit-3

1 Introduction to Numerical control (NC) and Basic components of NC
2 Explanation of NC procedure.
3 NC co-ordinate system
4 Open loop & closed loop system (position controlled NC).
5 NC motion control system.
6 Application of NC, Advantage & limitations of NC.
7 Functions of CNC.
8 CNC machining centers.
9 CNC turning centers,
10 High speed CNC machine tools.

Unit-4

1 CNC hardware basics
2 Introduction to CNC tooling.
3 Structure of CNC machine tools, spindle design, drives.
4 Actuation systems, feedback devices, Axes-standards.
5 Cutting tool materials and parameters.
6 Explanation of Tool representation.
7 Explain Milling tooling system.
8 Introduction and explain Tool presetting.
9 Explanation of ATC.
10 Work holding devices.

Unit-5

1 Introduction to CNC programming.
2 Part program fundamentals.
3 ISO Codes and standards.
4 Simple programming exercises in drilling.
5 Simple programming exercises in canned cycle
6 Turning and milling using ISO codes.
7 Simple programs on turning.
8 Simple programs on turning.
9 Simple programs on milling.
10 Simple programs on milling.
11 Simple programs on milling

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Describe in-put and out-put devices used in CAD.	3	1	1											
Apply modeling techniques to **solve** problems on transformations.	3	3	1		1									
Discuss the basic components of NC system and the different NC motion control systems.	3	2	1									1	1	
Identify CNC machine components.	3	2	2									2	2	
Develop CNC part program for different operations. and **use** it for the production of parts	3	3	2		3							2	2	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15CS13/23	Computer Concept & C Programming	P15ME552	CAD/CAM	P13ME65	CAD/CAM
2	P15ME46	Manufacturing Process-II				

Course Title: Optimization Techniques			
Course Code: P15ME553	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Knowledge of basics of statistics in Engineering Mathematics-IV (P15MAAC41).

Course objective: The course aims at understanding the project networks, their construction and analysis.

Course Content

Unit-1

Gantt Chart, Mile stone chart and Network-Introduction to PERT, CPM and Gantt chart, Construction of Gantt chart, weakness of Gantt chart, mile stone chart, work breakdown structure. **Network:** Activity, dummy activity, event and type of event. Hint to draw network, Redundancy check, Numbering the event, drawing the network, drawing the network and identifying the critical path by i) Identifying all paths, ii) calculating ES,EF,LS.LF, iii) event oriented calculations. Forward pass and back word pass, signification of critical path and calculation of total back and free slack. **12 hrs**

Unit-2

PERT- Time estimates: Optimistic time, pessimistic time, most likely time. Estimated time of completing the activity identify the probable critical path and near critical path variance and standard deviation of the project probability of completing project, PERT cost accounting. **10 hrs**

Unit-3

CPM: Introduction direct cost, indirect cast, drawing network and identifying critical path schedule graph, reducing project duration by crashing the activity based on crash cost normal duration , minimum duration, optimum duration and their corresponding cost. **10 hrs**

Unit-4

Updating- Introduction, Why and when to update reason for updating based on progress report. **10 hrs**

Unit-5

Scheduling with limited resources- Introduction, resource planning, Resource smoothening and resource leveling by studying the resource requirement. **10 hrs**

Text books

1 Jerome D Wiest, Ferdinand K levy, "**A Management Guide to PERT/CPM,"** Prentice Hall, 2nd edition, 1977, ISBN: 978-0135491058.

2 L S Srinath **"PERT and CPM Principles and Applications"** Affiliated East-West Press (Pvt.) Ltd., 3rd edition, 2001, ISBN: 978-8185336206

References

1 Prem Kumar Gupta, D. S. Hira, "**Operation Research,"** S Chand Pub, New Delhi, 2007, ISBN: 978-8121902816.

2 Ravindran, Phillips & Solberg, "**Operations Research: Principles and Practice,"** John Wiley & Sons, 2nd Revised edition 2007, ISBN: 978-0471086086.

Course Outcomes

At the end of the course the students should be able to:

1. **Define** and **Recognise** project networks.
2. **Discuss** major types of networks.
3. **Interpret** different types of networks.
4. **Identify** why and when to update progress report.
5. **Appraise** resource smoothening and resource leveling.

Lesson Plan

Unit-1

1 Introduction to PERT, CPM
2 Gantt chart, Construction of Gantt chart,
3 Weaknesses of Gantt chart, mile stone chart,
4 Network: Activity, dummy activity, event and type of event.
5 How to draw network,
6 Illustrations with numerical
7 Redundancy check, Numbering the event,
8 Drawing the network and identifying all paths,
9 Calculation of ES,EF,LS.LF, and Event oriented calculations,
10 Numerical problems
11 Numerical problems
12 Forward pass and back word pass, signification of critical path and calculation slack,

Unit-2

1 Introduction to PERT
2 Time estimates: Optimistic time, pessimistic time, most likely time
3 .Numerical problems
4 Estimated time of completing the activity
5 Numerical problems
6 Identify the probable critical path and near critical path
7 Numerical problems
8 Variance and standard deviation of the project
9 Probability of completing project within stipulated time.
10 PERT cost accounting

Unit-3

1 Introduction **to CPM**
2 Direct cost, indirect cast, drawing network
3 Identifying critical path
4 Schedule graph,
5 Reducing project duration by crashing the activity based on crash cost.
6 Reducing project duration by crashing the activity based on crash cost.
7 Numerical problems.
8 Numerical problems.
9 Normal duration, minimum duration, optimum duration.
10 Normal duration, minimum duration, optimum duration and their corresponding cost.

Unit-4

1 Introduction to Updating
2 Why updating?
3 When to update?
4 Reasons for updating
5 Numerical problems
6 Numerical problems
7 Relevance of Updating
8 Assessment time
9 Progress report.
10 Progress report.

Unit-5

1 Introduction to Scheduling
2 Scheduling with limited resources
3 Scheduling with limited resources
4 Resource planning
5 Resource planning
6 Resource smoothening

7 Resource smoothening
8 Resource leveling
9 Resource leveling
10 Resource requirement

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Define and **Recognise** project networks	**3**	**2**	**-**						**3**	**3**	**1**	**3**		
Discuss major types of networks	**2**	**3**	**-**						**3**	**3**	**1**	**3**		
Interpret different types of networks	**3**	**3**	**-**						**3**	**3**	**2**	**3**		
Identify why and when to update progress report	**3**	**3**	**-**						**3**	**3**	**2**	**3**		
Appraise resource smoothening and resource leveling	**3**	**3**	**-**						**3**	**3**	**3**	**3**		

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15MAAC41	Engineering Mathematics-IV	P15ME553	Optimization Techniques	---	---

Course Title: Mechanism Design: Analysis and Synthesis			
Course Code: P15ME554	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Students should have acquired the knowledge of Kinematics of Machinery (P15ME45) and Engineering Mathematics – I & II (P15MA11/21).

Course objective: To develop student understanding of the theoretical background for basic and advanced kinematics and synthesis of mechanisms to achieve desired motion.

Course Content

Unit-1

Kinematics and Mechanisms: Introduction, analysis versus synthesis, motion, mechanism terminology and definitions- mechanism, and machine, rigid and resistant body, link, kinematic pair, types of joints, classifications of kinematic pairs, kinematic chain, mechanism and structure, classification of mechanism, mobility of mechanism, equivalent mechanism. Four-bar linkage, science of relative motion, kinematic diagrams, Grashoff's law, mechanical advantage, transmission angle. **10 hrs**

Unit-2

Velocity Analysis: Definition of velocity, rotation of a rigid body, velocity difference between points of the same rigid body. Velocity analysis by analytic, complex-algebra and vector methods, problems. Instantaneous center of velocity, the Aronhold-Kennedy theorem of three centers, locating instant centers of velocity. Angular-velocity ratio theorem, problems. Determination of mechanical advantage, correlation of mechanical advantage and transmission angle, minimum value of mechanical advantage. **11 hrs**

Unit-3

Acceleration Analysis: Definition of acceleration, angular acceleration, acceleration difference between points of a rigid body, relative acceleration. Acceleration analysis of four-link mechanism by analytic method and complex-algebra method, problems on acceleration analysis of simple four-link and slider-crank mechanisms.

Synthesis of Linkages: Type, number and dimensional synthesis, function generation, path generation and motion generation. Number synthesis- the associated linkage concept for synthesis of some slider crank mechanism, tools of dimensional synthesis. **9 hrs**

Unit-4

Graphical Synthesis for Function Generation: Precession positions, structural error, Chebychev spacing. Two-position synthesis of slider-crank mechanisms, two-position synthesis of crank-rocker mechanisms, crank-rocker mechanism with optimum transmission angle, problems. Function generation by inverse method- synthesis of crank-rocker mechanism for two-position, synthesis of slider-crank mechanism for two-position, synthesis of crank-rocker mechanism for three and four positions, Overlay method, problems. **12 hrs**

Unit-5

Graphical Synthesis for Motion Generation: pole, properties of pole points, relative pole. Motion generation by relative pole method- Synthesis of four-link mechanism for two-positions, synthesis of slider-crank mechanisms for two-positions, problems. **Analytical Synthesis:** Bloch's method of synthesis, Freudenstein's equation, problems on analytical synthesis. **10 hrs**

Text books

1. John J. Uicker, Jr., Gordon R. Pennock and Joseph E. Shigley, "**Theory of Machines and Mechanisms,"** Oxford University Press, 4th Edition, 2014, ISBN: 9780199454167.
2. Arthur G. Erdman, George N. Sandor and Sridhar Kota, **"Mechanism Design: Analysis and Synthesis,"** Pearson Publishers, 4th Edition, 2001, ISBN:9780130408723.

References

1. S.S. Rattan "Theory of Machines" Tata McGraw-Hill, New Delhi, 4th edition, 2015, ISBN: 9789351343479.
2. Amitabha Ghosh and A. K. Mallik, "Theory of Mechanisms and Machines," East West Press, 3rd Edition, 2006, ISBN: 9788185938936.

3 Ashok G. Ambekar, "Mechanism and Machine Theory," Prentice Hall India, 1st Edition, 2007, ISBN: 9788120331341.
4 David H. Myszka, "Machines & Mechanisms: Applied Kinematic Analysis**,"** Pearson Publishers, 4th Edition, 2011, ISBN: 9780132157803.

Course Outcomes

At the end of the course the students should be able to:

1. **Define** mechanism terminology and **apply** Gruebler's criteria to determine mobility of mechanisms.
2. **Calculate** displacement and velocity of four-bar mechanisms using analytic methods.
3. **Analyze** the acceleration of simple four-bar mechanisms and **understand** the basics of mechanism synthesis.
4. **Prepare** synthesis of four-link mechanisms for function generation using graphical methods.
5. **Prepare** synthesis of four-link mechanisms for motion generation using graphical and analytical methods.

Lesson Plan

Unit-1

1 Kinematics and Mechanisms**:** Introduction, analysis versus synthesis, motion.
2 Mechanism terminology and definitions- mechanism, and machine, rigid and resistant body, link.
3 Kinematic pair, types of joints, classifications of kinematic pairs.
4 Kinematic chain, mechanism and structure, classification of mechanism.
5 Mobility of mechanism-definition, derivation of Grubler's criteria.
6 Problems on mobility of mechanisms.
7 Equivalent mechanisms- Introduction and rule for writing equivalent mechanisms.
8 Problems on equivalent mechanisms.
9 Four-bar linkage, science of relative motion, kinematic diagrams.
10 Grashof's law, mechanical advantage, transmission angle.

Unit-2

1 **Velocity Analysis:** Definition of velocity, rotation of a rigid body, velocity difference between points of the same rigid body.
2 Velocity analysis by analytic method-derivation of equations.
3 Problems on analytic method of velocity analysis.
4 Velocity analysis by complex-algebra method and vector method.
5 Problems on complex algebra method.
6 Problems on complex vector method.
7 Instantaneous center of velocity, the Aronhold-Kennedy theorem of three centers.
8 Locating instant centers of velocity.
9 Angular-velocity ratio theorem and problems
10 Determination of mechanical advantage, correlation of mechanical advantage and transmission angle.
11 Minimum value of mechanical advantage and problems.

Unit-3

1 **Acceleration Analysis:** Definition of acceleration, angular acceleration, acceleration difference between points of a rigid body.
2 Relative acceleration. Acceleration analysis of four-link mechanism by analytic method
3 Problems on acceleration analysis of simple four-link and slider-crank mechanisms.
4 Problems on acceleration analysis of simple four-link and slider-crank mechanisms.
5 Acceleration analysis by complex algebra method.
6 Problems on acceleration analysis of simple four-link and slider-crank mechanisms.
7 Problems on acceleration analysis of simple four-link and slider-crank mechanisms.

8 **Synthesis of Linkages:** Type, number and dimensional synthesis, function generation, path generation and motion generation
9 Number synthesis- the associated linkage concept for synthesis of some slider mechanism, tools of dimensional synthesis.

Unit-4

1 **Graphical Synthesis for Function Generation:** Precession positions, structural error, Chebychev spacing.
2 Numerical on Chebychev spacing.
3 Two-position synthesis of slider-crank mechanisms and problems.
4 Two-position synthesis of crank-rocker mechanisms and problems.
5 Crank-rocker mechanism with optimum transmission angle and problems.
6 Function generation by inverse method- introduction to inverse method.
7 Synthesis of crank-rocker mechanism for two-position using inverse method.
8 Problems on Synthesis of crank-rocker mechanism for two-position using inverse method.
9 Synthesis of slider-crank mechanism for two-position and problems.
10 Synthesis of crank-rocker mechanism for three positions and problems.
11 Synthesis of crank-rocker mechanism for four positions and problems.
12 Overlay method, problems and problems.

Unit-5

1 **Graphical Synthesis for Motion Generation:** pole, properties of pole points, relative pole.
2 Motion generation by relative pole method- Synthesis of four-link mechanism and slider-crank mechanism for two-positions.
3 Problems.
4 Problems.
5 Problems.
6 **Analytical Synthesis:** Bloch's method of synthesis.
7 Problems.
8 Freudenstein's equation-derivation.
9 Problems.
10 Problems.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Define mechanism terminology and **apply** Gruebler's criteria to determine mobility of mechanisms.	2	2	-	-	-							1	1	
Calculate displacement and velocity of four-bar mechanisms using analytic methods.	3	3	2	2	-					2		2	1	
Analyze the acceleration of simple four-bar mechanisms and **understand** the basics of mechanism synthesis.	3	3	2	2	-					2		2	1	
Prepare synthesis of four-link mechanisms for function generation using graphical methods.	3	2	2	2	-					1		2	-	
Prepare synthesis of four-link mechanisms for motion generation using graphical and analytical methods.	3	2	2	2	-					1		2	-	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME45	Kinematics of Machinery	P15ME554	Mechanism Design: Analysis and Synthesis	---	---
2	P15MA11/21	Engineering Mathematics – I & II				

Course Title: Mechatronics and Microprocessor			
Course Code: P15ME561	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Electronic Devices and Communication (P15EC15/25) and Basic Electrical Engineering (P15EE15/25).

Course objective: The course aims at enabling the students to understand the basic concepts of Mechatronics, Mechatronic 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

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**

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

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**

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**

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.

References

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.

Course Outcomes

At the end of the course the students should be able to:

1. **Identify** Mechatronics system, measurement systems, Open & Closed loop control systems and different types of sensors.
2. **Understand** Electrical systems, Mechanical switches, relays, solid state switches, diodes, thyristors and triacs, bipolar transistors, MOSFETS, solenoids and distinguish DC motors, permanent magnet DC motors with field coils, brushless permanent magnet DC motors, AC motors, stepper motors and their merits and demerits.
3. **Analyse** signal conditioning process, protection, filtering, Multiplexers, Data Acquisition system.
4. **Evaluate** Organization of Microprocessor, instructions, machine and mnemonics codes, machine and assembly language programming, High level language programming.
5. **Generate** Decimal number system, Hexadecimal number system, conversion from one number system to another, negative number representation.

