SYLLABUS

(With effect from 2013-2014)
Out Come Based Education

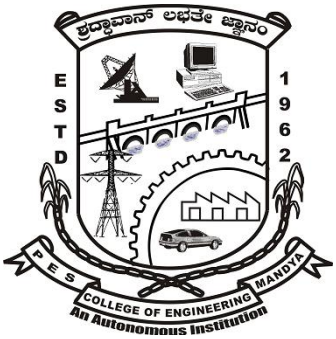
ಪಠ್ಯಕ್ರಮ

(ಶೈಕ್ಷಣಿಕವರ್ಷ 2013–14)
ಫಲಿತಾಂಶ ಆಧಾರಿತ ಶಿಕ್ಷಣ

V and VI Semester

Bachelor Degree
in

MECHANICAL ENGINEERING



P.E.S. College of Engineering

Mandya - 571 401, Karnataka
(An Autonomous Institution Affiliated to VTU, Belagavi)
Grant -in- Aid Institution
(Government of Karnataka)
Accredited by NBA, New Delhi
Approved by AICTE, New Delhi.

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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 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.

In order to increase the Industry/Corporate readiness, many Soft Skills and Personality Development modules have been added to the existing curriculum of 2013-14.Industry Interactions have been made compulsory to enhance the field experience. In order to enhance creativity and innovation Mini Project is included in all undergraduate programs.

(Dr.H.V.RAVINDRA)
Dean (Academic)
Professor,
Dept. of Mechanical Engg.

(B.DINESH PRABHU)
Deputy Dean (Academic)
Associate Professor,
Dept. of Automobile Engg

P.E.S.COLLEGE OF ENGINEERING, MANDYA-571401
(KARNATAKA)
(An Autonomous Institution under VTU, Belagavi)

Vision

"An institution of high repute, imparting quality education to develop innovative and humane engineers"

Mission

"Committed to develop students potential through high quality teaching- learning processes and state of the art infrastructure"

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"

Mission

"To provide quality education, essential technical skills and inculcate sense of higher education, by competent faculty, adequate infrastructure and necessary 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

	By the time of graduation, students will have:
1	Ability to apply fundamentals of science, mathematics and engineering to solve problems related to mechanical engineering.
2	Ability to identify, analyze and solve problems related to mechanical systems.
3	Ability to design mechanical components, systems and processes considering economic and safety aspects.
4	Ability to carry out experimental investigations/simulations, interpret data and arrive at meaningful conclusions.
5	Ability to use the techniques, skills, and modern engineering tools necessary for engineering practices.
6	Ability to use contextual knowledge to understand the impact of technology on public health and safety.
7	Ability to recognize the need for sustainable solutions and their influence on environment.
8	An understanding of professional and ethical responsibility.
9	Ability to work individually and in multidisciplinary teams by applying interpersonal skills.
10	Ability to communicate in oral, written, and graphical forms.
11	Ability to apply management principles and to lead multidisciplinary teams to execute projects.
12	Ability to recognize the changes and advancements in technology and engage in life-long learning by adapting to the changes.

EVALUATION SCHEME							
Scheme	**Weightage**	**Marks**	**Event Break Up**				
CIE	50%	50	**Test I**	**Test II**	**Quiz I**	**Quiz II**	**Assignment**
			35	35	5	5	10
SEE	50%	100	**Questions to Set: 10**		**Questions to Answer: 5**		

Scheme of SEE Question Paper (100 Marks)		
Duration: 3Hrs	**Marks: 100**	**Weightage: 50%**

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

P.E.S COLLEGE OF ENGINEERING, MANDYA
(An Autonomous Institution under VTU)
SCHEME OF TEACHING AND EXAMINATION
V Semester B.E Mechanical Engineering

Sl No.	Course Code	Course Title	Teaching Dept.	Hours pattern L:T:P:H	Total Credits	Examination Marks			Exam Duration in hours
						CIE	SEE	Total	
1	P13ME51	Dynamics of Machines	Mechanical	2:2:0:4	3	50	50	100	3
2	P13ME52	Design of Machine Elements I	Mechanical	4:0:0:4	4	50	50	100	3
3	P13ME53	Turbomachines	Mechanical	4:0:0:4	4	50	50	100	3
4	P13ME54	Manufacturing Process- III	Mechanical	4:0:0:4	4	50	50	100	3
5	P13ME55	Engineering Economics	Mechanical	4:0:0:4	4	50	50	100	3
6	P13ME56	Mechatronics &Microprocessor	Mechanical	4:0:0:4	4	50	50	100	3
7	P13MEL57	Machine shop	Mechanical	0:0:3:3	1.5	50	50	100	3
8	P13MEL58	Energy Conversion Lab	Mechanical	0:0:3:3	1.5	50	50	100	3
9	P13HU59	Professional & efficient avocation I (PEA I)	HS & M	2:0:0:2	--	(50)	--	--	--
10	P13MEL510	Industry visit and interaction-II	Mechanical	0:0:1:1	--	(50)	--	--	--
				Total	**26**	**400**	**400**	**800**	

VI Semester B.E Mechanical Engineering

Sl No.	Course Code	Course Title	Teaching Dept.	Hours pattern L:T:P:H	Total Credits	Examination Marks			Exam Duration in hours
						CIE	SEE	Total	
1	P13MA61	Design of Machine Elements II	Mechanical	2:2:0:4	3	50	50	100	3
2	P13ME62	Mechanical Vibrations	Mechanical	4:0:0:4	4	50	50	100	3
3	P13ME63	Heat and Mass Transfer	Mechanical	4:0:0:4	4	50	50	100	3
4	P13ME64	Finite Element Method	Mechanical	4:0:0:4	4	50	50	100	3
5	P13ME65	CAD/CAM	Mechanical	4:0:0:4	4	50	50	100	3
6	P13ME66x	Elective I	Mechanical	4:0:0:4	4	50	50	100	3
7	P13MEL67	CAMA Lab	Mechanical	0:0:3:3	1.5	50	50	100	3
8	P13MEL68	Heat & Mass Transfer Laboratory	Mechanical	0:0:3:3	1.5	50	50	100	3
9	P13HU69	Professional & efficient avocation II (PEA II)	HS & M	2:0:0:2	--	(50)	--	--	--
10	P13MEL610	Mini Project - II	Mechanical	0:0:1:1	--	(50)	--	--	--
				Total	**26**	**400**	**400**	**800**	