Lesson Plan

Unit-1

1 Introduction to Mechatronics systems
2 Measurement systems, control systems,
3 Open & Closed loop control systems
4 Basic elements of closed loop control system
5 Microprocessor - based controllers such as automatic camera
6 Engine management system
7 Classification of sensors, light sensors
8 Tactile sensors, inputting data by switches their merits and demerits.
9 Hall – effect sensors
10 Selection of sensors.

Unit-2

1 Electrical systems, Mechanical switches.
2 Relays, solid state switches.
3 Diodes, thyristors and triacs
4 Bipolar transistors, MOSFETS
5 Solenoids, DC motors
6 Permanent magnet DC motors with field coils
7 Brushless permanent magnet DC motors.
8 AC motors
9 MOSFETS
10 Stepper motors and their merits and demerits

Unit-3

1 Introduction to signal conditioning, signal conditioning process
2 Operational amplifiers
3 Inverting Operational amplifiers
4 Non-Inverting Operational amplifiers
5 Protection, filtering.
6 Wheat stone bridge, Digital signals.
7 ADC
8 DAC
9 Multiplexers, Data Acquisition system.
10 Pulsed modulation.

Unit-4

1 Evolution of Microprocessor.
2 Organization of Microprocessor, instructions.
3 Machine and mnemonics codes, machine, assembly language programming and High level language programming.

4 Organization of INTEL 8085.
5 Organization of INTEL 8085.
6 Data and Address busses, registers in the 8085.
7 Instruction set of 8085.
8 Instruction types, CPU of Microprocessors.
9 The fetch operation, execute cycle.
10 HALT and HOLD states.

Unit-5

1 Positional number system, binary number system
2 Octal number system, decimal number system
3 Hexadecimal number system, conversion from one number system to another
4 Problems
5 Problems
6 Negative number representation, representation of floating point numbers
7 Accuracy and range in floating point numbers,
8 Binary Arithmetic, addition, subtraction of binary integers.
9 Overflow and underflow
10 Logic gates, AND, OR, NOT, NAND.
11 NOR and EXCLUSIVE – OR gate
12 Boolean algebra.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Identify Mechatronics system, measurement systems, Open & Closed loop control systems and different types of sensors.	3	2	1											
Understand Electrical systems, Mechanical switches, relays, solid state switches, diodes, thyristors and triacs, bipolar transistors, MOSFETS, solenoids and distinguish DC motors, permanent magnet DC motors with field coils, brushless permanent magnet DC motors, AC motors, stepper motors and their merits and demerits.	3	1	1											
Analyse signal conditioning process, protection, filtering, Multiplexers, Data Acquisition system.	3	3	2											
Evaluate Organization of Microprocessor, instructions, machine and mnemonics codes, machine and assembly language programming, High level language programming.	3	3	2											
Generate Decimal number system, Hexadecimal number system, conversion from one number system to another, negative number representation.	3	2	2											

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15EC15/25	Electronic Devices and Communication	P15ME561	Mechatronics & Microprocessor	P13ME56	Mechatronics & Microprocessor
2	P15EE15/25	Basic Electrical Engineering				

Course Title: Automotive Engineering			
Course Code: P15ME562	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Students should have acquired the knowledge of Basic Thermodynamics (P15ME35), Applied Thermodynamics (P15ME42) and Kinematics of Machinery (P15ME45).

Course objective: To develop student understanding of the theoretical background of Automobile basic components and systems.

Course Content

Unit-1

Cooling and Lubrication Systems: Function of lubrication, mechanism of lubrication, elastohydrodynamic lubrication, journal bearing lubrication, stable lubrication. Lubrication system: mist lubrication system, wet sump lubrication system, and dry sump lubrication system; crank case ventilation, properties of lubricants, SAE rating of lubricants, additives of lubricants. **Need for cooling system**, characteristics of efficient cooling system, types of cooling systems, liquid cooled systems, direct or non return system, thermosymphon system, forced circulation cooling system, evaporative cooling system, pressure cooling system. Air cooled system: cooling fins, baffles, comparison of liquid and air cooling systems, advantages and limitations of liquid and air cooling systems.

10 hrs

Unit-2

Mechanical & Electronic Injection Systems: Introduction, functional requirements of an injection system, classification of injection systems (air, solid, individual pump & nozzle, unit, common rail & distributor system), fuel feed pump, injection pump (jerk & Distributor type), fuel injector, types of nozzle, spray formation, quantity of fuel & the size of nozzle orifice. **Electronic Injection Systems:** types of injection system, components of injection system, Electronic Fuel Injection system, merits and demerits of EFI system, D-MPFI system, L-MPFI, Electronic control system, Electronic Control Unit (ECU), cold start injection, air valve, electronic diesel injection control, electronically controlled unit injectors, electronically controlled injection pumps(inline & Distributor type), Common – Rail Fuel injection system, **Governors:** injection pump, mechanical and pneumatic governors. **10 hrs**

Unit-3

Ignition Systems: introduction, energy requirements for ignition, requirements of an ignition system, Battery ignition, magneto ignition, spark advance mechanism (centrifugal advance and vacuum advance). **Automotive Emission measurement:** NDIR analyzers, gas chromatograph, thermal conductivity, and flame ionization detectors, analyzers for NO_x, smoke measurements, comparison method, obscuration method, ringelmann chart, continuous filter type smoke meter, bosch smoke meter, Hartridge smoke meter. **10 hrs**

Unit-4

Clutch: Definition, requirements of clutch, types of friction clutches, principle of friction clutches, dry friction clutches, cone clutch, single plate clutch, diaphragm spring type single plate clutch, multi - plate clutch, semi – centrifugal clutch, centrifugal clutch, fluid fly wheel.

Gear Box: function & necessary of transmission, types of transmission, manual transmission, sliding mesh gear box, constant mesh gear box, sysnchro mesh gear box, epicyclic gear box, flywheel unit, and torque converter. **12 hrs**

Unit-5

DRIVE TO WHEELS: drive line, propeller shaft, half shaft, universal joint, rear axle drives. **SUSPENSION, SPRINGS AND BRAKES:** basic requirements, function of suspension springs, types of suspension springs, leaf springs, coil springs, torsion bars, rubber springs, shock absorbers (Dampers), air suspension, **BRAKES**: principle, braking requirements, Drum brakes: construction & types, factors influencing braking effect, theoretical analysis, Mechanical brakes: brake shoe operation, linkages, brake components. Hydraulic brakes: layout & components, two shoe leading brake, brake adjusters, automatic brake adjusters, bleeding of hydraulic brakes, advantages of hydraulic system **10 hrs**

Text books

1 Kirpal Singh, "**Automobile engineering Vol I,"** Standard Publishes-Distributors, Delhi, 13th Edition, 2012, ISBN: 978-8180141966.
2 Kirpal Singh, "**Automobile engineering Vol II,"** Standard Publishes-Distributors, Delhi, 13th Edition, 2014, ISBN: 978-8180142062.
3 N. K. Giri, **"Automobile Mechanics,"** Khanna Publishers, 2013, ISBN: 978-8174092168.

References

1 William H Crouse & Donald L Anglin, "**Automotive mechanics,"** Tata McGraw Hill Publishing Company Ltd., 10th Edition, 2007, ISBN: 978-0070634350.
2 V. Ganeshan, **"Internal Combustion Engines"**, Mc Graw Hill Education., 4th Edition, 2012,ISBN:9781259006197
3 S.Srinivasan, **"Automotive Mechanics,"** Tata McGraw Hill, 2003, ISBN: 9780070494916.
4 K.K.Ramalingam, "**Fundamentals of Automobile Engineering,"** Scitech Publications (India) Pvt. Ltd, ISBN: 9798188429485.

Course Outcomes

At the end of the course the students should be able to:

1. **Explain** the different engine lubrication and cooling systems.
2. **Describe** the mechanism and working principle of mechanical and electronic fuel injection systems.
3. **Outline** the different types of ignition systems and **distinguish** different automotive emission measuring systems.
4. **Understand** the requirements of clutch and gear box systems in automobiles.
5. **Explain** different types of drive train arrangements, suspension and braking systems in automobiles.

Lesson Plan

Unit-1

1 Function of lubrication, mechanism of lubrication.
2 Elastohydrodynamic lubrication, journal bearing lubrication, stable lubrication.
3 Lubrication system: mist lubrication system, wet sump lubrication system, and dry sump lubrication system
4 Crank case ventilation, properties of lubricants
5 SAE rating of lubricants, additives of lubricants
6 Need for cooling system, characteristics of efficient cooling system, types of cooling systems, liquid cooled systems
7 Direct or non return system, thermosymphon system, forced circulation cooling system.
8 Evaporative cooling system, pressure cooling system
9 Air cooled system: cooling fins, baffles, comparison of liquid and air cooling systems,
10 Advantages and limitations of liquid and air cooling systems...

Unit-2

1 Mechanical & Electronic Injection Systems: **I**ntroduction, functional requirements of an injection system
2 classification of injection systems, air, solid system
3 Individual pump & nozzle, unit, common rail & distributor system
4 Fuel feed pump, injection pump (jerk & Distributor type)
5 Fuel injector, types of nozzle, spray formation
6 Quantity of fuel & the size of nozzle orifice. Electronic Injection Systems: types of injection system, components of injection system
7 Electronic Fuel Injection system, merits and demerits of EFI system, D-MPFI system, L-MPFI, Electronic control system, Electronic Control Unit (ECU)
8 Cold start injection, air valve, electronic diesel injection control, electronically controlled unit injectors

9 Electronically controlled injection pumps(inline & Distributor type), Common – Rail Fuel injection system
10 Governors: injection pump, mechanical and pneumatic governors

Unit-3

1 Ignition Systems: introduction, energy requirements for ignition, requirements of an ignition system
2 Battery ignition, magneto ignition
3 Spark advance mechanism (centrifugal advance and vacuum advance).
4 Automotive Emission measurement**:** NDIR analyzers
5 Gas chromatograph, thermal conductivity
6 Flame ionization detectors, analyzers for NO_x
7 Smoke measurements, comparison method
8 Obscuration method, ringelmann chart
9 Continuous filter type smoke meter
10 Bosch smoke meter, Hartridge smoke meter

Unit-4

1 Clutch: Definition, requirements of clutch.
2 Types of friction clutches, principle of friction clutches
3 Dry friction clutches, cone clutch
4 Single plate clutch, diaphragm spring type single plate clutch
5 Multi - plate clutch, semi – centrifugal clutch
6 Centrifugal clutch, fluid fly wheel
7 Gear Box**:** function & necessary of transmission
8 Types of transmission, manual transmission
9 Sliding mesh gear box
10 Constant mesh gear box
11 Sysnchro mesh gear box, epicyclic gear box
12 Flywheel unit, and torque converter

Unit-5

1 Drive to wheels**:** drive line, propeller shaft, half shaft
2 Universal joint, rear axle drives
3 Suspension, springs and brakes**:** basic requirements, function of suspension springs,
4 Types of suspension springs, leaf springs, coil springs
5 Torsion bars, rubber springs, shock absorbers (Dampers), air suspension, Brakes: principle
6 Braking requirements, Drum brakes: construction & types
7 Factors influencing braking effect, theoretical analysis
8 Mechanical brakes: brake shoe operation, linkages, brakes components. Hydraulic brakes: layout & components
9 Two shoe leading brake, brake adjusters, automatic brake adjusters,
10 Bleeding of hydraulic brakes, advantages of hydraulic system.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Explain the different engine lubrication and cooling systems.	2		2				1							
Describe the mechanism and working principle of mechanical and electronic fuel injection systems.	3		2			1	2							
Outline the different types of ignition systems and **distinguish** different automotive emission measuring systems.	3		2			1	2					1		
Understand the requirements of clutch and gear box systems in automobiles.	3		2			1								
Explain different types of drive train arrangements, suspension and braking systems in automobiles.	2		2			1								

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME35	Basic Thermodynamics	P15ME562	Automotive Engineering	---	---
2	P15ME42	Applied Thermodynamics				
3	P15ME45	Kinematics of Machinery				

Course Title: Advanced Materials Science			
Course Code: P15ME563	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Knowledge of Material Science and Metallurgy (P15ME32).

Course objective: The objective of the course is to enable the students to understand the fundamentals of materials science and engineering and get an exposure to some of the advanced materials processing technologies.

Course Content

Unit-1

Structural features of Materials: Introduction, Atomic bonding, primary interatomic bonds, ionic bonding, covalent bonding, metallic bonding, secondary bonding or van der waals bonding, bonding forces and energies, density computations-metals, density computations-ceramics, polymorphic forms of carbon, crystallographic directions, crystallographic planes, atomic arrangements, close-packed crystal structures, Bragg's law, single crystals, polycrystalline materials, anisotropy, noncrystalline solids. Impurities in solids, impurities in metals, solid solutions, specification of composition. **10 hrs**

Unit-2

Structure-Property relationship: Introduction, dislocations, edge dislocation, screw dislocation, mixed dislocations, burgers vector, interfacial defects, external surfaces, grain boundaries, twin boundaries, grain size. dislocation density, slip systems, Deformation mechanisms for metals, elastic deformation, plastic deformation, influence of dislocation on plastic deformation, plastic deformation of polycrystalline metals, mechanisms of strengthening in metals, strengthening by grain size reduction, solid-solution strengthening, strain hardening, recovery, recrystallization and grain growth, recrystallization temperature. Time-Temperature-Transformation (T-T-T) of Iron-Carbon alloys, precipitation hardening, solution heat treating, precipitation heat treating, mechanism of precipitation hardening.

10 hrs

Unit-3

Polymer Structures: Introduction, hydrocarbon molecules, polymer molecules, chemistry of polymer molecules, molecular shape, molecular structure, linear polymers, branched polymers, cross-linked polymers, network polymers, thermoplastic and thermosetting polymers, copolymers, polymer crystallinity, polymer crystals, types of polymers-plastics and elastomers. **Mechanical behaviour of polymers:** stress-strain behaviour, macroscopic deformation, tear strength and hardness of polymers, mechanisms of deformation of polymers, mechanism of elastic deformation, mechanism of plastic deformation, deformation of elastomers, vulcanization. **10 hrs**

Unit-4

Composite Materials: Introduction, classification, matrix and reinforcement materials, properties, rule of mixtures, longitudinal strength and modulus (isostrain model), transverse strength and modulus (isostress model), Numericals, applications of composites. Processing of PMCs - hand lay-up process, filament winding process. Processing of MMCs-Stir casting, squeeze casting, **Powder metallurgy technique:** Blending of powder, Powder Compaction, Sintering. **12 hrs**

Unit-5

Nano technology: Concept of Nanotechnology, Nanomaterials, preparation of Nanomaterials: plasma arcing, CVD, sol-gel method, electrode deposition, ball milling, New forms of carbon, types of nanotubes, properties of nanotubes, applications of nanotechnology.

10 hrs

Text books

1 William D. Callister, Jr., **"Fundamentals of Materials Science and Engineering,"** John Wiley & Sons, Inc , 5th Edition , 2001, ISBN: 9780471395515.

2 William F Smith, Javad Hashemi, Ravi Prakash, **"Materials Science and Engineering,"** Tata McGraw Hill Publishing Company, Ned Delhi , 5th edition, ISBN: 9781259062759.

3 Mick Wilson, Kamali kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, **"Nano Technology- Basic science and Emerging Technology,"** Chapman and Hall/CRC, 1st edition, 2002, ISBN: 978-1584883395.

References

1 V.S.R Murthy, A. K. Jena, K.P.Gupta, G.S.Murthy, **"Structure and Properties of Engineering Materials,**" Tata McGraw Hill, .
2 Er. Rakesh Rathi, **" Nanotechnology,"** S. Chand and Company, 2010, ISBN: 978-8121930826.

Course Outcomes

At the end of the course the students should be able to:

1. **Explain** the structural characteristics of materials.
2. **Analyze** the structure – property relationship of materials.
3. **Explain** the structural and mechanical characteristics of polymer materials.
4. **Explain** the characteristics and processing techniques of composite materials.
5. **Explain** the characteristics and processing techniques of nano-materials.

Lesson Plan

Unit-1

1 Introduction to Atomic bonding, primary interatomic bonds and ionic bonding.
2 Covalent bonding, metallic bonding and secondary bonding or van der waals bonding.
3 Bonding forces and energies, density computations-metals and density computations-ceramics.
4 Crystallographic directions and crystallographic planes.
5 Polymorphic forms of carbon and atomic arrangements.
6 Close-packed crystal structures and Bragg's law.
7 Single crystals, polycrystalline materials and anisotropy.
8 Noncrystalline solids and Impurities in solids.
9 Impurities in metals and solid solutions.
10 Specification of composition.

Unit -2

1 Introduction to dislocations, edge dislocation, screw dislocation and mixed dislocations.
2 Burgers vector, interfacial defects, external surfaces and grain boundaries.
3 Twin boundaries. Grain size. dislocation density and slip systems.
4 Deformation mechanisms for metals, Elastic deformation and plastic deformation.
5 Influence of dislocation on plastic deformation and Plastic deformation of polycrystalline metals.
6 Mechanisms of strengthening in metals and strengthening by grain size reduction and Solid-solution strengthening.
7 Recrystallization temperature and Time-Temperature-Transformation (T-T-T) of Iron-Carbon alloys.
8 Strain hardening, recovery, recrystallization and grain growth.
9 Precipitation hardening and solution heat treating.
10 Precipitation heat treating and mechanism of precipitation hardening.

Unit-3

1 Introduction to hydrocarbon molecules, polymer molecules and chemistry of polymer molecules.
2 Molecular shape, molecular structure, linear polymers and branched polymers.
3 Cross-linked polymers, network polymers and thermoplastic.
4 Thermosetting polymers, copolymers, polymer crystallinity and polymer crystals.
5 Types of polymers-plastics and elastomers.
6 Introduction to Mechanical behaviour of polymers and stress-strain behavior.
7 Macroscopic deformation and tear strength.
8 Hardness of polymers and mechanisms of deformation of polymers.

9 Mechanism of elastic deformation and mechanism of plastic deformation.
10 Deformation of elastomers and vulcanization.

Unit-4

1 Introduction to Composite Materials and classification.
2 Matrix and reinforcement materials and properties.
3 Rule of mixtures, longitudinal strength and modulus (isostrain model).
4 Transverse strength and modulus (isostress model).
5 Numerical Problems.
6 Numerical Problems.
7 Applications of composites.
8 Processing of PMCs - hand lay-up process and filament winding process.
9 Processing of MMCs-Stir casting.
10 Processing of MMCs -Squeeze casting.
11 Powder metallurgy technique: Blending of powder, Powder Compaction,
12 Sintering.

Unit-5

1 Introduction to Nano technology.
2 Concept of Nanotechnology.
3 Nanomaterials and preparation of Nanomaterials.
4 plasma arcing and CVD.
5 Sol-gel method and electrode deposition.
6 Ball milling .
7 New forms of carbon.
8 Types of Nanotubes.
9 Properties of Nanotubes.
10 Applications of Nanotechnology.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Explain the structural characteristics of materials.	2	2		2									2	
Analyze the structural – property relationship of materials.	3	3	3	3			2					2	2	
Explain the structural characteristics of polymer materials.	2	2	2	2			2					2	2	
Explain the characteristics and processing techniques of composite materials.	3	3	3	2			2					2	2	
Explain the characteristics and processing techniques of nano-materials.	2		2	3			2					2	2	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME32	Material Science and Metallurgy.	P15ME563	Advanced Material Science	---	---

Course Title: Numerical Analysis and Algorithms			
Course Code: P15ME564	**Sem: 05**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Students should have acquired the knowledge of subjects Engineering Mathematics – I to IV (P15MA11/21, P15MAT31 & P15MAAC41/MAES41) and Computer Concept & C Programming (P15CS13/23).

Course objective: To give students necessary background on numerical analysis needed to solve Mechanical Engineering problems.

Course Content

Unit-1

Review of Mathematical Foundation- physical meaning of derivatives and integrals, Taylor series expansion, definition of matrix and vectors, matrix algebra- summation, subtraction and multiplication of matrices, transpose, determinant, inversion and rank of a matrix. Errors in numerical calculations- Introduction, numbers and their accuracy, errors and their analysis, absolute, relative and percentage errors, general error formula, errors in series approximation. Computer Arithmetic- Introduction, floating point representation of numbers, arithmetic operations with normalized floating point numbers, some pitfalls in computing. **10 hrs**

Unit-2

Solution of Algebraic and Transcendental Equations: Introduction, Bisection method and its algorithm, Method of false position and its algorithm, Newton-Raphson method and its algorithm and Secant method and its algorithm.

Solution of Simultaneous Equations: Introduction, Direct methods- Gauss elimination method and its algorithm, Gauss elimination with row pivoting. Iterative methods- Jacobi method, Gauss-Seidel method and its algorithm, comparison of direct and iterative methods. **10 hrs**

Unit-3

Interpolation: Introduction, Finite differences- difference operators and relation between them, forward differences, backward differences and central differences. Newton's forward and backward interpolation formulae. Difference formulae for unequal intervals- Lagrange's interpolation formula, difference tables and Hermite's interpolation formula.

Curve Fitting: Introduction, Least-Squares approximation of function, linear regression, algorithm for linear regression, polynomial regression, fitting exponential curve, sum of exponentials curve, hyperbola curve, trigonometric function and geometric curve. **10 hrs**

Unit-4

Numerical Differentiation and Integration: Introduction, differentiation formula derived from interpolation formulae. Numerical integration- Trapezoidal rule, algorithms for Trapezoidal rule, Simpson's 1/3 and 3/8 rules and their computer algorithms to integrate known functions, Boole's and Weddle's rules, Newton-Cotes integration formula. Gaussian quadrature formulae and its computer algorithm. **10 hrs**

Unit-5

Numerical Solution of Differential Equations: Numerical solution of ordinary differential equations-Introduction, Taylor series method, Picard's method, Euler's method, modified Euler's method, Runge-Kutta methods, Runge-Kutta fourth order formula, algorithm for Runge-Kutta method and Predictor-Corrector method and its algorithm. Numerical solution of partial differential equations- Introduction, Finite difference approximation of partial derivatives, solution of Laplace equations by Jacobi's method, Gauss-Seidel method and Successive Over-Relaxation method. **12 hrs**

Text books

1 B. S. Grewal, "**Numerical Methods in Engineering and Science"** Khanna Publishers, New Delhi, 10th Edition, 2014, ISBN: 9788174092489.

2 S. S. Sastry, **"Introductiory Methods of Numerical Analysis,"** Prentice Hall of India, New Delhi, 4th Edition, March 30, 2006 1997, ISBN: 9788120327610.

References

1 V. Rajaraman, **"Computer Oriented Numerical Methods,"** Prentice Hall of India, New Delhi, 3rd Edition, 1998, ISBN: 9788120307865.
2 Amos Gilat and Vish Subramaniam, **"Numerical Methods for Engineers and Scientists: An Introduction with Applications using MATLAB,"** John Wiley & Sons, 1st Edition, 2008, ISBN: 978-0470290705.
3 John Mathews, **"Numerical Methods for Mathematics, Science & Engineering,"** Prentice Hall of India, New Delhi, 2nd Edition, 1992, ISBN: 9780136249900.

Course Outcomes

At the end of the course the students should be able to:

1. **Recognize** the importance of mathematical basics in implementation of numerical methods and error analysis in the implementation of numerical methods.
2. **Apply** direct/iterative methods to solve algebraic and transcendental equations as well as simultaneous equations and **write** computer algorithms to these methods.
3. **Write** interpolation formulae for equally spaced and unequally spaced points and **use** linear and polynomial regression for curve fitting.
4. **Use** numerical methods for differentiation and integration of functions for which the differentiation and integration using closed form formula of calculus is difficult.
5. **Predict** numerical solution of ordinary and partial differential equations.

Lesson Plan

Unit-1

1 **Review of Mathematical Foundation**- physical meaning of derivatives and integrals, Taylor series expansion.
2 Definition of matrix and vectors, Matrix summation and subtraction.
3 Multiplication of matrix, matrix transpose, determinant.
4 Matrix inversion and rank of a matrix.
5 Errors in numerical calculations- Introduction, numbers and their accuracy.
6 Errors and their analysis, absolute, relative and percentage errors.
7 General error formula, errors in series approximation.
8 Computer Arithmetic- Introduction, floating point representation of numbers.
9 Arithmetic operations with normalized floating point numbers-addition, subtraction, multiplication and division.
10 Some pitfalls in computing-examples.

Unit-2

1 **Solution of Algebraic and Transcendental Equations:** Introduction, Bisection method and its algorithm.
2 Method of false position and its algorithm.
3 Newton-Raphson method and its algorithm.
4 Secant method and its algorithm.
5 **Solution of Simultaneous Equations:** Introduction, Direct methods- Gauss elimination method and its algorithm.
6 Algorithms for Gauss elimination method.
7 Gauss elimination with row pivoting.
8 Iterative methods- Jacobi method.
9 Gauss-Seidel method and its algorithm. Comparison of direct and iterative methods.
10 Examples.

Unit-3

1 **Interpolation:** Introduction, Finite differences- difference operators and relation between them.
2 Forward differences, backward differences and central differences.
3 Newton's forward and backward interpolation formulae.
4 Difference formulae for unequal intervals- Lagrange's interpolation formula, difference tables.

5 Hermite's interpolation formula.
6 **Curve Fitting:** Introduction, Least-Squares approximation of function, Linear regression.
7 Algorithm for linear regression, Polynomial regression, examples.
8 Fitting exponential curve and sum of exponentials curve, examples.
9 Fitting hyperbola, trigonometric functions and a geometric curve.
10 Examples.

Unit-4

1 **Numerical Differentiation and Integration:** Introduction, differentiation formula derived from interpolation formulae.
2 Numerical integration- Trapezoidal rule.
3 Computer algorithm for Trapezoidal rule.
4 Simpson's 1/3 rule and its computer algorithms to integrate known functions.
5 Simson's 3/8 rule and its computer algorithms.
6 Boole's and Weddle's rules.
7 Newton-Cotes integration formula.
8 Gaussian quadrature formulae and its computer algorithm.
9 Examples.
10 Examples.

Unit-5

1 **Numerical Solution of Differential Equations:** Numerical solution of ordinary differential equations-Introduction, Taylor series method.
2 Picard's method and Euler's method.
3 Modified Euler's method, examples on Euler's method.
4 Runge-Kutta methods, Runge-Kutta fourth order formula, algorithm for Runge-Kutta method.
5 Examples on Runge-Kutta methods.
6 Predictor-Corrector method and its algorithm.
7 Examples on Predictor-Corrector method.
8 Numerical solution of partial differential equations- Introduction, Finite difference approximation of partial derivatives.
9 Solution of Laplace equations by Jacobi's method.
10 Gauss-Seidel method, Examples.
11 Successive Over-Relaxation method.
12 Examples.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Recognize the importance of mathematical basics in implementation of numerical methods and error analysis in the implementation of numerical methods.	2	2	-	2	-							1	1	
Apply direct/iterative methods to solve algebraic and transcendental equations as well as simultaneous equations and **write** computer algorithms to these methods.	3	3	-	2	1							2	2	
Write interpolation formulae for equally spaced and unequally spaced points and **use** linear and polynomial regression for curve fitting.	3	3	-	2	2							2	3	2
Use numerical methods for differentiation and integration of functions for which the differentiation and integration using closed form formula of calculus is difficult.	3	3	-	3	2							3	3	
Predict numerical solution of ordinary and partial differential equations.	3	3	-	3	2							3	3	

Prerequisites & Equivalents for Courses of 2015-16

Sl. No.	Prerequisites Course 2015-16		Course of Regulations 2015-16		Equivalent Course for 2013-14	
	Code	Title	Code	Title	Code	Title
1	P15MA11/21/31/41	Engineering Mathematics – I to IV	P15ME564	Numerical Analysis & Algorithms	---	---
2	P15CS13/23	Computer Concept & C Programming				

Course Title: Machine Shop			
Course Code: P15MEL57	**Sem: 05**	**L-T-P-H : 0:0:3:3**	**Credit: 1.5**
Contact Period: Practical: 36 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Knowledge of Manufacturing process-I (P15ME34) and Manufacturing process-II (P15ME46).

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. **Production Technology**: HMT.

Course Outcomes

At the end of the course the students should be able to:

1. **Prepare** a model by executing machining operations such as plain turning, Taper turning, Step turning, facing, Knurling, Eccentric turning using lathe.
2. **Perform** cutting of gear teeth using milling Machine.
3. **Perform** cutting of v-groove/rectangular/dovetail groove using shaping machine.
4. **Demonstrate** Surface Grinding.

Evaluation Scheme					
Scheme	**Weightage**	**Marks**	**Event Break Up**		
CIE	50%	50	**Test**	**Record**	**Seminar/viva**
			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**

Course Articulation Matrix

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
Prepare a model by executing machining operations such as plain turning, Taper turning, Step turning, facing, Knurling, Eccentric turning using lathe.	3	1	1							1		1	1	
Perform cutting of gear teeth using milling Machine.	3	1	1							1		1	1	
Perform cutting of v-groove/rectangular/dovetail groove using shaping machine.	3	1	1							1		1	1	
Demonstrate Surface Grinding.	3	1	1							1		1	1	

Prerequisites & Equivalents for Courses of 2015-16

Sl. No.	Prerequisites Course 2015-16		Course of Regulations 2015-16		Equivalent Course for 2013-14	
	Code	Title	Code	Title	Code	Title
1	P15ME34	Manufacturing process-I	P15MEL57	Machine shop	P13MEL57	Machine shop
2	P15ME46	Manufacturing process-II				

Course Title: I C Engines and Fluid Machinery Lab			
Course Code: P15MEL58	**Sem: 05**	**L –T-P-H: 0:0:3:3**	**Credit: 1.5**
Contact Period: Lecture: 36 Hrs, Exam: 3Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Knowledge of Fluid Mechanics (P15ME33) and Basic Thermodynamics (P15ME35).

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

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.

Course Outcomes

At the end of the course the students should be able to:

1 **Carry out** performance test on I.C.Engines.
2 **Determine** the performance of turbomachines such as Pelton wheel, Centrifugal pump and Centrifugal blower.
3 **Determine** the performance of reciprocating pumps and compressor.
4 **Function** effectively as a member of a team.
5 **Prepare** and **present** clear and concisely written lab reports.

Evaluation Scheme					
Scheme	**Weightage**	**Marks**	**Event Break Up**		
CIE	50%	50	**Test**	**Record**	**Seminar/Mini Project**
			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**

Course Articulation Matrix

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
Carry out performance test on I. C. Engines.	1	2	1	2										
Determine the performance of turbomachines such as Pelton wheel, Centrifugal pump and Centrifugal blower.	1	2	1	2										
Determine the performance of reciprocating pumps and compressor.	1	2	1	2										
Function effectively as a member of a team.									2					
Prepare and **present** clear and concisely written lab reports.										2				

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME33	Fluid Mechanics	P15MEL58	Fluid Machinery & I C Engine Lab	P13MEL48/ P13MEL58	Fluid Machinery Laboratory/ E. C. lab
2	P15ME35	Basic Thermodynamics				

Course Title : Aptitude and Reasoning Development - Advanced (ARDA)		
Course Code : P15HU510	Semester : 5	L : T : P : H : 0 : 0 : 2 :2
Contact Period: Lecture: 32 Hr, Exam: 3 Hr		Weightage: CIE:50;% SEE:50%
Prerequisites: Vocabulary builder, Concept of Percentage.		