ELECTIVE I		
Sl.No.	**Course Code**	**Course Title**
1	P13ME661	Theory of Elasticity
2	P13ME662	Refrigeration & Air Conditioning
3	P13ME663	Statistical Quality Control
4	P13ME664	Non-Traditional Machining

EVALUATION SCHEME							
Scheme	**Weightage**	**Marks**	**Event Break Up**				
CIE	50%	50	**Test I**	**Test II**	**Quiz I**	**Quiz II**	**Assignment**
			35	35	5	5	10
SEE	50%	100	**Questions to Set: 10**		**Questions to Answer: 5**		

Scheme of SEE Question Paper (100 Marks)		
Duration: 3Hrs	**Marks: 100**	**Weightage: 50%**

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

Fifth Semester

Course Title: Dynamics of Machines			
Course Code: P13ME51	Sem: 05	L-T-P-H : 2-2-0-4	Credit: 03
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		Weightage: CIE: 50% SEE:50%	

Prerequisites & Equivalents for Courses of 2013-14

Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13MA11	Engineering Mathematics-I	P13ME61	Dynamics of Machines	P08ME61	Theory of Machines - II
2	P13CV13	Engineering Mechanics				
3	P13ME33	Mechanics of Materials				
4	P13ME51	Kinematics of Machines				

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. **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

Governors: Introduction, Types, working principle and application [without numericals].

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. **Theory of Machines and Mechanisms** by Joseph E. Shigley, Jr. Uicker John**,** Mcgraw-hill publications., 2nd International Edition, 1995
2. **Theory of Machines:** V.P. Singh, Dhanpat Rai & Co., 3rd Edition, 2013.
3. **Theory of Machines:** Rattan S.S. Tata McGraw Hill Publishing Company Ltd., 3rd Edition, 2009.

References

1. **Theory of Machines** by P.L. Ballaney, Khanna Publishers., 25th Edition.
2. **Kinematics & Dynamics of Machinery** by R L. Norton, Tata - Mc Graw Hill., 1st Edition.
3. **Theory of Machines** by R.S.Khurmi and J.K.Gupta, S.Chand and Co., 14th Edition

COURSE OUTCOMES

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

1. **Recognize** the mechanisms, solve graphically and **determine** the static forces acting in different links of simple planar four bar mechanisms and slider crank mechanism.
2. **Explain** the D'Alembert's principle, **Recognize** the inertia force, inertia torque and line of action of inertia force, solve graphically and **determine** the inertia forces acting on different links of simple planar four bar and slider crank mechanisms.
3. **Recognize** the type of machinery, **calculate** the fluctuation of energy in the system and **determine** the size of a suitable fly wheel for the system.
4. **Calculate** the unbalanced forces and couples in case of mechanical systems having rotating and reciprocating unbalanced masses, and **determine** the magnitude and location of balancing masses.
5. **Explain** the types and working principle of Governors.
6. **Explain** the concept of gyroscopic couple and its effects; **calculate** the magnitude and direction of gyroscopic couple in case of simple mechanical systems and **analyze** the stability of mechanical systems.

Topic Learning Objectives (Unit wise)

Unit I

By the end of the topic, student will be able to

1	**Recognize** static force acting on a mechanism.
2	**Explain** equilibrium condition of a mechanism, due to static forces.
3	**Draw** free body diagrams and **analyze** graphically static forces acting on individual elements of the mechanism.
4	**Analyze** graphically static forces acting on the entire mechanism and **determine** the equilibrating forces and torques.

Unit II

By the end of the topic, student will be able to

1	**Explain** D'Alembert's principle.
2	**Recognize** the inertia force, inertia torque and line of action of inertia force.
3	**Determine** the inertia forces acting on different links of simple planar four bar and slider crank mechanisms.

Unit III

By the end of the topic, student will be able to

1	**Recognize** the type of machinery–whether energy consuming or energy producing.
2	**Draw** turning moment diagram for a given system.
3	**Calculate** fluctuation of energy and fluctuation of speed of a system.
4	**Determine** size of a suitable fly wheel for a system.

Unit IV

By the end of the topic, student will be able to

1	**Calculate** the unbalanced forces and couples in rotating systems.
2	**Determine** the magnitude and location of balancing mass for a given rotating system
3	**Calculate** primary and secondary unbalanced forces and couples in in-line and radial reciprocating systems.

Unit V

1	**Explain** the working principles and application of Governors.
1	**Explain** the concept of gyroscopic couple.
2	**Calculate** the magnitude and direction of gyroscopic couple in case of simple mechanical systems.
3	**Analyze** the effect of gyroscopic couple on the motion and stability of ships, aeroplane, two and four wheelers.

Review Questions

1	Discuss conditions to be satisfied for the static equilibrium of a mechanism.
2	Analyze the equilibrium conditions of 2, 3 and 4 force members.
3	Discuss method of superposition for solving static force problems.
4	Explain D'Alembert's principle.
5	Discuss equivalent dynamic system.
6	Discuss correction couple.
7	Write the equation for inertia force due to reciprocating mass in slider crank mechanism.
8	Discuss turning moment diagram.
9	Derive the expression for maximum fluctuation of energy in a flywheel.
10	Write the expression for coefficient of fluctuation of energy.
11	Prove that the maximum fluctuation of energy 'C' is given by C=0.02qE for a flywheel, where E=Mean KE of flywheel and q= total percentage fluctuation of speed.
12	In a punching press, one hole is punched for every rotation of flywheel. Actual punching requires 10 kNm of energy and is completed in 90^o rotation of flywheel. If the punching machine is driven by a constant torque motor, draw a symbolic T-θ diagram indicating the values stated.
13	The maximum primary unbalanced force in a reciprocating engine is 100 N. If the crank and connecting rod lengths are 50 mm and 200 mm respectively, what is the magnitude of maximum secondary unbalanced force?
14	Define static and dynamic balancing.
15	Discuss how single revolving mass is balanced by two masses revolving in different planes.
16	Explain the term partial balancing of primary force. Why it is necessary?
17	Drive an expression for heel angle of a motor cycle to avoid skidding.
18	Explain the stability of a four wheeler automobile negotiating a curve and derive the necessary condition for stability.