Course Learning Objectives (CLOs)

This course aims to

1. Describe the importance of reading with comprehension.
2. Explain seven dimensions approach to better reading skills.
3. Explain the purpose, plan and the ways to identify specific details in a paragraph for better comprehension.
4. Formulate easier ways to solve problems of averages.
5. Explain the Application of the technique of alligation while solving weighted average and mixture problems.
6. Describe the concepts of profit, loss, discount, Marked price.
7. Explain the application of percentage in our daily life.
8. Discover different ways to identify the progressions and to compare between AP< GP and HP.
9. Explain the basic concepts in calculating simple interest and compound interest.
10. Differentiate between simple interest and compound interest and describes the importance of compound interest and its behaviour.

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. **10 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

Profit and Loss: percentage change, original 100 concept effect of percentage increase or decrease in number, effect of successive percentage change, amount of change, comparison of two numbers through percentage and ratio, return to original concept, net percentage change to keep product fixed. Definition of basic terms— cost price, selling price, profit percentage, discount and marked price, solving problems using n/d method, techniques to tackle from standard set of problems, the concept of mark up. Concept of partnership and problems involving partnership **6 Hrs**

Unit IV

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 **6 Hrs**

Unit V

Simple Interest and Compound Interest

Concept of time value of money, Terminology pertaining to interest, Relation among Principal, Time, Rate percent per annum and total interest. Compound interest, Depreciation of value, Population, Application of interest in D.I.– The difference between simple annual growth rate and compound annual growth rate. **4 hrs**

Reference books:

1. The Trachtenberg speed system of basic mathematics, published by Rupa publications.
2. CAT Mathematics by AbhijithGuha. 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.

Course Outcomes (CO)

After learning all the units of the course, the student is able to:

1. Apply the approach of seven dimension to better reading skills. L2
2. Solve the questions under reading comprehension confidently with higher accuracy than random reading. L4
3. Apply the technique of alligation for effective problem solving. L2
4. Interpret the requirement of different methods of calculating average and apply the right method at right scenario. L4
5. Effectively solve problems of profit and loss and problems related to discount, simple interest and compound interest. L5
6. Formulate the equations for summation and other functions for all the kinds of progressions– AP, GP and HP. L1

T L O

After learning all the topics of UNIT -1, the student is able to

1. Explain the importance of reading skills. L1
2. Interpret the importance of vocabulary in solving Reading comprehension questions. L4
3. Identify the main idea and supporting details in the paragraph. L2
4. Identify purpose and tone of the author.L2
5. Interpret the use of transition and idea organization pattern. L4
6. Recognize and evaluate arguments and their common structures. L1
7. Solve RC questions methodologically.L5
8. Classify types of questions asked in the RC passages. L2
9. Apply flow chart or mind map to solve RC questions. L4

After learning all the topics of UNIT- 2, the student is able to

1. Analyze the properties of average and apply them in the right scenarios.L5
2. Apply the mean deviation method in certain set of questions. L2
3. Distinguish between the usage of simple average and weighted average.L1
4. Apply weighted average concept and formula to solve the problems of mixtures.L2
5. Compare the weighted average method with the alligation method and understand their strengths and limitations. L4
6. Apply the technique of alligation to solve problems in very less duration of time. L2

7. Understand the concept of homogeneity and other properties of mixtures. L4
8. Apply the basic properties of mixtures while solving the problems under the concept of removal and replacement. L2
9. Extend the application of alligation technique to solve the problems of other topics such as Profit and loss, time speed and distance, ratio and comparison etc. L6

After learning all the topics of UNIT -3, the student is able to

1. Define the meaning of basic terms such as Profit, loss, Profit percentage, Loss percentage. L1
2. Understand the meaning of Discount, Discount percentage, Marked price and mark up percentage and explain them. L4
3. Describe the importance of percentage in this chapter and combine the concepts of percentage to simplify the methodology of solving. L4
4. Apply n/d technique the solve the problems efficiently. L2
5. Apply the percentage fraction table for simplification.L2
6. Extend the application of n/d technique in other areas of aptitude where concept of product constancy is involved. L2
7. Solve the problems involving discount and discount percentage.L5
8. Formulate the mark up concept and apply it for better problem solving. L4
9. Apply the knowledge of Profit and loss, discount, discount percentage in day-to-day life.L2
10. Understand the factors to be considered during partnership and solve the solve the problems under partnership. L4

After learning all the topics of UNIT -4, the student is able to

1. Interpret the series of numbers in Arithmetic, Geometric and Harmonic Progression. L1
2. Summarize the basic concepts of progressions, i.e., arithmetic mean, nth term of a progression. L6
3. Predict the missing terms of the given progression. L5
4. Compare AM, HM and GM. L4
5. Compute the sum or product of n terms in the given progression. L4
6. Differentiate between increasing and decreasing progression and solve application based problems accordingly. L1
7. Understand the theorems governing progressions. L4
8. Identify the similarity and difference between AP, HP and GP. L1
9. Analyze application problems involving combination of concepts of AP, HP and GP or all the three. L5
10. Create own problems based on creative progressive patterns and it's combinations. L6
11. Solve problems based on average speed using concept of HP and AP. L6

After learning all the topics of UNIT -5, the student is able to

1. Recognize the concept of money and time, their relation and interdependency with respect to banking. L1
2. Outline the meaning of Principal, Time, Rate of Interest and Interest earned, and also their relation with one another. L1
3. Interpret the importance of CI in day to day life. L3
4. Illustrate the concept of Interest earned. L2
5. Distinguish between the types of interests.ie, Simple and Compound Interests.L4
6. Understand the difference between Simple and Compound annual growth.L4
7. Compute problems based on Simple Interests, Compound Interests and combination of both.L4
8. Solve application problems based on depreciation value, population of a city etc. L2
9. Apply various concepts of Percentages, Ratio, Algebra, HCF and LCM to solve application based problems. L2
10. Construct own questions involving multiple concepts ranging different difficult levels. L5
11. Solve MCQs faster by application of shortcut methods of Vedic Mathematics to find squares, cubes and roots. L5

A. Course Assessment Matrix (CaM)															
Course Outcome (CO)	**Program Outcome (ABET/NBA-(3a-k))**														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
Apply the approach of seven dimension to better reading skills.	L2	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Solve the questions under reading comprehension confidently with higher accuracy than random reading.	L4	-	-	-	-	-	-	2	-	2	-	-	-	-	-
Apply the technique of alligation for effective problem solving.	L2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Interpret the requirement of different methods of calculating average and apply the right method at right scenario.	L4	2	-	-	-	-	-	-	-	2	-	-	-	-	-
Effectively solve problems of profit and loss and problems related to discount, simple interest and compound interest.	L5	3	-	-	-	-	-	-	-	2	-	-	-	-	-

Course Title: Design of Machine Elements-II			
Course Code: P15ME61	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Kinematics of Machines (P15ME45) and Design of Machine Elements I (P15ME52).

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**

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**

Unit-3

Spur, helical, Bevel and worm 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. Worm Gears- terminology, design based on strength, dynamic, wear loads and efficiency of worm gear drives. **12 Hrs**

Unit-4

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. **08 Hrs**

Unit-5

Sliding and rolling contact 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, dynamic load rating, bearing life, selection of ball and roller bearings. **12 Hrs**

Design data hand book:

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

Text books

1. **Richard G Budynas** and **Keith J Nisbett**, "**Shigley's Mechanical Engineering Design,"** McGraw Hill Education, 9th Edition, 2011, ISBN: 9780071077835.
2. V. B. Bhandari, "**Design of Machine Elements,"** Tata McGraw Hill Publishing Company Ltd., New Delhi, 4th Edition 2016, ISBN: 9789339221126.

References

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 Rajendra Karwa, "**A text book of Machine Design,"** Laxmi Publications, 2nd Edition, 2006, ISBN: 9788170088332.

Course Outcomes

At the end of the course the students should be able to:

1. **Design** curved beams**,** helical and leaf springs, with an understanding of safety issues related to springs.
2. **Determine** stresses in cylindrical pressure vessels with different types of fits. **Recognize** safety aspects related to pressure vessels.
3. **Design** spur, helical, bevel and worm gears.
4. **Design** simple clutches and brakes, with an understanding of safety issues related to brakes.
5. **Design** sliding and rolling contact bearings.

Lesson Plan

Unit-1

1 Curved beams-Introduction, difference between curved and straight beams, stresses in curved beam.
2 Numericals on design of curved beams.
3 Springs-Introduction, types of springs, terminology
4 Derivation of equations for stress induced in helical springs and deflection
5 Design of springs under static and dynamic loads
6 Numerical problems
7 Numerical problems
8 Laminated springs - equations for stress induced and deflection
9 Pre-stressing of leaf springs, equalized stresses
10 Numerical problems

Unit-2

1 Introduction to pressure vessels, stresses in thick cylinders
2 Lame's equation
3 Clavarino's and Birnie's equations
4 Design of thick cylinders with internal and external pressure
5 Numerical problems
6 Numerical problems
7 Compound cylinders, stresses due to different types of fits, Autofrettage
8 Numerical problems
9 Design of cover plates
10 Numerical problems

Unit-3

1 Introduction, classification of gears, standard proportions of gear systems.
2 Stresses in gear tooth, Derivation of Lewis equation
3 Design of spur gears based on strength, dynamic load and wear load
4 Numerical problems
5 Numerical problems
6 Helical Gears – introduction, formative number of teeth
7 Design of helical gears based on strength, dynamic load and wear load
8 Bevel Gears - terminology, formative number of teeth
9 Design of bevel gears based on strength, dynamic load and wear load
10 Worm Gears – terminology, design procedure
11 Numerical problems
12 Numerical problems

Unit-4

1 Introduction, working principle, types of clutches
2 Uniform pressure theory, Uniform wear theory
3 Design of single plate clutch and multi plateclutch .
4 Design of cone clutch.

5 Numerical problems
6 Introduction to brakes, classification of brakes.
7 Design of block brakes and band brakes
8 Numerical problems

Unit-5

1 Introduction, principle of hydrodynamic lubrication, assumptions in hydrodynamic lubrication
2 Derivation of Petroff's equation for coefficient of friction
3 Bearing characteristic number and modulus, Sommerfeld number
4 Power loss, heat Generated and heat dissipated in journal bearings, design of journal bearings
5 Numerical problems
6 Numerical problems
7 Numerical problems
8 Rolling contact bearings - types of bearings, static equivalent load, dynamic load rating, bearing life.
9 Method of selection of rolling element Bearings
10 Numerical problems
11 Numerical problems
12 Numerical problems

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Design curved beams**,** helical and leaf springs, with an understanding of safety issues related to springs.	3	2	2			2							2	
Determine stresses in cylindrical pressure vessels with different types of fits. **Recognize** safety aspects related to pressure vessels.	3	3	3	1		2							2	
Design spur, helical, bevel and worm gears.	3	3	3	1									2	
Design simple clutches and brakes, with an understanding of safety issues related to brakes.	3	2	3			2							2	
Design sliding and rolling contact bearings.	3	3	3	3								2	2	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME45	Kinematics of Machines	P15ME61	Design of Machine Elements II	P13ME61	Design of Machine Elements II
2	P15ME52	Design of Machine Elements I				

Course Title: Mechanical Vibrations			
Course Code: P15ME62	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Engineering Physics (P15PH12), Engineering Mechanics (P15CV13) and Mechanics of Materials (P15ME44)

Course objective: The course aims at enabling the students to synthesize their knowledge of engineering science and mathematics to formulate the solutions of mechanical vibratory systems.

Course Content

Unit-1

Undamped Free Vibrations: Introduction, basic concepts of vibration, Simple harmonic motion, types of vibration, elements of vibrating system, Single degree of freedom systems, determination of natural frequency using Newton's law and energy methods. **Damped Free Vibrations:** Introduction, types of damping, free vibrations with viscous damping, under-damped, over-damped and critically-damped systems, logarithmic decrement. **12 hrs**

Unit-2

Forced Vibrations: Introduction, forced vibration with constant harmonic excitation, steady state vibrations, forced vibration with rotating and reciprocating unbalance. Vibration isolation, force transmissibility. Forced vibrations due to excitation of the support: Absolute motion and relative motion. **10 hrs**

Unit-3

Vibration measuring instruments: Vibrometer, velocity pick-up and accelerometer**. Whirling of Shafts:** Introduction, critical speed of a light shaft having a single disc without damping, critical speed of a light shaft having a single disc with damping. **Fourier Series and Harmonic Analysis:** Analytical methods and numerical methods. **08 hrs**

Unit-4

Two Degrees of Freedom Systems: Introduction, undamped systems, principle and normal modes of vibration, co-ordinate coupling, generalized and principal co-ordinates, free vibration in terms of initial conditions, combined rectilinear and angular modes, undamped dynamic vibration absorber (No numerical on vibration absorber). Influence coefficients, Maxwell's reciprocal theorem. **10 hrs**

Unit-5

Multi Degree Freedom Systems: Introduction, determination of natural frequencies, Rayleigh's method, Dunkerley's method, Stodola's method, Holzer's method. orthogonality principle, matrix iteration method. **12 hrs**

Text books

1. G.K. Grover, **"Mechanical vibrations,"** Nem Chand & Brothers, 8th edition, 1st Jan, 2009, ISBN: 9788185240565.
2. V.P. Singh, **"Mechanical Vibrations,"** Dhanpat Rai & Company Pvt. Ltd., 2016, ISBN: 978-8177004014.

References

1. Singiresu S Rao, **"Mechanical Vibrations,"** Pearson Education India, 4th edition, 2003, ISBN: 978-8177588743.
2. S. Graham Kelly, Schaum's Outline Series, "**Mechanical Vibrations,"** Tata McGraw Hill, Special Indian edition, 2007, ISBN: 9780070616790.
3. J.S. Rao & K. Gupta, **"Theory & Practice of Mechanical vibrations,"** New Age International Publications, New Delhi, 2001, ISBN: 9788122404425.
4. Leonanrd Meirovitch, **"Elements of Vibrations Analysis,"** Tata McGraw Hill, Special Indian edition, 2007, ISBN: 81-7700-047-0.
5. Austin H Church, **"Mechanical Vibrations,"** John Wiley & Sons, ISBN: 978-1114187887.

Course Outcomes

At the end of the course the students should be able to:

1. **Formulate** mathematical models of single degree of freedom damped and undamped free vibratory systems and **determine** their natural frequencies.
2. **Analyze** the response of simple single degree of freedom systems subjected to forced vibration.
3. **Explain** the working principle of vibration measuring instruments. **Determine** the whirling speed of shafts and harmonics of general forcing functions using Fourier series.
4. **Formulate** mathematical models and **determine** natural frequencies and corresponding mode shapes of two degrees of freedom systems.
5. **Use** numerical methods to **solve** multi degree of freedom systems for their natural frequencies and mode shapes.

Lesson Plan

Unit-1

1 Introduction to mechanical vibration causes of vibration, effects of vibration, basic concepts of vibration, Simple harmonic motion, types of vibration.
2 Elements of vibrating system, definition of the terms: periodic motion, time period, frequency, amplitude, natural frequency, resonance, damping and degree of freedom, etc.
3 Single degree of freedom systems, determination of natural frequency using Newton's law and energy methods.
4 Numerical problems on determination of natural frequency/time period of single dof systems.
5 Numerical problems on determination of natural frequency/time period of single dof systems.
6 Numerical problems on determination of natural frequency/time period of single dof systems.
7 Introduction to damped free vibration, types of damping, derivation of governing differential equation of motion of spring-mass-damper system.
8 Solution of governing differential equation of under damped, critical damped and over damped systems.
9 Logarithmic decrement and Derivation of expressions for the logarithmic decrement.
10 Numerical problems.
11 Numerical problems.
12 Numerical problems.

Unit-2

1 Introduction to forced vibration, Derivation of expression for equation of motion of a spring-mass-damper subjected to harmonic excitation.
2 Magnification factor and its variation with frequency ratio, Phase angle and its variation with frequency.
3 Derivation of expression for steady state amplitude of spring-mass-damped system subjected to rotating and reciprocating unbalance.
4 Vibration isolation-force and motion isolation, derivation of expression for force transmissibility.
5 Derivation of expression for force transmissibility.
6 Derivation of expression for motion transmissibility- absolute and relative motion.
7 Numerical problems
8 Numerical problems
9 Numerical problems
10 Numerical problems

Unit-3

1 Introduction to vibration measuring instruments, Seismic instrument, working principles of vibrometer and accelerometer.
2 Numerical problems

3 Numerical problems
4 Introduction to whirling of shafts, critical speed of a light shaft having a single disc without damping, critical speed of a light shaft having a single disc with damping.
5 Numerical problems
6 Numerical problems
7 Introduction to Fourier series and Harmonic analysis.
8 Examples on representation of periodic motion into harmonic series.

Unit-4

1 Introduction to Two degree of freedom system, generalized and principal co-ordinates, principle and normal modes of vibration, coordinate coupling.
2 Determination of natural frequencies and mode shape for spring-mass system.
3 Derivation of equation of motion of undamped-free vibration of two dof system in terms of initial conditions.
4 Determination of natural frequencies and mode shape for double pendulum and string problems.
5 Natural frequencies of a system having combined rectilinear and angular modes.
6 Introduction to undamped vibration absorber.
7 Example problems on determination of natural frequencies and mode shapes.
8 Example problems on determination of natural frequencies and mode shapes.
9 Introduction to influence coefficients, Maxwell's reciprocal theorem.
10 Example problems on determination of influence coefficients.

Unit-5

1 Introduction to multi-degree of freedom systems, Numerical methods in the determination of natural frequencies of multi-dof systems, Rayleigh's method.
2 Dunkerley's method, Example problems on determination of fundamental natural frequency using Rayleigh's and Dunkerley's methods.
3 Introduction to Stodola's method, an example problem on determination of fundamental natural frequency using Stodola's method.
4 Example problems on determination of fundamental natural frequency using Stodola's method.
5 Introduction to Holzer's method, an example problem on determination of natural frequencies using Holzer's method.
6 Example problem on determination of natural frequencies using Holzer's method.
7 Example problem on determination of natural frequencies using Holzer's method.
8 Example problem on determination of natural frequencies using Holzer's method.
9 Introduction to orthogonality principle, formation of equation of motion in terms of influence coefficients, Matrix iteration method.
10 Example problem on determination of natural frequencies using matrix iteration method.
11 Example problem on determination of natural frequencies using matrix iteration method.
12 Example problem on determination of natural frequencies using matrix iteration method.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Formulate mathematical models of single degree of freedom damped and undamped free vibratory systems and **determine** their natural frequencies.	3	3	2	2		1							3	
Analyze the response of simple single degree of freedom systems subjected to forced vibration.	3	3	3	2		2						2	3	
Explain the working principle of vibration measuring instruments. **Determine** the whirling speed of shafts and harmonics of general forcing functions using Fourier series.	3	3	3	2		2							3	
Formulate mathematical models and **determine** natural frequencies and corresponding mode shapes of two degrees of freedom systems.	3	3	3	2		2							2	
Use numerical methods to **solve** multi degree of freedom systems for their natural frequencies and mode shapes.	3	3	3	3		2						2	3	

Prerequisites & Equivalents for Courses of 2015-16

Sl. No.	Prerequisites Course 2015-16		Course of Regulations 2015-16		Equivalent Course for 2013-14	
	Code	Title	Code	Title	Code	Title
1	P15PH12	Engineering Physics	P15ME62	Mechanical Vibrations	P13ME62	Mechanical Vibrations
2	P15CV13	Engineering Mechanics				
3	P15ME44	Mechanics of Materials				

Course Title: Heat and Mass Transfer			
Course Code: P15ME63	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Basic Thermodynamics (P15ME35), Fluid Mechanics (P15ME33) and Engineering Mathematics (P15MA31)

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, hallow cylinder, hallow 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**

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**

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**

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

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**

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.

References

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.

Course Outcomes

At the end of the course the students should be able to:

1. **Understand** the fundamentals of three heat transfer modes and **formulate** governing differential equation to solve problems of one-dimensional steady state conduction heat transfer problems, with focus on fin design.
2. **Solve** one dimensional steady state and transient heat conduction problems considering heat generation and variable thermal conductivity.
3. **Understand** the concepts of convection heat transfer and solve related problems using both analytical and empirical approaches.
4. **Demonstrate** fundamentals of radiation heat transfer problems.
5. **Apply** the heat transfer basics to design heat exchanger and understand the concept of condensation and boiling of liquids.

Lesson Plan

Unit-1

1 Modes of heat transfer , Basic laws governing conduction, convection and radiation
2 3D heat conduction equation in Cartesian coordinate system , Laplace, Fourier, Poisons heat conduction equation
3 Discussion on heat conduction equation in spherical and cylindrical coordinate system
4 Boundary and initial conditions, Numerical Problems
5 One dimensional steady state conduction in slab and composite slab
6 One dimensional steady state conduction in cylinder and composite cylinder
7 One dimensional steady state conduction in Sphere and composite Sphere
8 Critical thickness of insulation,
9 Extended surface heat transfer (FINS), general governing differential equation
1 Equation for long fin, short fin with end insulated, short fin with free convection
10 Numerical Problems
11 Numerical Problems
12 Numerical Problems

Unit-2

1 Conduction with thermal energy generation in slab
2 Temperature effect on thermal conductivity in slab
3 Transient conduction: lumped capacity, Biot and Fourier numbers
4 One-dimensional transient conduction in slab with convection
5 One-dimensional transient conduction in cylinder with convection
6 One-dimensional transient conduction in sphere with convection
7 Semi-infinite solids, Use of Heisler Chart solution
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-3

1 Flow over a body, velocity and thermal boundary layers, critical Renold's number
2 Drag-co-efficient and heat transfer coefficient. significance of Reynolds, Prandtl and Nusselt and Grashoff numbers;
3 Dimensional analysis applied to Free and forced convection

4 Free convection heat transfer from vertical surface and vertical cylinder, horizontal surface and horizontal cylinders
5 Use of various correlations in forced convection heat transfer, flow over a flat plate, and flow across a single cylinder and tube bundles, flow through tubes and ducts.
6 Numerical Problems
7 Numerical Problems
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-4

1 Introduction- absorption, reflection &transmission of radiation,
2 Black and grey body concept
3 Kirchoff's law, Lambert's Cosine Law, Stefan-Boltzman's law,
4 Plank's distribution law, Wein's displacement law,
5 Radiation heat exchange between two parallel plates, radiation shielding,
6 Radiation heat exchange in an enclosure,
7 Hottel’s cross string formula
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-5

1 Classification of heat exchangers overall heat transfer coefficient, fouling and fouling factor
2 LMTD methods of analysis of heat exchangers
3 Numerical Problems
4 effectiveness- NTU methods of analysis of heat exchangers
5 Numerical Problems
6 Numerical Problems
7 Numerical Problems
8 Types of condensation Nusselt’s theory for laminar condensation on a vertical flat surface
9 Regimes of pool boiling
10 Mass transfer concept and Fick’s law of diffusion (no numerical)

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Understand fundamentals of three heat transfer modes and **formulate** governing differential equation to solve problems of one-dimensional steady state conduction heat transfer problems, with focus on fin design.	2	1	1	1						1		1	1	
Solve one dimensional steady state and transient heat conduction problems considering heat generation and variable thermal conductivity.	3	2	2	2						1		2	2	
Understand the concepts of convection heat transfer and solve related problems using both analytical and empirical approaches	3	2	2	2						1		2	2	
Demonstrate fundamentals of radiation heat transfer problems.	3	2	1	1						1		1	1	
Apply the heat transfer basics to design heat exchanger and understand the concept of condensation and boiling of liquids.	3	2	2	2						1		3	2	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME35	Basic Thermodynamics	P15ME63	Heat And Mass Transfer	P13ME63	Heat And Mass Transfer
2	P15ME33	Fluid Mechanics				
3	P15MA31	Engineering Mathematics				

Course Title: Finite Element Methods			
Course Code: P15ME64	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Engineering Mathematics– I & II (P13MA11/21) and Mechanics of Materials (P13ME33)

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**

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. **10Hrs**

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, special characteristics of stiffness matrix, Treatment of boundary conditions- elimination and penalty methods. Analysis of axially loaded uniformly tapered and stepped bars. **12 Hrs**

Unit-4

ANALYSIS OF PLANE TRUSSES AND BEAMS: Local and global coordinate systems, 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**

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**

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.

References

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.

Course Outcomes

At the end of the course the students should be able to:

1. **Understand** the basic concepts and mathematical preliminaries of FEM required to solve basic field problems.
2. **Develop** interpolation models for 1D and 2D elements that satisfy convergence criteria and geometric isotropy and **use** isoparametric concept in the finite element analysis.
3. **Formulate** element stiffness matrices and load vectors for different elements using variational principle and **analyze** axially loaded bars.
4. **Use** finite element formulations in the **determination** of stresses, strains and reactions of trusses and transversely loaded beams.
5. **Formulate** finite element equations for heat transfer problems using Variational and Galerkin techniques and **apply** these models to **analyze** conduction and convection heat transfer problems.

Lesson Plan

Unit-1

1 Need for use of FEM, Advantages and disadvantages of FEM, Engineering Applications of FEM, Steps involved in FEM
2 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.
3 Gauss elimination method, numericals
4 Numericals
5 Numerical integration by Gaussian quadrature (one point and two point formula).
6 Numericals
7 Numericals
8 Basic elastic equations – body force and traction force, strain-displacement relations.
9 Basic elastic equations – contd.
10 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.

Unit-2

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

9 Jacobian matrix for CST
10 Numericals

Unit-3

1 Strain displacement matrix, Stiffness matrix for 1D bar element–Cartesian coordinates.
2 Strain displacement matrix, Stiffness matrix for 1D quadratic bar element – Natural coordinates.
3 Load vectors for 1D linear bar element.
4 Load vectors for 1D quadratic bar element.
5 Strain displacement matrix, Stiffness matrix for CST element.
6 Load vectors for CST element.
7 Assembly of elements by direct stiffness method, special characteristics of stiffness matrix.
8 Treatment of boundary conditions- elimination method and penalty method.
9 Analysis of axially loaded bars.
10 Numericals
11 Numericals
12 Numericals

Unit-4

1 Local and global coordinate systems, stiffness matrix for plane truss element.
2 Numericals
3 Numericals
4 Numericals
5 Shape functions for beam element.
6 Stiffness matrix and load vectors for beam element.
7 Element shear force and bending moment diagrams for beam element.
8 Numericals
9 Numericals
10 Numericals

Unit-5

1 Steady state heat transfer, 1D heat conduction- governing equation, boundary conditions.
2 1D heat transfer element, shape functions, gradient heat flux relations.
3 Element conduction matrix by functional approach.
4 Element conduction matrix by Galerkin's method.
5 Load vectors.
6 Numericals with conduction through composite walls.
7 Numericals with conduction and convection from thin fins.
8 Numericals with heat generation.
9 Numericals.
10 Numericals.

Course Articulation Matrix

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

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15MA11/21	Engineering Mathematics – I & II	P15ME64	Finite Element Methods	P13ME64	Finite Element Methods
2	P15ME44	Mechanics of Materials				

Course Title: Theory of Elasticity			
Course Code: P15ME651	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Engineering Mathematics – I & II (P15MA11/21), Engineering Mechanics (P15CV13) and Mechanics of Materials (P15ME44)

Course objective: The course aims at enabling the students to understand the mathematical and physical principles of Elasticity, with different solution strategies while applying them to practical cases.

Course Content

Unit-1

Stress Analysis: Introduction to the general theory of elasticity, assumptions and applications of linear elasticity. Stress tensors, state of stress at a point, principal stresses, direction cosines, stress invariants, equilibrium equations in Cartesian coordinate & cylindrical coordinate, Mohr's stress circle and construction of Mohr Circle for 2D stress systems. **10Hrs**

Unit-2

Strain Analysis: Deformation, strain-displacement relation, strain components, The state of strain at a point, principal strains, strain invariants, Equations of Compatibility for Strain, cubical dilation. **08Hrs**

Unit-3

Stress–Strain Relations: Generalized Hooke's law in terms of engineering constants. Existence and uniqueness of solution, Saint Venant's principle, principle of superposition, Prandtl's membrane analogy, Kirchoff's law, Fundamental boundary value problems, Inverse and Semi-inverse method of solving elasticity problems. General case of Plane stress and Plane strain, transformation of compatibility condition from strain component to stress components. Relation between plane stress and plane strain. **10Hrs**

Unit-4

2D Problems in Cartesian Coordinates: Airy stress function, stress function for plane stress and plane strain case. Investigation for simple beam problems. Bending of narrow cantilever under end load, simply supported beam with uniform load by the use of polynomials. **Torsion** of circular and elliptical bars, stress function, torsion of thin walled and multiple cell closed sections. **12Hrs**

Unit-5

General Equations in Cylindrical coordinate: Thick cylinder under uniform internal and / or external pressure, stresses in composite tubes. Sphere with purely radial displacements, problem of thick hollow sphere.

Thermal Stresses: Thermo elastic stress strain relationship, equations of equilibrium, thermal stresses in thin circular disks and in long circular cylinder, problem of a sphere. **12Hrs**

Text books

1. Timoshenko and Goodier, **"Theory of Elasticity,"** McGraw Hill Book Company, 3rd edition, 2nd February 2010, ISBN: 978-0070701229.
2. L S Srinath, **"Advanced Mechanics of Solids,"** McGraw Hill Book Company, 3rd edition, 26th June 2008, ISBN: 978-0070139886.

References

1. Sadhu Singh, **"Theory of Elasticity,"** Khanna publisher, 2012, ISBN: 8174090606.
2. Wang. C. T, **"Applied Elasticity,"** McGraw-Hill Inc., US 1st December 1963, ISBN: 978-0070681255.
3. T.G.Sitharam. Govindraju, **"Applied Elasticity,"** Interline publishing Pvt. Ltd., ISBN: 9788172960834.
4. Arthur P Boresi and Richard J Schmidt, **"Advanced Mechanics of Materials,"** John Wiley & Sons; 6th Revised edition, 12th November 2002, ISBN: 978-0471438816.

Course Outcomes

At the end of the course the students should be able to:

1. **Understand** the basic concept of solid mechanics and **calculate** the state of stress and principal stresses at a point.
2. **Explain** and **evaluate** the state of a strain and principal strains at a point.
3. **Describe** the stress-strain relations for 3D elastic body and plane stress and plane strain problems.
4. **Compute** and **analyze** bending and shear stresses, deflections induced in beams and torsional stresses of thin walled and multiple cell closed sections.
5. **Determine** stresses due to internal and external pressure for thick cylinders and thermal stresses for circular disk and long cylinder.

Lesson Plan

Unit-1

1 Introduction to the general theory of elasticity with assumptions and applications of linear elasticity
2 Stress tensors, State of stress at a point. 3D Equilibrium equation.
3 Problems on state of stress.
4 Problems on state of stress.
5 Principal stresses, direction cosines, stress invariants
6 Problems on Principal stresses
7 Problems on Principal stresses
8 Problems on Principal stresses
9 Mohr's stress circle and construction of Mohr Circle for two dimensional stress systems.
10 Problem on the Mohr Circle for two dimensional stress systems.