Lesson Plan

Unit I

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 II

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 III

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 IV

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 V

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													
Sl No	**Course Outcomes**	**Program Outcomes**											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Recognize** the mechanisms, solve graphically and **determine** the static forces acting in different links of simple planar four bar mechanisms and slider crank mechanism.	M	M	L							M		
2	**Explain** the D'Alembert's principle, **Recognize** the inertia force, inertia torque and line of action of inertia force, solve graphically and **determine** the inertia forces acting on different links of simple planar four bar and slider crank mechanisms.	M	M	L							M		
3	**Recognize** the type of machinery, **calculate** the fluctuation of energy in the system and **determine** the size of a suitable fly wheel for the system.	M	M	L							L		
4	**Calculate** the unbalanced forces and couples in case of mechanical systems having rotating and reciprocating unbalanced masses, and **determine** the magnitude and location of balancing masses.	H	M	M							H		
5	**Explain** the types and working principle of Governors. **Explain** the concept of gyroscopic couple and its effects; **calculate** the magnitude and direction of gyroscopic couple in case of simple mechanical systems and **analyze** the stability of mechanical systems.	M	M	L							L		

Course Plan

Course Title: Design of Machine Elements-I			
Course Code: P13ME52	Sem: 05	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13ME33	Mechanics of Materials	P13ME52	Design of Machine Elements-I	P08ME52	Design of Machine Elements-I
2	P13ME32	Material Science and Metallurgy				

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], Design of Cotter and Knuckle joints, design of flange type of rigid coupling. **12 hrs**

Unit - 2

Theories of failure - Maximum normal stress theory, Maximum shear stress theory, Distortion energy theory. **Stress concentration**, Stress concentration factor, design of simple elements with stress raisers. **Design 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. **12 hrs**

Unit- 3

Impact loading: Impact stresses due to axial, bending and torsional loads, effect of inertia. **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. **10 hrs**

Unit - 4

Threaded joints: Introduction, Stresses in threaded fasteners due to static loading, Effect of initial tension, threaded joints for cylinder covers. **Power screws** - Introduction, Types of screw threads, Design of Power Screws, efficiency, self-locking and over hauling. **08 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 structural (Lozenge) and 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:

Design Data Hand Book by K. Mahadevan and Balaveera Reddy, CBS Publication

Text books:

1. **Mechanical Engineering Design:** Joseph E Shigley and Charles R. Mischke. Tata McGraw Hill Publishing Company, 8th Edition 2008.
2. **Design of Machine Elements:** V.B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

3. **A text book of Machine Design:** R.S. Khurmi and J.K. Gupta, S.Chand & co., 15th Edition.

References:

1. **Theory and problems of Machine Design:** Hall, Holowenko, Laughlin (Schaum's Outlines series), Tata McGraw Hill Publishing Company Ltd., New Delhi., 2008
2. **Machine design:** Robert L Norton, Prentice hall., 2nd Edition, 1998.
3. **A text book of Machine Design:** Dr. Rajendra Karwa, Laxmi Publications, 2nd Edition, 2006.

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 biaxial static loads.
2. **Explain** theories of failure**, determine** stress concentration factors, **Explain** fatigue failure concept**, recognize** the influence of load, surface and size factors on fatigue life and **design** under fatigue loading conditions.
3. **Determine** the stresses in machine elements due to impact loads; **Design** simple power transmission shafts subjected to bending and torsional loads.
4. **Design** threaded joints and power screws.
5. **Design** typical welded joints and riveted joints for boiler and structural applications.

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1 **Explain** failure mechanism of ductile and brittle materials.

2 **Recognize** different materials based on their designation and **identify** their properties.

3 **Determine** the critical stresses acting in simple machine elements subjected to biaxial loading.

4 **Design** simple machine elements like cotter joint, knuckle joint and flange coupling.

Unit II

By the end of the topic, student will be able to

1 **Explain** different theories of failure and determine failure stresses.
2 **Determine** stress concentration factors for different geometries.
3 **Recognize** different types of fatigue loads and **explain** their influence on failure stress.
4 **Design** for infinite life, simple machine elements subjected to fatigue load

Unit III

By the end of the topic, student will be able to

1 **Determine** the stresses acting on simple machine elements due to impact load.

2 **Determine** bending and shear stresses induced in shafts due to different types of transmission elements.

3 **Design** transmission shafts subjected to axial, bending and torsional loads.

Unit IV

By the end of the topic, student will be able to

1 **Recognize** different types of threaded fasteners and **determine** stresses induced in them.
2 **Explain** the effect of initial tension and **design** threaded joints for cylinder covers.
3 **Recognize** different types of power screws and **determine** stresses induced.
4 **Design** power screws for C-clamp, Screw Jack, power press, lead screws, etc.

Unit V

By the end of the topic, student will be able to

1 **Identify** types of rivets and riveted joints.
2 **Analyze** different types of failures of riveted joints.
3 **Design** boiler joints.
4 **Explain** types of welded joints and **determine** stresses induced in welded joints.
5 **Design** simple welded joints.

Review Questions

1. What is the difference between mechanical & physical properties? Give two examples for each.
2. Mention design considerations
3. Define factor of safety. Mention any four points to be considered for selection of factor of safety
4. Define maximum shear stress theory with relevant equation
5. What is stress concentration? Illustrate the methods of reducing stress concentration.
6. A cylindrical pin of dia. 'd' mm and length 'l' mm is supported in a bush. If the transverse load on pin is 'P' N, then the crushing stress acting on the pin is _____
7. Distinguish between crushing stress and bearing stress.
8. If a component is subjected to principal stresses of 40 MPa & 50 MPa and yield strength of the material is 180 MPa, then according to Von Mises theory, the factor of safety is _____.
9. Discuss with necessary figs. and eqns. (i) endurance limit (ii) notch sensitivity factor
10. Discuss Miner's rule.
11. Derive Soderberg equation considering load, size and surface finish factors.
12. A steel spindle transmits 4 kW at 800 rpm. The angular deflection should not exceed 0.25° per metre. If the modulus of rigidity of the material is 84 GPa, find diameter of the spindle and the shear stress induced.
13. Diameter of shaft A is twice that of shaft B and of same material. If A can transmit 80 kW safely, what is the power that can be transmitted by B, running at the same speed?
14. Design a double riveted lap joint with zig-zag riveting for 13 mm thick plates. Assume σ_t = 80 MPa ; τ = 60 MPa ; and σ_c = 120 MPa. Find the efficiency of the joint.
15. A cam shaft 20 mm in diameter is mounted on ball bearings and carries a cam midway between the bearings. The distance between the bearings is 150 mm. The follower which weighs 2500 N is out of adjustment so that impact is produced when it is contacted by the cam. The height of the follower end is 0.25 mm. Determine (i) bending stress due to impact and (ii) deflection due to impact.