Unit-2

1 Deformation, strain-displacement relation, strain components.
2 The state of strain at a point and problems.
3 Problems on state of strain at a point.
4 Principal strains, strain invariants.
5 Problems on principal strains, strain invariants.
6 Problems on principal strains, strain invariants.
7 Equations of Compatibility.
8 Cubical dilation.

Unit-3

1 Generalized Hooke's law in terms of engineering constants.
2 Problems on Generalized Hooke's law.
3 Problems on Generalized Hooke's law.
4 Problems on Generalized Hooke's law.
5 Existence and uniqueness of solution, Saint Venant's principle
6 Principle of superposition, Prandtl's membrane analogy,
7 Kirchoff's law, Fundamental boundary value problems
8 Inverse and Semi inverse method of solving Elasticity problems.
9 General case of Plane stress and Plane strain.
10 Transformation of compatibility condition from strain component to stress components. Relation between plane stress and plane strain.

Unit-4

1 Airy stress function, Investigation for simple beam problems.
2 Bending of narrow cantilever under end load and problems.
3 Simply supported beam with uniform load and problems.
4 Numerical problems.
5 Torsion of circular bar.
6 Torsion of elliptical cross section.

7 Torsion of triangular cross section.
8 Numerical problems
9 Stress function, torsion of thin walled tubes.
10 Problems on torsion of thin walled tubes.
11 Torsion of multiple cell closed sections.
12 Problems Torsion of multiple cell closed sections.

Unit-5

1 Thick cylinder under uniform internal and / or external pressure
2 Thick cylinder under uniform internal and / or external pressure
3 Problems on Thick cylinder under uniform internal and / or external pressure
4 Problems on Thick cylinder under uniform internal and / or external pressure
5 Shrink fit and force fit.
6 Rotating disks of uniform thickness.
7 Problems on Rotating disks of uniform thickness,
8 Circular disk with a hole.
9 Stress concentration.
10 Problems on Circular disk with a hole.
11 Problems on Circular disk with a hole.
12 Problems on stress concentration.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Understand the basic concept of solid mechanics and **calculate** the state of stress and principal stresses at a point.	3	3	2		2	1						3	3	
Explain and **evaluate** the state of a strain and principal strains at a point.	3	3	2	1	2	1						3	3	
Describe the stress-strain relations for 3D elastic body and plane stress and plane strain problems.	3	3	3	2	3	1				2		3	3	
Compute and **analyze** bending and shear stresses, deflections induced in beams and torsional stresses of thin walled and multiple cell closed sections.	3	3	3	1	3	1				2		3	3	
Determine stresses due to internal and external pressure for thick cylinders and thermal stresses for circular disk and long cylinder.	3	3	3	1	3	1				2		3	3	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15MA11/21	Engineering Mathematics – I & II	P15ME651	Theory of Elasticity	P13ME661	Theory of Elasticity
2	P15CV13	Engineering Mechanics				
3	P15ME44	Mechanics of Materials				

Course Title: Refrigeration & Airconditioning			
Course Code: P15ME652	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Basic thermodynamics (P15ME35) and Heat and Mass transfer (P15ME63).

Course objective: The course aims at understanding the concept of

- Operation, application and analysis of the basic refrigeration cycles, refrigerant properties, and refrigeration components.
- Operation, application and design of Air conditioning systems

Course Content

Unit-1

Introduction - Unit of refrigeration, Refrigeration systems, Refrigeration cycles and concepts, Coefficient of Performance, Reversed Carnot cycle, Refrigeration system as heat pump, Air Refrigeration, Introduction to Steam Jet Refrigeration, vapour compression refrigeration, vapour absorption refrigeration and Solar refrigeration , Properties of refrigerants and their choice for different applications – Eco friendly refrigerant (no numericals). **10Hrs**

Unit-2

Performance Analysis of vapour Compression cycle, Ideal and actual conditions, Numerical Problems, Representation of cycle on p-h and T-S diagrams, Numerical problems **10Hrs**

Unit-3

Refrigeration equipment Compressors: Reciprocating, centrifugal, screw, open, hermetic and semi-hermetic units, Condensers: air and water cooled condensers, evaporative condensers, Evaporators: Double tube, Shell and Tube, Dry and flooded types, Expansion devices, Protection devices, High and Low pressure cut out Thermostat, solenoid valve **11Hrs**

Unit-4

Psychrometry of Air conditioning Processes - Adiabatic mixing, sensible cooling and heating, latent heat process, total heat process, sensible heat factor, By-pass factor, Cooling and Dehumidifying coil, heat coils, air washer, adiabatic dehumidifiers, water and steam injection - Problems on psychrometric processes. **10Hrs**

Unit-5

Air conditioning system – classification, Unitary, packaged and central type summer and winter air-conditioning systems, Description with sketches, merits and demerits, Comfort indices, Air purification, Air conditioning, Heat gain and load calculations, RSHF, GSHF and ESHF, Need for reheating. **11Hrs**

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.

References

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.

Course Outcomes

At the end of the course the students should be able to:

1. **Understand** the working of different refrigeration cycle and **Classify** types of refrigerants, its properties and its effect on environment.
2. **Analyze** the Performance of vapour compression cycle
3. **Appreciate** the various components, their working and design and **identify** about system balancing and controls involved in refrigeration units.

4. **Recognize** the various Psychrometric processes and the importance of P-h , T-S and Psychrometric charts in air conditioning system.
5. **Calculate** the cooling and heating load and **design** the Air-Conditioning systems.

Lesson Plan

Unit-1

1 Defination of refrigeration, refrigeration effect , Tons of refrigeration , COP, Applications of refrigeration and air conditioning system
2 The Carnot refrigeration cycle & its practical limitations.
3 Working of Standard Air Refrigeration System
4 Working of Steam Jet Refrigeration Refrigeration System
5 Working of vapour compression refrigeration System
6 Working of vapour absorption refrigeration System
7 Working of Solar refrigeration System
8 The criteria used in Selection and Classification of refrigerants
9 Nomenclature or designation of refrigerants
10 Desirable properties of refrigerants

Unit-2

1 Analysis of Standard Vapour compression Refrigeration System
2 Effects of evaporator and condensing pressure and temperature on system performance.
3 Effects of subcooling and superheating on COP and Capacity
4 Actual vapour compression refrigeration systems
5 Numerical Problems
6 Numerical Problems
7 Numerical Problems
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-3

1 Compressors: Principle, types of compressors,
2 Compressors Types and construction.
3 Compressors Types and construction, capacity control
4 Condensers: Types and construction,
5 Condensers: Types and construction
6 Condensers: Types and construction
7 Evaporators - Double tube, Shell and Tube,
8 Evaporators - Dry and flooded types Sizing Evaporator
9 Expansion devices: Types- Automatic expansion valve
10 Thermostatic expansion valves, capillary tube.
11 High and Low pressure cut out Thermostat, solenoid valve.

Unit-4

1 Review of Psychometric processes,
2 Review of Psychometric processes,
3 Adiabatic mixing, sensible cooling and heating
4 latent heat process, total heat process
5 sensible heat factor - By-pass factor
6 Cooling and Dehumidifying coil
7 heat coils, air washer adiabatic dehumidifiers,
8 Problems on psychrometric processes.
9 Problems on psychrometric processes.
10 Problems on psychrometric processes.

Unit-5

1 Introduction to air conditioning system
2 central type summer and winter air-conditioning systems -

3 Comfort chart
4 Design conditions: Outside design conditions, choice of inside conditions,
5 Heat gain and load calculations
6 Heat gain and load calculations
7 Cooling load estimate. Psychometric calculations for cooling.
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems
11 Numerical Problems

12 Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Understand the working of the different refrigeration cycle and **Classify** types of refrigerants, its properties and its effect on environment.	3	2	1	1						2		1	2	
Analyze the performance of vapour Compression cycle.	3	2	2	1						2		1	2	
Appreciate the various components, their working and design and **identify** about system balancing and controls involved in refrigeration units.	3	2	1	1						2		1	1	
Recognize the various Psychrometric processes and the importance of P-h , T-S and Psychrometric charts in air conditioning system.	3	2	1	1						2		1	1	
calculate the cooling and heating load and **design** the Air-Conditioning systems.	3	2	2	1						2		1	1	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME35	Basic thermodynamics	P15ME652	Refrigeration & Air conditioning	P13ME662	Refrigeration & Air conditioning
2	P15ME63	Heat and Mass transfer				

Course Title: Statistical Quality Control			
Course Code: P15ME653	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: Knowledge of Engineering Mathematics-IV (P15MAAC41).

Course objective: This course enables the students to understand the basic concepts and various available statistical tools of quality monitoring. It will also present the theory and methods of quality monitoring including process capability, control charts, acceptance sampling, quality engineering, and quality design.

Course Content

Unit-1

Introduction : Basic concepts of quality, Meaning and definition of quality, quality control, objectives of quality control, Quality Characteristics, Quality Costs, Quality of Design, Quality of conformance, optimum quality, Statistical quality control, objectives of Statistical quality control. **10 Hrs**

Unit-2

Basic Statistical Concepts: Concept of variation and its types, Variables and Attributes., Frequency distribution and its graphical representation- Frequency Polygon, Histogram, and Ogive, Central tendency and Measures of dispersion- Mean, Median, Mode, Range, and Standard deviation, Numerical Problems.

Probability and Probability Distributions: Theory of Probability Types of Probability distributions: Hypergeometric, Bi-nomial, Poisson and Normal distributions, Numerical Problems. **12 Hrs**

Unit-3

Control Charts For Variables : Theory and definition of control chart, control charts for X – bar and R charts, Type I and Type II errors, Numerical Problems.

Process Capability: Methods of calculating process capability, Natural Tolerance limits, process capability index $C_{P.}$ Numerical problems. **10 Hrs**

Unit-4

CONTROL CHARTS FOR ATTRIBUTES: Control charts for defects and defectives –p, np, c, and u charts and their applications, differences between control chart for variables, differences between p chart and c chart Numerical Problems. **10 Hrs**

Unit-5

ACCEPTANCE SAMPLING: Basis concepts, Sampling by attributes, single, double and multiple sampling plans, use of sampling table, Sequential sampling plan, construction and use of Operating Characteristic curves, Numerical problems. **10 Hrs**

Text books

1 E.L. Grant and R.S. Leavenworth, **"Statistical Quality Control,"** Tata McGraw Hill publishing Co. Ltd., New Delhi, 7th edition, 2005, ISBN: 9780070435551.

References

1 R.C.Gupta, **"Statistical Quality Control & Quality Management,"** Khanna Publishers, Delhi, 9th edition, 2001, ISBN: 978-8174091116.
2 Montgomery Douglas C, **"Introduction to statistical Quality Control,"** John Wiley and Sons, Inc., Hoboken. 7th edition, 19th June 2012, ISBN: 978-1118146811.
3 Juran Banks, **"Quality Planning & Analysis,"** TataMcGraw Hill Higher Education, 5th edition, 1st Feb 2006, ISBN: 978-0072966626.

Course Outcomes

At the end of the course the students should be able to:

1. **Explain** the basic concepts of quality, optimum quality, quality control necessity and objectives of quality control and SPC tools.
2. **Apply** measure of central tendency and measure of dispersion, various types of probabilities distribution to solve numerical problem using statistical technique.
3. **Prepare** suitable control chart using data collected for further analysis and **compute** Cp and Cpk.
4. **Construct** suitable control chart for attributes.
5. **Devise** appropriate sampling plan.

Lesson Plan

Unit-1

1 Basic concepts of Quality
2 Meaning and Definition of Quality
3 Quality control, Objectives of Quality Control
4 Quality Characteristics, Quality Costs
5 Quality of Design, Quality of Conformance
6 Optimum Quality
7 Statistical Quality Control
8 Objectives of Statistical Quality Control
9 Concepts in Quality Management
10 Quality Measurement

Unit-2

1 Concept of variation and its types.
2 Variables and Attributes
3 Frequency Distribution and its Graphical Representation
4 Frequency Polygon, Histogram, and Ogive
5 Mean, Median, Mode, Range, and Standard deviation
6 Numerical Problems
7 Theory of Probability
8 Types of Probability Distributions
9 Hypergeometric, Bi-Nomial
10 Poisson and Normal Distributions
11 Numerical Problems
12 Numerical Problems

Unit-3

1 Theory and Definition of Control Chart
2 Control Charts for X – bar and R Charts
3 Type I and Type II Errors
4 Numerical Problems
5 Methods of Calculating Process Capability
6 Natural Tolerance Limits
7 Process Capability Index C_P, C_{pk}
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-4

1 Control Charts for Defects and Defectives
2 p, np, c, and u Charts and their Applications
3 Differences between Control Chart for Variables
4 Differences between p Chart and c Chart
5 Numerical Problems.
6 Numerical Problems
7 Numerical Problems
8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Unit-5

1 Basic concepts of Sampling
2 Sampling by Attributes
3 Single, Double and Multiple Sampling Plans
4 Use of Sampling Table
5 Sequential Sampling Plan
6 Construction and Use of Operating Characteristic Curves
7 Numerical problems

8 Numerical Problems
9 Numerical Problems
10 Numerical Problems

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Explain the basic concepts of quality, optimum quality, quality control necessity and objectives of quality control and SPC tools.	3	2	3							1		1	1	2
Apply measure of central tendency and measure of dispersion, various types of probabilities distribution to solve numerical problem using statistical technique.	3	3	3							1		1	1	2
Prepare suitable control chart using data collected for further analysis and **compute** Cp and Cpk.	3	3	3							3		2	2	2
Construct suitable control chart for attributes.	3	3	3							3		2	2	2
Devise appropriate sampling plan.	3	3	3							2		2	2	2

Prerequisites & Equivalents for Courses of 2015-16

Sl. No.	Prerequisites Course 2015-16		Course of Regulations 2015-16		Equivalent Course for 2013-14	
	Code	Title	Code	Title	Code	Title
1	P15ME41	Engineering Mathematics-IV	P15ME653	Statistical Quality Control	P13ME663	Statistical Quality Control

Course Title: Non Traditional Machining			
Course Code: P15ME654	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Material Science and Metallurgy (P15ME32), Manufacturing Process-I (P15ME34) and Manufacturing Process-II (P15ME46).

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**

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**

Unit-3

Electro chemical and Chemical Processes and machining: 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. Introduction-fundamental principle types of chemical machining Maskants - Etchenes- Advantages and disadvantages-applications, environmental issues.

11 Hrs

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**

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**

Text books

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

References

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.

Course Outcomes

At the end of the course the students should be able to:

1. **Discuss** the difference between conventional and non conventional machining process.
2. **Characterize** the USM and AJM with the effect of parameters and process characteristics.
3. **Explain** the working principle of ECM and CHM with the effect of parameters and process characteristics.
4. **Discuss** about the working principle of EDM with the effect of parameters and process characteristics
5. **Describe** the working principle of PAM and LBM with the effect of parameters and process characteristics.

Lesson Plan

Unit-1

1 Introduction to Mechanical Process**.**
2 Need for nontraditional machining processes.
3 Process selection- classification on-comparative study of different processes
4 Comparison between conventional and Non-conventional machining process selection.
5 Introduction Ultrasonic Machining and Definition.
6 Mechanism of metal removal rate in Ultrasonic Machining process.
7 Elements of the process in Ultrasonic Machining process.
8 Tool feed mechanism in Ultrasonic Machining process.
9 Theories of mechanics of causing effect of parameter,
10 Applications.

Unit-2

1 Introduction to Abrasive Jet Machining and Principles.
2 Parameters of the process.
3 Applications-advantages and disadvantages.
4 Electric discharge machining-Principle of operation
5 Mechanism of metal removal basic EDM circuitry.
6 Spark erosion generators.
7 Analysis of relaxation type of circuit-material removal rate in relaxation circuits.
8 Critical resistance parameters in Ro Circuit-Die electric fluids.
9 Electrodes for spark erosion- surface finish.
10 Applications.