Lesson Plan

Unit I

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. Design of Cotter joint
9. Numerical problems
10. Design of Knuckle joint; Numerical problems
11. Design of flange type of rigid coupling
12. Numerical problems

Unit II

1. Introduction, failure concepts, Maximum normal stress theory, design equation, design space
2. Maximum shear stress theory, design equation, design space
3. Distortion energy theory, design equation, design space
4. Numerical problems
5. Numerical problems
6. Stress concentration factor, design of simple elements with stress raisers
7. Introduction to fluctuating load, types of fluctuating loads, fatigue and endurance limit, S-N Diagram
8. Endurance limit modifying factors: load, size and surface factors, Stress concentration effects; notch sensitivity, design for infinite life
9. Soderberg and Goodman relationship, derivation of equation

10 Numerical problems
11 Numerical problems
12 Stresses due to combined loading, Numerical problems

Unit III

1 Introduction to impact loading, types of impact, impact stress due to axial load
2 Impact stress due to bending and torsional loads
3 Numerical problems
4 Numerical problems
5 Introduction to transmission shafts, types of shafts, loads on shafts
6 Stresses induced in shafts due to different loads, ASME code for shaft design
7 Numerical problems
8 Numerical problems
9 Numerical problems
10 Numerical problems

Unit IV

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

Unit V

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											
	1	2	3	4	5	6	7	8	9	10	11	12
Explain basic design concept and **design** simple machine elements subjected to biaxial static loads.	**M**	**M**	**L**									
Explain theories of failure**, determine** stress concentration factors, **Explain** fatigue failure concept**, recognize** the influence of load, surface and size factors on fatigue life and **determine** safe stresses under fatigue loading conditions.	**M**	**M**	**L**									
Determine the stresses in machine elements due to impact loads; **Design** simple power transmission shafts subjected to bending and torsional loads.	**M**	**M**	**L**									
Design threaded joints and power screws.	**M**	**M**	**L**									
Design riveted joints and welded joints.	**M**	**M**	**L**									

Course Title: Turbomachines			
Course Code: P13ME53	Semester: 05	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	**Prerequisites Course 2013-14**		**Course of Regulations 2013-14**		**Equivalent Course for 2008-09**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P13ME35	Basic Thermodynamics	P13ME53	Turbomachines	P08ME53	Turbomachines
2	P13ME45	Fluid mechanics				

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. **Fundamentals of Turbomachinary:** B K Venkanna**,** PHI Learning Pvt Limited
2. **Turbomachines:** A Valan Arasu **,**Vikas Publishing House Pvt Ltd.
3. **Principles of Turbo Machinery;** D.G.Shepherd, the Macmillan Company (1964).

References

1. **Gas Turbines**: V.Ganesan Tata McGraw – Hill Company Limited 2nd Edition (2002).
2. **Turbines Compressors and Fans:** S.M.Yahya**,** , Tata-McGraw Hill Co.,2nd Edition (2002).
3. **A Treatise on Turbo machines:** G.Gopalakrishnan, D.Prithviraj**,** Scitech Publications (India) Pvt. Limited (2002).
   An introduction to energy conversion: V.Kadambi and Monohar Prasad**,** Volume III – Turbomachinery, , Wiley Eastern Ltd. (1977)

Course Outcomes

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

1. **Recognize** the principles and operations of Turbo-machines
2. **Illustrate** the momentum principles & its applications to various fluid machinery
3. **Apply** preliminary design fundamentals of turbomachines including axial and radial flow turbines.
4. **Apply** basics of fluid mechanics on hydraulic machineries like hydraulic turbines, pumps, and steam turbines
5. **Evaluate** the performance parameters of pumps and turbines with the use of velocity triangles

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1	Define and classify turbomachines and Comparison with positive displacement machines
2	Derive Euler turbine equation and appreciate alternate form of equations and significance of components involved in them
3	Understand the concept of velocity triangles, degree of reaction and utilization factor
4	Derive condition for maximum utilization in Impulse, reaction and 50% reaction turbine
5	Draw Velocity triangles for different values of degree of reaction.

Unit II

By the end of the topic, student will be able to

1	Classify hydraulic turbines.
2	Identify Unit quantities and their significance
3	Understand working of Pelton wheel and its Components
4	Evaluate Design parameters of Pelton turbines
5	Analyse the Turbine efficiencies and performance curves of Pelton wheel

Unit III

By the end of the topic, student will be able to

1	Classification of reaction turbines
2	Draw velocity triangle for reaction turbines
3	Understand types of draft tube and their functions
4	Evaluate Design parameters of Francis turbines
5	Evaluate Design parameters of Kaplan turbines

Unit IV

By the end of the topic, student will be able to

1	Classify of steam turbines
2	Explain need for compounding
3	Velocity triangles, power and efficiency for impulse turbine
4	Explain the Effect of friction and blade angles on blade efficiency.
5	Derive the condition for maximum utilization factor and condition for maximum efficiency.
6	Understand the importance of Reheat factor and stage efficiency.

Unit V

1	Understand the main parts of centrifugal pump
2	Understand different terminologies related to centrifugal pump
3	Analyze the working of centrifugal pump

4 Explain the concept of priming ans cavitation in centrifugal pump
5 Analyze the working of axial flow pump

Review Questions

1 Briefly discuss how the turbomachines are classified
2 Compare turbomachines and positive displacement machines
3 Derive an alternate form of Euler's equation and explain significance of each component.
4 Draw velocity triangles for different values of reaction
5 Discuss the design parameters for Pelton wheel
6 Explain the performance characteristics of Pelton wheel
7 Explain the effect of blade discharge angle and degree of reaction on turbomachine with radial flow.
8 Explain the working of Francis turbine
9 Explain the working of Kaplan turbine
10 What is the purpose of draft tube , explain different types of draft tube
11 Define i) utilization factor ii) hydraulic efficiency iii) Blade efficiency iv) stage efficiency
12 What is the need for compounding and explain velocity - pressure compounding with suitable sketch
13 Derive an expression for degree of reaction in terms of blade angle for axial flow pumps and compressors.
14 Derive an expression for maximum work and maximum blade efficiency in a single stage impulse turbine

Lesson Plan

Unit I

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 II

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 III

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 IV

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 V

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											
	1	2	3	4	5	6	7	8	9	10	11	12
Recognize about the principles and operations of Turbo-machines	**M**	**L**			**L**							
Illustrate the momentum principles & its applications to various fluid machinery	H	**L**			**L**							
Apply preliminary design fundamentals of turboma including axial and radial flow turbines and axia centrifugal flow compressors.	**M**	**L**			**L**							
Apply basics of fluid mechanics on hydraulic machineries like hydraulic turbines, pumps, and steam turbines	**M**	**M**			**L**							
Evaluate the performance parameters of pumps, compressors, turbines with the use of velocity triangles	**M**	**M**			**L**							

Course Title: MANUFACTURING PROCESS - III			
Course Code: P13ME54	Semester: 05	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50%; SEE:50%	

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

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 etc, 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. Variables in extrusion. 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. **08hrs**

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. **Mechanical Metallurgy:** G.E. Dieter, Mc Graw Hill pub.2001 **(SI units),**
2. **Manufacturing Engineering and Technology:** SeropeKalpakjian & Stevan

References

1. **Materials and Processes in Manufacturing**: E.paul,Degramo,J.T. Black,Ronald, A.K. Prentice -hall of India 2002
2. **Principles of Industrial metal working process:** G.W.Rowe,CBSpub2002
3. **Manufacturing Science:** AmitabhaGhosh & A.K.Malik - East-West press,

Theory of Plasticity: Sadhu Singh

Course Outcomes

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

1. **Describe** different metal working processes and its applications.
2. **Describe** 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.

Topic Learning Objectives

Unit I

By the end of the topic, student will be able to

1 **Identify** metal working processes.
2 **Discuss** concepts of true stress, true strain and other stresses.
3 **Compute** principal stresses and flow stress of metal workpiece.
4 **Explain** residual stresses in wrought products.

Unit II

By the end of the topic, student will be able to

1 **Identify** forging machines and equipment.
2 **Describe** forging die design parameters.
3 **Develop** expressions for residual stresses in forging.
4 **Explain** different types rolling mills.

Unit III

By the end of the topic, student will be able to

1 **Discuss** types of extrusion processes.
2 **Explain** defects in extruded products.
3 **Describe** types of wire drawing processes.
4 **Develop** expression for drawing load by slab analysis.

Unit IV

By the end of the topic, student will be able to

1 **Explain** different processes of sheet metal working.
2 **Describe** types dies used in sheet metal work.
3 **Explain** different type's deep drawing processes.
4 **Discuss** deep drawing process.

Unit V

By the end of the topic, student will be able to

1 **Discuss** basic steps in powder metallurgy.
2 **Explain** mechanism of sintering.
3 **Illustrate** processing of plastics.
4 **Illustrate** processing of ceramics.

Review Questions

1	Explain different types of classification of metal working process.
2	Define and derive expressions for true stress and true strain.
3	Explain forging die design parameter.
4	Briefly explain the different forging defects.
5	With the help of neat sketches explain different types of rolling mills.
6	With suitable sketches, explain direct and indirect extrusion.
7	With a neat sketch explain different zones of a drawing die.
8	Briefly explain roll forming.
9	List the different methods of producing metal powders and explain any method.
10	Briefly explain the effect of sintering conditions on the density of the part.

LESSON PLAN

Unit I

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.
4	Concepts of true stress, true strain, triaxial & biaxial stresses.
5	Determination of flow stress. Principal stresses, Tresca & von-Mises yield criteria
6	Concepts of plane stress & plane strain.
7	Temperature, strain rate, friction and lubrication, hydrostatic pressure in metalworking.
8	Deformation zone geometry Residual stresses in wrought products,

Unit II

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	Simple problems on residual stresses in forging.
6	Introduction to rolling and classification of Rolling processes.
7	Types of rolling mills, expression for Rolling load. Roll separating force.
8	Frictional losses in bearing etc, power required rolling, Effects of front & back tensions, frictions, friction hill.
9	Maximum possible reduction, defects in rolled products.
10	Problems on rolling variables.

Unit III

1	Introduction to extrusion types, Application, Variables in extrusion.
2	Extrusion dies, Variables in extrusion.
3	Relationship between speed of extrusion and extrusion pressure.
4	Special extrusion processes: Impact extrusion, hydrostatic extrusion, extrusion of brittle metals, Seamless Tube extrusion.
5	Closed cavity extrusion, Powder extrusion. Metal flow pattern in extrusion with and without lubrication.
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. Drawing equipment & dies, Drawing speed Vs wire diameter.
9	Drawing stress Vs strain, Expression for drawing load by slab analysis.
10	Power requirement. Redundant work and its estimation, optimal cone angle & dead zone formation, drawing variables.
11	Tube drawing process and classification of tube drawing, problems.

Unit IV

1	Introduction to sheet metal working and forming.

2 Forming methods dies & punches, progressive die, compound die, combination die. Rubber forming.
3 Rubber forming. 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 Deep drawing, stresses in deep drawing, Simple problems.

Unit V

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

Course Articulation Matrix

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

Course Plan

Course Title: ENGINEERING ECONOMICS			
Course Code: P13ME55	Semester : 05	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hrs Exam: 3 Hrs		Weightage: CIE:50%; SEE:50%	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	**Prerequisites Course 2013-14**		**Course of Regulations 2013-14**		**Equivalent Course for 2008-09**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P13MA11/21	Engineering Mathematics – I & II	P13ME33	Mechanics of Materials	P08ME33	Mechanics of Materials
2	P13CV13	Engineering Mechanics				

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. **Engineering Economics:** TARACHAND
2. **Industrial Management Engg & Economics:** Banga & Sharma.

References

1. **Engineering Economics:** Thuesen Prentice Hall
2. **Engineering Economics:** Ritz Grant & Ireson Ranald Press Co.
3. **Mechanical Estimating & Costing:** Kannapan Augutine & Paramdhaman Tata McGraw Hill.
4. **Engineering Economics** Horengren

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. taxation system.
2. **Understand** different types of interest rates causes for charging interest, interest factor for single payment, uniform series payment, arithmetic gradient. Evaluate alternatives based on PW method, annual worth method, rate of returns method for the purpose of investment
3. **Define** depreciation, cause of depreciation and **Calculate** depreciation by different methods **Perform** replacement analysis without- considering money value, considering money value, individual replacement and group replacement.
4. **Estimate** the cost of given component by reading the drawing and performing cost accounting and break even analysis.

Estimate costing, break even analysis and minimum cost analysis, material cost, labour cost, sunk cost, marginal cost, Allocation of Overheads by Different Methods, Man Hour Rate and Machine Hour Rate.