Unit-3

1 Introduction to Electro Chemical machining (ECM) -—. Electro Chemical grinding
2 Classification of ECM process-Principle of ECM
3 Chemistry of the ECM process- parameters of the process.
4 Determination of the metal removal rate in ECM.
5 Dynamics of ECM process
6 Hydrodynamics of ECM process-polarization-Tool Design
7 advantages and disadvantages-applications
8 Electro Chemical holding and Electrochemical deburring.
9 Introduction-fundamental principle of electrochemical
10 Types of chemical machining Maskants - Etchenes
11 Advantages and disadvantages-applications

Unit-4

1 Introduction to Laser Beam Machining and Ion Beam processes
2 Principles of generation of lasers,
3 Equipment and Machining Procedure-Types of Lasers-Process characteristics.
4 Advantages and limitations- applications.
5 Introduction-Mechanism of metal removal
6 Machiningand associated equipment-process characteristics applications.
7 Introductionto High Velocity forming.

8 Development of specific process-selection.
9 comparison of conventional and high velocity forming methods
10 Types of high velocity forming methods-explosion forming process.
11 Electro hydraulics forming-magnetic pulse forming.

Unit-5

1 Introductionto Plasma arc Machining**.**
2 Generation of Plasma and equipment.
3 Mechanism of metals removal rate in plasma.
4 PAN parameters in plasma.
5 Process characteristics
6 Type of torches.
7 Introduction to electron beam machining.
8 Thermal & Non thermal type process and comparison
9 Process characteristics.
10 Applications

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Discuss the difference between conventional and non-conventional machining process.	3	1	1									1	1	
Characterize the USM and AJM with the effect of parameters and process characteristics.	3	2	1									1		
Explain the working principle of ECM and CHM with the effect of parameters and process characteristics.	3	2	1									1		
Discuss about the working principle of EDM with the effect of parameters and process characteristics	3	2	1									1		
Describe the working principle of PAM and LBM with the effect of parameters and process characteristics.	3	2	1									1		

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME32	Material Science and Metallurgy	P15ME654	Non Traditional Machining	P13ME664	Non Traditional Machining
2	P15ME34	Manufacturing Process-I				
3	P15ME46	Manufacturing Process-II				

Course Title: Experimental Stress Analysis			
Course Code: P15ME661	**Sem : 06**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Mechanical Measurements & Metrology (P15ME43) and. Mechanics of Materials (P15ME44)

Course objective: The course aims at strengthening the analysing capabilities design parameters in mechanical components through experimental techniques which are commonly used in designing a mechanical component.

Course Content

Unit-1

Introduction: Basic terminologies, generalised measurement system, experiment planning, Generalised experimental procedure: preliminary, Intermediate and final stages of experimental programs. Causes and types of experimental errors, Error analysis, Statistical analysis of experimental data: Probability distribution, Histograms, Chi-square test of goodness of fit, Method of least square. Curve fitting, types of curve fitting, General considerations in data analysis. **10Hrs**

Unit-2

Strain gauges: Introduction, Types of Strain gauges: Mechanical, Optical, Pneumatic, Acoustic strain gauges. Electrical Resistance Strain Gauges, Gauge factor , properties of an ideal gauge material, backing material, adhesive material, protective coating; Method of bonding strain gauges, strain gauges lead wire and connections, Numerical.

Strain gauge circuits, Wheatstone bridge, Error due to input impedance of measuring instrument, temperature compensation, multiple gauge circuits, calibration of strain measuring system, load cells, Numerical. **12Hrs**

Unit-3

Two dimensional photoelasticity: Introduction, nature of light, wave theory of light, polarization, natural double refraction, stress optic law, Basic elements of a polariscope, effect of stressed models in plane and circular polariscope: dark field and bright field, isoclinic, isochromatic, fringe order determination, fringe sharpening: Fringe compensation techniques: Tardy's method, Babinet-soleil and Friedel's method compensation method, separation methods-oblique incidence method, shear difference method, numerical problems. **12Hrs**

Unit-4

Coating methods: introduction, Birefringence coating technique, reflection polariscope, sensitivity of Birefringent coating, separation of principal stresses. Brittle coating: coating technique, laws of failure of brittle coating, isostatics and isoentatics, properties of stress coat materials, crack pattern, crack detection technique, Types of brittle coating, calibration of brittle coating materials, advantage of brittle coating, Application of brittle coating. **10Hrs**

Unit-5

Moire's fringe methods: Introduction, Moire fringe analysis techniques, Fringe ordering, Sensitivity of Moire's fringe shifting, Generalised moire's gap equation , mechanism of fringe shifting, Sharpening and multiplication of moire's fringes, Application and advantages of moire's technique.

Holography Equation for plane waves and spherical waves, Spherical radiator as an object, Magnification, Displace measurement, computer techniques and fringe analysis. **08Hrs**

Text books

1 Sadhu Singh "Experimental Stress Analysis", Khanna publications, 5th Edition , 2015, ISBN: 9788174091826

2 R. S. Sirohi, H. C. Radha Krishna, "Mechanical measurements" New Age International Pvt. Ltd., New Delhi, 3rd Reprint 2016, ISBN: 9788122403831

References

1 Dally and Riley, Experimental Stress Analysis McGraw Hill, 3rd sub Edition, 1991, ISBN: 9780070152182

2 Experimental Stress Analysis - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1st Edition, 1984, ISBN: 9780074519264

3 Holman, "Experimental Methods for Engineers" Tata McGraw-Hill Companies, Inc, New York, 7th Edition, 2007, ISBN: 9780071181655

Course Outcomes

At the end of the course the students should be able to:

1. **Understand** the basic aspects of measurement system
2. **Discuss** various types of strain gauges and their circuits.
3. **Choose** the appropriate techniques of two-dimensional photo elasticity.
4. **Distinguish** different coating methods.
5. **Explain** Moire's fringe analysis and Holography techniques.

Lesson Plan

Unit-1

1 Introduction: Basic terminologies, generalised measurement system
2 Experiment planning, Generalised experimental procedure
3 Preliminary, Intermediate and final stages of experimental programs
4 Causes and types of experimental errors, Error analysis
5 Statistical analysis of experimental data
6 Probability distribution, Histograms,
7 Chi-square test of goodness of fit
8 Method of least square. Curve fitting,
9 Types of curve fitting
10 General considerations in data analysis.

Unit-2

1 Introduction, Types of Strain gauges
2 Mechanical, Optical, Pneumatic, Acoustic strain gauges
3 Electrical Resistance Strain Gauges, Gauge factor
4 Properties of an ideal gauge material, backing material,
5 Adhesive material, protective coating;
6 Method of bonding strain gauges, strain gauges lead wire and connections
7 Numerical.
8 Strain gauge circuits, Wheatstone bridge,
9 Error due to input impedance of measuring instrument
10 Temperature compensation, multiple gauge circuits
11 Temperature compensation, multiple gauge circuits
12 Calibration of strain measuring system, load cells, Numerical.

Unit-3

1 Introduction, nature of light, wave theory of light,
2 Polarization, natural double refraction
3 Stress optic law, Basic elements of a polariscope,
4 Effect of stressed models in plane and circular polariscope: dark field and bright field
5 Isoclinic, isochromatic, fringe order determination
6 Fringe sharpening: Fringe compensation techniques
7 Tardy's method
8 Babinet-soleil and Friedel's method compensation method,
9 Separation methods-oblique incidence method
10 Shear difference method
11 Numerical problems.
12 Numerical problems.

Unit-4

1 Introduction, Birefringence coating technique
2 Reflection polariscope
3 Sensitivity of Birefringent coating
4 Separation of principal stresses. Brittle coating:
5 Coating technique, laws of failure of brittle coating
6 Isostatics and isoentatics,

7 Properties of stress coat materials, crack pattern
8 Crack detection technique, Types of brittle coating,
9 Calibration of brittle coating materials, advantage of brittle coating,
10 Application of brittle coating.

Unit-5

1 Introduction, Moire fringe analysis techniques,
2 Fringe ordering, Sensitivity of Moire's fringe shifting
3 Generalised moire's gap equation
4 Mechanism of fringe shifting, Sharpening and multiplication of moire's fringes
5 Application and advantages of moire's technique
6 Equation for plane waves and spherical waves, Spherical radiator as an object,
7 Magnification, Displace measurement
8 Computer techniques and fringe analysis.

Course Articulation Matrix

Course Outcomes	**Program Outcomes (POs)**												**PSOs**	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Understand the basic aspects of measurement system	3	1	1		1							1		
Discuss various types of Strain gauges and its circuits	3	1	1		1							1	1	
Choose the appropriate techniques of two dimensional photoelasticity	3	1	1		1							1		
Distinguish different coating methods	3	1	1		1							1		
Explain Moire's fringe analysis and Holography techniques	3	2	1		1							1	1	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME43	Mechanical Measurements & Metrology	P15ME661	Experimental Stress Analysis	P13ME763	Experimental Stress Analysis
2	P15ME44	Mechanics of Materials.				

Course Title: I C ENGINES			
Course Code: P15ME662	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Basic Thermodynamics (P15ME35) and. Applied Thermodynamics (P15ME42)

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; knock rating of diesel fuels - cetane number; diesel index; aniline point API gravity and specific gravity; Alternative fuels – alcohols ; vegetable oils; bio gas as Diesel engine fuels. **12 Hrs**

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. HUCR values. Anti Knock agents – Pre ignition – Post ignition. **10 Hrs**

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**

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. **10Hrs**

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. **10Hrs**

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.

References

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.

Course Outcomes

At the end of the course the students should be able to:

1. **Summarise** working of an internal combustion engine and **apply** engineering science (thermo, fluids, heat transfer) to **analyze** the operation and performance of an internal combustion engine.
2. **Study** combustion and its controlling factors in spark ignition, compression ignition engines.
3. **Compare** various types of combustion chambers for spark ignition and compression ignition engines.
4. **Extend** experience in fuel injection systems and modern developments, such as a turbocharger, supercharger multi fuel engines.
5. **Identify** emissions from IC engines and its controlling methods, various controlling norms.

Lesson Plan

Unit-1

1 Fuel- Air cycle; Variation of specific heat; loss due to variation of specific heat; Dissociation
2 Effect of variables- compression ratio; effect of fuel –air ratio on efficiency;
3 Maximum temperature; maximum pressure;
4 Exhaust temperature; MEP ; Numerical problems
5 Numerical problems
6 Hydro carbons ; structure of petroleum – paraffin, olefin, napthene; aromatic series;
7 Requirements of an ideal gasoline; effect of volatility engine performance;
8 Knock rating on SI engine fuels- octane number; research & motor octane number; performance number
9 Knock rating of diesel fuels - cetane number; diesel index; aniline point.
10 API gravity and specific gravity; Alternative fuels – alcohols ;
11 Vegetable oils; bio gas as Diesel engine fuels.
12 Revision of unit 1

Unit-2

1 Carburettor; types of carburettors and its limitations.
2 Knock free and knocking combustion; stages of combustion process in S.I. engines
3 Stages of combustion process in S.I. engines.
4 Features of different types of combustion chambers system for S.I. engine
5 I-head, F-head combustion chambers. Effect of engine variables on ignition lag;
6 Effect of engine variables on ignition lag;
7 Effect of variables on flame propagation. Detonation;
8 Effect of detonation; control of detonation. HUCR values
9 Anti Knock agents – Pre ignition – Post ignition
10 Revision for unit 2

Unit-3

1 Ricardo's three stages of combustion process in C.I. engines
2 Delay period & factors affecting delay period
3 Factors affecting delay period
4 Variables affecting delay period
5 Diesel knock- Methods of controlling diesel knock.
6 C.I. engine combustion chambers
7 Methods of generating air swirl; induction air swirl and open combustion chambers
8 Induction air swirl and open combustion chambers
9 Turbulent swirl chambers; M. type combustion chamber
10 Revision for unit 3

Unit-4

1 Diesel injection systems; types of injection systems
2 Fuel pump; Nozzles of different types;
3 Petrol injection systems for S.I. engines;
4 Electronic fuel injection system. MPFI system
5 MPFI system; spark advance mechanisms;
6 Various factors affecting piston temperature in an engine
7 Cooling system-Water cooling,
8 Air cooling ; Radiators
9 Radiators.
10 Revision for unit 4

Unit-5

1 Turbo charging and super charging of I.C. engines
2 Stratified charge engines (Lean burned SI engine)
3 Multi fuel engines. Two injector engines
4 Multi fuel engines. Two injector engines
5 Pilot ignition engine, all ceramic swirl chamber engines
6 Mechanism of pollutant formation.
7 Thermal reactor package-cata**l**ytic converter package
8 Cata**l**ytic converter package; ; chemical method.
9 Control of NOx ;Exhaust gas recirculation
10 Revision for unit 5

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Summarise working of an internal combustion engine and **apply** engineering science (thermo, fluids, heat transfer) to **analyze** the operation and performance of an internal combustion engine.	3	2	3							1		2	1	
Study combustion and its controlling factors in spark ignition, compression ignition engines	3	2	2							1		2	2	
Compare various types of combustion chambers for spark ignition and compression ignition engines.	3	2	1							1		2	1	
Extend experience in fuel injection systems and modern developments, such as a turbocharger, supercharger multi fuel engines.	3	2	1							1		2	1	
Identify emissions from IC engines and its controlling methods, various controlling norms.	3	2	3							1		2	1	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME35	Basic Thermodynamics	P15ME662	I C Engines	P13ME754	I C Engines
2	P15ME42	Applied Thermodynamics				

Course Title: Maintenance Engineering			
Course Code: P15ME663	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of Mechanical Vibrations (P15ME62).

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. **12Hrs**

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. **10Hrs**

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. **10Hrs**

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. **10Hrs**

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. **10Hrs**

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.

References

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.

Course Outcomes

At the end of the course the students should be able to:

1. **Distinguish** maintenance system types, scope, objective, functions and importance.
2. **Recognize** causes of machine failure, performance evaluation and overhauling.
3. **Evaluate** overhauling, maintenance planning, scheduling, estimation and maintenance control.
4. **Analyse** benefits and application of computer aided maintenance, and pollution control.
5. **Analyse** accident records, accident investigations, industrial and accident safety.

Lesson Plan

Unit-1

1 Definition, Scope, Objective and Functions of maintenance system
2 Importance of maintenance system
3 Break down maintenance system
4 Preventive maintenance
5 Predictive maintenance design out maintenance
6 Corrective maintenance
7 Planned maintenance
8 Total productive maintenance
9 Condition monitoring
10 Problems on selection of methods like preventive maintenance.
11 Problems on selection of methods like breakdown maintenance.
12 Problems

Unit-2

1 Repair for Machinery Maintenance
2 Replacement for Machinery Maintenance
3 Repair complexity in Maintenance of Machinery
4 Finding out most optimal preventive maintenance frequency
5 Numerical treatment required for machinery maintenance
6 Numerical treatment required for machinery maintenance
7 Causes of machine failure
8 Causes of machine failure
9 Performance evaluation
10 Complete overhauling of Machines tools

Unit-3

1 Maintenance planning and scheduling
2 Repair order control and manpower requirement
3 Maintenance job analysis and spare parts control
4 Planning of maintenance junctures man power allocation
5 Long range planning and short range planning
6 Planning of maintenance junctures man power allocation
7 Long range planning and short range planning
8 Planning techniques and procedure
9 Estimation of maintenance work
10 Maintenance control

Unit-4

1 Features of Computer aided maintenance
2 Benefits of Computer aided maintenance
3 Application of computer to maintenance work
4 Application of computer to maintenance work

5 Economic importance of accidents
6 Dust control- Fiber collectors, mechanical dust collectors and wet type collectors
7 Electro static precipitators
8 Noise pollution Control –Noise measurement and control
9 Noise pollution Control –Noise measurement and control
10 Industrial vibration and its control

Unit-5

1 Types of safety organizations
2 Analysis of accident records
3 Accident investigations
4 Analysis of accident Safety standards for Mechanical equipment
5 Analysis of accident Safety standards for Electrical system
6 Chemical hazards
7 material handling
8 Exhaust system and welding
9 plant house keeping-building, Aisles, Passages and floors
10 plant house keeping- tool cribs, washrooms and canteens

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Distinguish maintenance system types, scope, objective, functions and importance.	3	1												2
Recognize causes of machine failure, performance evaluation and overhauling.	3	3								1		1		3
Evaluate overhauling, maintenance planning, scheduling, estimation and maintenance control.	3	2				1	1			1		2		3
Analyse benefits and application of computer aided maintenance, and pollution control.	3	1	1			2	2					2		3
Analyse accident records, accident investigations, industrial and accident safety.	3	1	2			3				1		2		3

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME62	Mechanical Vibrations	P15ME663	Maintenance Engineering	P13ME762	Maintenance Engineering

Course Title: Computer Integrated Manufacturing			
Course Code: P15ME664	**Sem: 06**	**L-T-P-H : 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites: The students should have acquired the knowledge of CAD/CAM (P15ME552).