Topic Learning Objectives (Unit-wise)

Unit I

By the end of the topic, student will be able to

1	**Define** Economic Terms
2	**Define** and **Classify** Goods, Wants, Wealth
3	**Explain** Demand, Equilibrium Demand Theory, Law of Demand, Price Elasticity of Demand
4	**Explain** Supply, Law of Supply
5	**Explain** Supply, Law of Supply
6	**List** Types of Wages
7	**Define** Taxation, Principle of Taxation
8	**Explain** Characteristics of a good Taxation System
9	**List** Kind of Taxes and their Merits and Demerits.

Unit II

By the end of the topic, student will be able to

1	**Explain** Simple and Compound Interest
2	**Apply** Interest Formulae to solve Numerical Problems
3	**Solve** Numerical Problems on Present worth method
4	**Solve** Numerical Problems on Equivalent Annual cost method
5	**Solve** Numerical Problems on Rate of Return method

Unit III

By the end of the topic, student will be able to

1	**Define** Depreciation, cause of depreciation
2	**Explain** Methods of Calculating Depreciation
3	**Solve** Numerical Problems on Straight Line Method, Sinking Funds Method, Sum of the Year Digits Methods, Declining Balance
4	**Define** Basic reasons of Replacement
5	**Explain** Present Asset and its Replacement, Consideration Leading to Replacement
6	**Explain** Installation and Removal Cost

Unit IV

By the end of the topic, student will be able to

1	**Explain** Procedure for Estimation
2	**Estimate** the Weight of Raw Materials
3	**Estimate** Material Cost

Unit V

By the end of the topic, student will be able to

1	**Define** Costs & Cost Accounting
2	**Explain** First Cost, Fixed Cost, Variable Cost, Incremental Cost, Sunk Cost and

Marginal Cost

3 **Describe** Break Even Analysis & Minimum Cost Analysis

4 **Solve** Numerical Problems on Allocation of Overheads by Different Methods, Man Hour Rate, Machine Hour Rate

Review Questions

1 Define wants. Explain characteristics of wants.

2 Explain price elasticity of demand? State the factors governing the price elasticity of demand

3 Explain the Law of Returns. Explain Marginal and Total Utility.

4 A machine is purchased for rs.75000. Its erection and installation cost is rs.5000. The salvage value of the machine is rs.20000. Calculate the depreciation fund accrued using
(i) Straight line method after 5 years.
(ii) Diminishing balance method after 2 years

5 A machine costs rs.500000 and has a useful life of 15 years after which scrap value is rs.50000. Find
(i) Book value at the end of 6 years by sum of year digit method
(ii) Depreciation in 10^{th} year by sinking fund method if interest rate is 10.5% compounded annually.
(iii) Depreciation in 5^{th} year by diminishing balance method

6 Mr. X plans to buy a house for 15lac rupees by making a down payment of 3lac rupees to take out 30 years of mortgage for the remaining amount at 10% per year. Determine
(i) Monthly payment if compounding is monthly
(ii) Half yearly payment if the amount is compounded half yearly
(iii) Monthly payment if compounding is half yearly.

7 Determine effective interest rate for a nominal interest rate of 9% when compounded (i) quarterly (ii) monthly

8 What is the present value of series of prospective receipts of rs.15000 for 15 years at 15% compounded annually?

9 For the following alternatives suggest the best plan based on Present worth comparison method using an interest rate of 7% compounded annually

Particulars	Plan A	Plan B
First Cost	2000 Rs	8000 Rs
Annual Cost	3200 Rs	700 Rs
Life in Years	6	6

10 Two types of converters A and B are under consideration for a particular application. An economic is made at an interest rate of 10%. The estimation is as follows. What is your recommendation based on present worth comparison method.

Particulars	A	B
Purchase Price	21000 Rs	25000 Rs
Estimated Life	6 years	9 years
A.O.C	250	120
Salvage Value	3000 Rs	5000 Rs

11 A manufacturer of a certain product has 2 Alternatives. Alternative 1 involves getting the machine for 5900Rs and a salvage value after 10 years is 400Rs. Alternative 2 involves getting the machine on lease. The Lease amount is 792Rs per year. What are your recommendations based on Rate of Return Method. Write Cash Flow Diagrams.

12 Following information is available about a company. Total fixed cost is 8000Rs, Total Variable cost is 12000Rs, Total Sales Revenue is 25000Rs and units sold are 4000 units Calculate (i) Contribution (ii) Break Even Sales in Units (iii) Profit (iv) MOS.

13 A factory produces 2 components A and B. Component A requires 20 hours and is manufactured by the workers paid at a rate of 10rs/hr, While Component B also requires 20 hours, but the workers producing it are paid at the rate of 7.5rs/hr. Find the On Cost,

if (a) it is 40% of direct labour cost (b) Rs. 4 per man hour.

14 A firm is manufacturing 8000 Valves per year. The expenses are as follows, Direct Material Cost is 110400Rs, Direct Labour Cost 95600Rs, Factory Overheads is 110% of Direct Material Cost, Administrative overheads is 15% of factory cost, Sales Overheads is 11% of all the above cost. Find selling price of unit, if the expected profit id 14% of selling price.

Lesson Plan

Unit I

1 Definition and Meaning of Economic
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
7 Supply, Law of Supply
8 Terms Utility, Total and Marginal Utility
9 Types of Wages
10 Taxation, Principle of Taxation
11 Characteristics of a good Taxation System
12 Kind of Taxes and their Merits and Demerits.

Unit II

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

Unit III

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 IV

1 Estimation of Material Cost
2 Procedure for Estimation
3 Estimating the Weight of Raw Materials
4 Estimating Material Cost
5 Numerical Problems.

Unit V

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													
Sl No.	**Course Outcomes**	**Program Outcomes**											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Understand** the basic concept and terminology used in engineering economics- goods, wants, wealth etc. taxation system.	**M**						**L**					
2	**Understand** different types of interest rates causes for charging interest, interest factor for single payment, uniform series payment, arithmetic gradient. Evaluate alternatives based on PW method, annual worth method, rate of returns method for the purpose of investment	**M**				**M**		**L**			**L**		
3	**Define** depreciation, cause of depreciation and **Compute** depreciation by different methods. **Perform** replacement analysis without- considering money value, considering money value, individual replacement and group replacement.	**L**	**L**			**M**	**M**						
4	**Estimate** the cost of given component by reading the drawing and performing cost accounting and break even analysis.	**M**				**L**					**L**		
5	**Estimate** costing, break even analysis and minimum cost analysis, material cost, labour cost, sunk cost, marginal cost, Allocation of Overheads by Different Methods, Man Hour Rate and Machine Hour Rate.	**M**							**L**		**M**		

Course Title: MECHATRONICS & MICROPROCESSOR			
Course Code: P13ME56	Semester: 05	L-T-P-H: 4-0-0-4	Credits: 4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE: 50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13EC15/25	Basic Electronics Engineering	P13ME56	Mechatronics & Microprocessor	P08ME56	Mechatronics & Microprocessor
2	P13EE12/22	Basic Electrical Engineering				

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.

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, 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. **12 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. **Mechatronics:** W. Bolton, Longman, 2Ed, Addison Wesely Longman, Pearson? Pub, 1999 (Delhi).
2. **Introduction to microprocessor**: A P Mathur 3rd edition,.
3. **Microprocessor Architecture, programming and applications with 8085/8085A**: R S Ganokar, Wiley Eastern.

References

1. **Digital computer Electronics:** Malvino.
2. **Mechatronics & Microprocessors:** K P Ramachandran, G K Vijaya Raghava, M S Bala sundaram, Wiley

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 identify 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

Topic Learning Objectives (Unit Wise)

Unit I

By the end of the topic, student will be able to

1 **Define** Mechatronics systems.
2 **Define** Open & Closed loop control systems.
3 **Explain** Basic elements of closed loop control system
4 **Determine** Microprocessor - based controllers & different types of ensors.

Unit II

By the end of the topic, student will be able to

1 **Define** Different types of Actuation systems.
2 **Explain** Mechanical switches, relays, solid state switches, diodes
3 **Determine** different types of motors
4 **Judge** merits and demerits of different motors

Unit III

By the end of the topic, student will be able to

1 **Identify** signal conditioning process.
2 **Formulate** inverting and non- inverting operational amplifiers.
3 **Determine** different types of signals.
4 **Analyse** ADC DAC**.**

Unit IV

By the end of the topic, student will be able to

1 **Explain** Evolution of Microprocessor, Organization of Microprocessor.
2 **Formulate** organization of INTEL 8085
3 **Determine** Data and Address busses, registers in the 8085.
4 **Discuss** instruction set of 8085, instruction types
5 **Describe** CPU of Microprocessors, the fetch operation, execute cycle, HALT and HOLD states.

Unit V

1 **Define** Positional number system.
2 **Formulate** different number systems.
3 **Describe** accuracy and range in floating point numbers.
4 **Identify** logic gates **demonstrate** AND, OR, NOT, NAND, NOR and EXCLUSIVE – OR gate, Boolean algebra..

Review Questions

1 Define generalized measurement system.

2 Sketch and explain basic elements of closed loop control system.
3 List different types of light sensors, explain photodiode..
4 Sketch and explain Hall-effect sensor.
5 Explain mechanical switched.
6 Sketch and explain brushless permanent magnet DC motors.
7 Explain signal conditioning process.
8 Derive and expression to find total voltage gain in non- inverting operational amplifiers.
9 Explain Data Acquisition system.
10 Sketch and explain different types of filters.
11 Explain Evolution of Microprocessor.
12 Differentiate machine, assembly and High level language programming.
13 Explain instruction set of 8085.
14 Explain different laws in Boolean algebra

Lesson Plan

Unit I

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 II

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 III

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 IV

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 V

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											
	1	2	3	4	5	6	7	8	9	10	11	12
Identify Mechatronics system, measurement systems, Open & Closed loop control systems and identify different types of sensors.	**M**	**M**	**L**									
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	**M**	**M**										
Analyse signal conditioning process, , protection, filtering, Multiplexers, Data Acquisition system.	**M**	**M**										
Evaluate Organization of Microprocessor, instructions, machine and mnemonics codes, machine and assembly language programming, High level language programming.	**M**	**M**	**L**									
Generate decimal number system, Hexadecimal number system, conversion from one number system to another, negative number representation	**M**	**M**	**L**									

Course Title: MACHINE SHOP LABORATORY			
Course Code: P13MEL57	Semester: V	L-T-P-H : 0-0-3-3	Credits: 1.5
Contact Period: Practicals: 36 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13ME34	Manufacturing process-I	P13MEL57	Machine shop Laboratory	P08MEL57	Machine shop Laboratory
2	P13ME46	Manufacturing process-II				

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

Sl. No.	Course Outcomes
	At the end of the course the students should be able to:
1	**Prepare** a model to **Carry out** the following operations such as plain turning, Taper turning, Step turning, facing, Knurling, Eccentric turning using lathe.
2	**Carry out** cutting of gear teeth using milling Machine.
3	**Carry out** cutting of v-groove/rectangular/dovetail groove using shaping machine.
4	**Demonstrate** Surface Grinding.

Course Content

PART-A

Exp-1 Lathe operations on model-1 operations like plain turning, facing, knurling, taper turning and thread cutting.	**6Hrs**
Exp-2 Lathe operations on model-2.	**6Hrs**
Exp-3 Preparation of eccentric model by lathe machine using 4-jaw chuck.	**6Hrs**

PART-B

Exp-4 Gear teeth cutting on model1 using milling machine.	**6Hrs**
Exp-5 Performing grooving operation on model 2 using shaping machine.	**3Hrs**
Exp-6 Surfacing grinding operation on model 3 using grinding machine.	**3Hrs**
Seminar/viva	**3Hrs**
Test	**3Hrs**

	References
1	**Workshop Technology:** Hazara Choudhry **vol 2**
2	**Production Technology**: HMT.

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	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Prepare a model to **Carry out** the following operations such as plain turning, Taper turning, Step turning, facing, Knurling, Eccentric turning using lathe.				**M**	**M**					**M**		
Carry out cutting of gear teeth using milling Machine.				**M**	**M**					**M**		
Carry out cutting of v-groove/rectangular/dovetail groove using shaping machine.				**M**	**M**					**M**		
Demonstrate Surface Grinding.					**M**							

Course Title: Energy Conversion Engineering Laboratory			
Course Code: P13MEL58	Semester: V	L-T-P-H : 0-0-3-3	Credits
Contact Period: Practicals: 36 Hr; Exam: 3 Hrs		Weightage: CIE:50%; SEE:50%	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13ME33	Basic Thermodynamics	P13MEL58	Energy Conversion Engineering Laboratory	P08MEL58	Energy Conversion Engineering Laboratory
2	P13ME42	Applied Thermodynamics				

Course Objective: The course aims at empowering the students with practical knowledge about properties of fuels, performance of IC Engines as well as skill enhancement.