Course objective: This course helps the students to understand production concepts in industries and to analyze automated flow line and manual assembly line. It also exposes the students to various inspection technologies used in industry

Course Content

Unit-1

Computer Integrated Manufacturing Systems: Introduction, Automation definition, Types of automation, CIM, processing in manufacturing, Production concepts, Mathematical Models-Manufacturing lead time, production rate, components of operation time, capacity, Utilization and availability, Work-in-process, WIP ratio, TIP ratio, Problems using mathematical model equations.

High Volume Production System: Introduction Automated flow line symbols, objectives, Work part transport-continuous, Intermittent, synchronous, Pallet fixtures, Transfer Mechanism-Linear-Walking beam, roller chain drive, Rotary-rack and pinion, Rachet & Pawl, Geneva wheel, Buffer storage. **11Hrs**

Unit-2

Analysis of Automated Flow Line: General terminology and analysis, Analysis of Transfer Line without storage-upper bound approach, lower bound approach and problems, Analysis of Transfer lines with storage buffer, Effect of storage, buffer capacity with simple problem, Partial automation-with numerical problem, flow lines with more than two stages, numerical problems.

Manual Assembly Lines: Line balancing & problems, work station process time, Cycle time, precedence constraints. Precedence diagram, balance delay methods of line balancing largest candidate rule, Kilbridge and Westers method, Ranked positional weight method, Numerical problems covering above methods and computerized line balancing. **11Hrs**

Unit-3

Automated Assembly Systems: Design for automated assembly systems, types of automated assembly system, Parts feeding devices elements of parts delivery system-hopper, part feeder, Selectors, feedback, escapement and placement analysis of multi station assembly machine, analysis of single station assembly.

Computerized Manufacturing Planning System: Introduction, Computer Aided process planning, Retrieval types of process planning , Generative type of process planning, Material requirement planning, Fundamental concepts of MRP inputs to MRP, Capacity planning. **10Hrs**

Unit-4

Automated Material Handling And Storage: Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system, automated guided vehicle systems, automated storage/retrieval systems, carousel storage systems work in process storage, interfacing handling & storage with manufacturing.

Industrial Control and Process Planning: Industrial Control Systems, Sensors, Actuators, & other Control Systems, Discrete Control using PLC. **10Hrs**

Unit-5

Automatic Identification and Data Capture: Overview of automatic identification methods, Bar code technology, Radio frequency identification, other AIDC technologies.

Inspection Technologies: Introduction, coordinate measuring machines, construction, operation & programming, software, application and benefits, machine vision & its applications, optical inspection methods & noncontact non optical inspection techniques. **10Hrs**

Text books

1 M.P.Groover, **"Automation, Production system & Computer Integrated manufacturing,"** PHI Publication, 2nd edition, 2007, ISBN: 9780132393218.

2 S. Kant Vajpayee **"Principles of Computer Integrated Manufacturing,"** Prentice Hall India, 1st Edition, 1998, ISBN: 9780024222411.

References

1 James. A. Rehg and Henry.W. Kraebber, **"Computer Integrated Manufacturing,"** Pearson Publication, 3rd Edition, 2004, ISBN: 9780131134133.
2 Ibrahim Zeid, **"CAD/CAM,"** Tata McGraw Hill, 2nd Edition, 2009, ISBN: 9780070151345

Course Outcomes

At the end of the course the students should be able to:

1. **Estimate m**anufacturing lead time and **identify** part transfer mechanism and devices used in high volume production system.
2. **Analyze** automated flow lines and line balancing process.
3. **Summarize** computer aided process planning, MRP and automated assembly systems.
4. **Identify** material handling, storage systems & different control systems.
5. **Create** new identification methods & **Apply** inspection techniques.

Lesson Plan

Unit-1

1 Introduction to manufacturing support system.
2 Define automation and types of automation.
3 CIM and its components.
4 Processing in manufacturing.
5 Production concepts.
6 Mathematical Models.
7 Problems on mathematical models.
8 Introduction automated flow line.
9 Automated flow line symbols & objectives.
10 Work part transport systems.
11 Different transfer mechanisms

Unit-2

1 Introduction to automated flow line.
2 Analysis of Transfer Line without storage & with storage.
3 Numerical problems on without storage & with storage.
4 Numerical problems on buffer storage & partial automation.
5 Numerical problems on flow line with two stages.
6 Line balancing & problems.
7 Precedence diagram
8 Balance delay methods of line balancing largest candidate rule.
9 Kilbridge and Westers method,
10 Ranked positional weight method.
11 Numerical problems.

Unit-3

1 Introduction to automated assembly systems.
2 Design for automated assembly systems.
3 Types of automated assembly system.
4 Parts feeding devices elements of parts delivery systems.
5 Analysis of multi station assembly machine.
6 Analysis of single station assembly.
7 Introduction to Manufacturing Support System
8 Computer Aided Process Planning
9 Material requirement planning & its fundamentals.
10 Capacity planning.

Unit-4

1 Introduction to material functions & types of material handling equipment.
2 Analysis of material handling systems.
3 Automated guided vehicle system.

4 Automated storage/retrieval systems.
5 Carousel storage systems work in process storage.
6 Interfacing handling & storage with manufacturing.
7 Introduction to Industrial Control Systems.
8 Sensors & Actuators.
9 Other Control Systems.
10 Discrete Control using PLC.

Unit-5

1 Overview of automatic identification methods.
2 Bar code technology.
3 Radio frequency identification.
4 Other AIDC technologies.
5 Introduction to automated Inspection.
6 Coordinate Measuring Machines Construction, operation & Programming.
7 Software, Application & Benefits, Flexible Inspection System.
8 Probes on Machine Tools.
9 Machine Vision, Optical Inspection Techniques.
10 Non contact Non optical Inspection Technologies.

Course Articulation Matrix

Course Outcomes	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Estimate manufacturing lead time and **identify** part transfer mechanism and devices used in High volume production system.	3	3	2									1	2	
Analyze automated flow lines and line balancing process.	3	3	3									1	1	
Summarize computer aided process planning, MRP and Automated assembly systems.	3	1	1									1	1	
Identify material handling, storage systems & different control systems.	3	2	2									1	1	
Create new identification methods & **Apply** inspection techniques.	3	1	1									1	1	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15ME552	CAD/CAM	P15ME664	CIM	P13ME761	CIM

Course Title: Computer Aided Modeling & Analysis Lab			
Course Code: P15MEL67	**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%**	

Prerequisites: Knowledge of Mechanics of Materials (P15ME44), Fluid Mechanics (P15ME33), Finite Element Method (P15ME64), Heat and Mass Transfer (P15ME63) and Computer Concepts & C Programming (P15CS13/23).

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 and MATLAB fundamentals.
Analysis of bars of constant cross section area, tapered cross section area and stepped bars using ANSYS and MATLAB code. **3Hrs**

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

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

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

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

PART-B

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

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

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

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

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

Seminar **3Hrs**

Test **3Hrs**

References

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

2 A. J. M. Ferreira, "MATLAB Codes for Finite Element Analysis: Solids and Structures," Springer Science & Business Media, 2008, ISBN: 978-1402091995.

3 **ANSYS 15** documentation.

Course Outcome

At the end of the course the students should be able to:

1. **Explain** the applications of commercial finite element analysis package like ANSYS 15 and MATLAB.
2. **Solve** structural engineering problems using ANSYS 15.
3. **Solve** thermal engineering problems using ANSYS 15.
4. **Validate** finite element results with results of analytical/experimental/MATLAB code.
5. **Function** effectively as a member of a team

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**

Course Articulation Matrix

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
Explain the applications of commercial finite element analysis package like ANSYS 15.	3	2	2							2		2	1	
Solve structural engineering problems using ANSYS 15.	3	2	2							2		2	1	
Solve thermal engineering problems using ANSYS 15.	3	2	2							2		2	1	
Validate finite element results with analytical or experimental results.	3	2	2							2		2	1	
Function effectively as a member of a team	3	2	2							2		2	1	

Prerequisites & Equivalents for Courses of 2015-16						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P15CS13/23	Computer Concepts & C Programming	P15MEL67	Computer Aided Modeling & Analysis Lab	P13MEL67	CAMA Lab
2	P15ME44	Mechanics of Materials				
3	P15ME33	Fluid Mechanics				
4	P15ME64	Finite Element Method				
	P15ME63	Heat and Mass Transfer				

Course Title: Heat and Mass Transfer Lab			
Course Code: P15MEL68	**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%**	

Prerequisites: Knowledge of Heat and Mass Transfer (P15ME63).

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. **3Hrs**

Exp-2: Determination of Overall Heat Transfer Coefficient of a Composite wall **3Hrs**

Exp-3: Determination of Effectiveness and Efficiency of a Metallic fin. **3Hrs**

Exp-4: Determination of free Convective Heat Transfer Coefficient of a vertical Cylinder **3Hrs**

Exp-5: Determination of Heat Transfer Coefficient in Forced Convection **3Hrs**

Exp-6: Determination of Emissivity of a Surface. **3Hrs**

Exp-7: Determination of thermal conductivity of liquid **3Hrs**

PART-B

Exp 8: Determination of Stefan Boltzman Constant. **3Hrs**

Exp 9: Determination of Effectiveness in Parallel Flow and Counter Flow Heat Exchangers. **3Hrs**

Exp-10: Performance Test on Vapour Compression Refrigeration. **3Hrs**

Seminar **3Hrs**

Test **3Hrs**

References

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.

Course Outcome

At the end of the course the students should be able to:

1. **Identify** safe operating practices and requirements for laboratory experiments
2. **Analyze** thermal and fluid systems.
3. **Understand** basic thermal and fluid measurement techniques
4. **Perform** one dimensional conduction, convection and radiation experiments
5. **Function** effectively as a member of a team

Evaluation Scheme					
Scheme	**Weightage**	**Marks**	**Event Break Up**		
CIE	50%	50	**Test**	**Record**	**Seminar**
			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**

Course Articulation Matrix

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
Identify safe operating practices and requirements for laboratory experiments	3	2		2					1	1			1	
Analyze thermal and fluid systems.	3	2		2					1	1			1	
Understand basic thermal and fluid measurement techniques	3	2		2					1	1			1	
Perform one dimensional conduction, convection and radiation experiments	3	2		2					1	1			1	
Prepare and present clear and concisely written lab reports	3	2		2					1	1			1	

Prerequisites & Equivalents for Courses of 2015-16

Sl. No.	Prerequisites Course 2015-16		Course of Regulations 2015-16		Equivalent Course for 2013-14	
	Code	Title	Code	Title	Code	Title
1	P15ME63	Heat and mass transfer	P15MEL68	Heat and Mass Transfer Lab	P13MEL68	Heat and Mass Transfer Laboratory

Course Title : Aptitude and Reasoning Development - EXPERT (ARDE)		
Course Code : P15HU610	**Semester : 6**	**L : T : P : H - 0 : 0 : 2 : 2**
Contact Period: Lecture: 32 Hr, Exam: 3 Hr	**Weightage: CIE:50%; SEE:50%**	
Prerequisites : Number system, Concept of percentage, Analytical reasoning-2.		

Course Learning Objectives (CLOs)

This course aims to

1. Explain different types of functions, representation of different functions on the graphs.
2. Describe the properties of quadratic equations and application of quadratic equations.
3. Demonstrates the principle of counting.
4. Differentiates between permutation and combination and solve problems conceptually.
5. Predict the probabilities in different scenarios and its application in our day-to-day life.
6. Evaluate the cause and effect of the statements logically.
7. Recognize different ways in which a statement can be strengthened or weakened.
8. Explain the criticality of data sufficiency chapter., universal methodology to solve any problem.
9. Analyse the data in a bar graph , pie chart and tabular column and line graph and the combination of these graphs.
10. Compare the data in different format and understand the difference between them

Course Content

Unit – I

Functions and Quadratic equations:

Functions: Basic methods of representing functions– Analytical representation, tabular representation, graphical representation of functions. Even and odd functions, Inverse of a function, Shifting of graph. Representation of standard set of equations. Methodology to tackle inverse functions. Graphical process for solving inequalities, graphical view of logarithmic function.

Quadratic equations: Theory, properties of quadratic equations and their roots, the sign of quadratic equation, Equations in more than one variable. Simultaneous equations, number of solutions of the simultaneous equations. **6 hrs**

Unit – II

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. **8 hrs**

Unit – III

Analytical reasoning 3: Punchline: Introduction, format of the problem, An analysis, Does a suggested statement qualify as a punchline?. If a given statement fits as a punchline, what is its idea or wavelength?, The complete method of solving a punchline problem, Solved examples, conclusion, Sample company questions.

Strengthening and Weakening arguments: Format of the problem, An analysis, Suggested methods, solved examples, conclusion, sample company questions.

Cause and Effect : Cause and Effect—A theoretical discussion, Immediate cause, Principal cause, A quick check– Cause always antecedent. The strategy for solution. **6 hrs**

Unit IV

Data Sufficiency: Introduction, answer choices in data sufficiency, tips to solve data sufficiency problems, directions of questions, classification of sections in data sufficiency– Number system, Algebra, series and sequence, logical, geometry and mensuration, arithmetic. **6hrs**

Unit V

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 **6 hrs**

Reference Books:

1. "The Trachtenberg speed system of basic mathematics, published by Rupa publications.
2. CAT Mathematics by AbhijithGuha. 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.
6. Analytical reasoning by M.K Pandey BSC PUBLISHING.CO.PVT.LTD

Course Outcomes (CO)

After learning all the units of the course, the student is able to:

1. Graphically represent the functions and analyze it. L5
2. Infer the conclusions based on the roots obtained by solving quadratic equations and establish relationship between them. L6
3. Effective solve the problems of permutation and combination. L4
4. Predict different possibilities by the principle of probability. L3
5. Interpret the data given in the graphical format and infer the results. L5
6. Analyze the statement critically and solve the questions from verbal logic section. L5

A. Course Assessment Matrix (CaM)

Course Outcome (CO)	Program Outcome (ABET/NBA-(3a-k))														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Graphically represent the functions and analyze it.	L5	2	-	-	-	2	-	-	-	-	-	-	-	-	-
Infer the conclusions based on the roots obtained by solving quadratic equations and establish relationship between them.	L6	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Effective solve the problems of permutation and combination.	L4	3	-	-	-	2	-	-	-	2	-	-	-	-	-
Predict different possibilities by the principle of probability.	L3	3	-	-	-	-	-	-	-	2	-	-	-	-	-
Interpret the data given in the graphical format and infer the results.	L5	2	-	-	-	-	-	-	-	-	-	-	-	-	-