Course Outcomes

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

1. Identify safe operating practices and requirements for laboratory experiments
2. Determine properties like Flash point, Fire point, and viscosity of lubricating oil
3. Estimate the calorific value of solid and gaseous fuel
4. Demonstrate Valve, Timing/port opening diagram of an I.C. engine and uses of planimeter
5. Carry out performance test on I.C.Engine.
6. Function effectively as a member of a team
7. Prepare and present clear and concisely written lab reports

Course Content

PART-A

Exp-1 Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Pensky Apparatus. **3Hrs**

Exp-2
Use of planimeter **3Hrs**

Exp-3
Determination of Calorific value of solid fuel using Lewis Thomson calorimeter. **3Hrs**

Exp-4
Determination of Calorific value of gaseous fuels using Junkers Gas calorimeter. **3Hrs**

Exp-5
Determination of Viscosity of lubricating oil using Redwoods, Saybolts and Torsion Viscometers. **3Hrs**

Exp-6
Drawing Valve Timing diagram of an I.C. engine. **3hrs**

PART-B

Exp-7 **3hrs**
Four stroke Diesel Engine

Exp-8 **3hrs**
Four stroke Petrol Engine

Exp-9 **3hrs**
Two stroke Petrol Engine

Exp-10 **3hrs**
Morse test on Multi Cylinder Engine.

Seminar **3Hrs**

Test **3Hrs**

References

1 **Internal combustion engine:** M.L .Mathur and R.P.Sharma , Dhanpat Rai and Co

2 **Basic and Applied thermodynamics:** P.K.Nag, Tata McrGraw Hill, third edition 2006

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	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Identify safe operating practices and requirements for laboratory experiments		**L**										
Determine properties like Flash point, Fire point, and viscosity of lubricating oil	**L**	**M**		**M**								
Estimate the calorific value of solid and gaseous fuel	**L**	**M**		**M**								
Demonstrate Valve, Timing/port opening diagram of an I.C. engine and uses of planimeter	**L**	**M**		**M**								
Carry out performance test on I.C.Engine.	**L**	**M**		**M**								
Function effectively as a member of a team									**L**			
Prepare and present clear and concisely written lab reports										**M**		

Sixth Semester
Course Plan

Course Title: Design of Machine Elements-II			
Course Code: P13ME61	Sem: VI	L-T-P-H: 2-2-0-4	Credits: 3
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE: 50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13ME44	Kinematics of Machines	P13ME52	Design of Machine Elements II	P08ME52	Design of Machine Elements II
2	P13ME52	Design of Machine Elements I				

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

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:

Design Data Hand Book by K. Mahadevan and Balaveera Reddy, CBS Publication

Text books

1. **Mechanical Engineering Design:** Joseph E Shigley and Charles R. Mischke. Tata McGraw Hill Publishing Company, 8th Edition 2008.
2. **Design of Machine Elements:** V.B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

3	**A text book of Machine Design:** R.S. Khurmi and J.K. Gupta, S.Chand & co., 15th Edition.

References

1	**Theory and problems of Machine Design:** Hall, Holowenko, Laughlin (Schaum's Outlines series), Tata McGraw Hill Publishing Company Ltd., New Delhi, 2008
2	**Machine design:** Robert L Norton, Prentice hall., 2nd Edition, 1998.
3	**A text book of Machine Design:** Dr. Rajendra Karwa, Laxmi Publications, 2nd Edition, 2006.

Course Outcomes

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

1. **Design** 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.
3. **Recognize** safety aspects related to pressure vessels.
4. **Design** spur, helical, bevel and worm gears.
5. **Design** simple clutches and brakes, with an understanding of safety issues related to brakes.
6. **Design** sliding and rolling contact bearings.

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1	**Derive** the equation for stress induced in spur gear tooth.
2	**Design** spur gears based on strength and wear considerations.
3	**Design** Helical gears based on strength and wear considerations.
4	**Design** Bevel gears based on strength and wear considerations.
5	**Design** Worm gears based on strength and wear considerations, calculate amount of heat generated, heat dissipated and efficiency of gear drive.

Unit II

By the end of the topic, student will be able to

1	**Classify** springs, **Derive** expressions for stress and deformation of helical springs
2	**Design** helical springs under static and fluctuating loads
3	**Derive** expressions for stress and deformation of laminated springs
4	**Design** laminated springs under static loads

Unit III

By the end of the topic, student will be able to

1	**Explain** about pressure vessels
2	**Derive** expression for stresses induced in thick cylinders
3	**Explain** autofrettage
4	**Determine** the thickness of cylindrical pressure vessel subjected to internal and external pressure

Unit IV

By the end of the topic, student will be able to

1	**Explain** working principle and types of clutches
2	**Design** single plate, multi plate and cone clutches
3	**Explain** working principle and types of brakes
4	**Design** single block brakes and simple band brakes

Unit V

By the end of the topic, student will be able to

1	**Explain** the principle of hydrodynamic lubrication
2	**Derive** expression for coefficient of friction; **Explain** power loss and heat generated in journal bearings
3	**Explain** bearing characteristic number and Sommerfeld number
4	**Design** journal bearings

5 **Classify** different types of rolling contact bearings
6 **Explain** static and dynamic load carrying capacity; rated life of bearing
7 **Select** standard rolling element bearing based on application

Review Questions

1 Derive Lewis equation for a spur gear and state the assumptions made.
2 A pair of spur gears is required to transmit 25 kW at 300 rpm with a speed reduction of 3:1. The centre distance between them is 40mm. The pinion is made of SAE1030 steel and gear from cast steel. The teeth are 20° full depth involute. Design the gears.
3 Discuss the merits and demerits of worm gear drive over other gear drives
4 A pair of bevel gears transmits 8 kW at 300 rpm of the pinion. The pitch diameters of the pinion and gear at their larger ends are 150 mm and 200 mm respectively. Face width of the gears is 40 mm. Design suitable gears.
5 Derive the expression for formative number of teeth of a bevel gear.
6 The valve spring of a petrol engine is 40mm long when the valve is open and 48 mm when the valve is closed. The spring loads are 200N when the valve is closed and 400 N when the valve is open. The inside diameter of the spring, should not be less than 25mm. Design the spring.
7 An automotive leaf spring consisting of 10 graduated leaves and two full length leaves is supported at two points 1000 mm apart. The central load is to be 50 kN. The width of central band is 120 mm. The material of the leaves has a design stress of350MPa and a modulus of elasticity of 207GPa. The ratio of total depth of spring to its width is 2.5. Determine: i) Width and thickness of leaves ii) Central bolt load iii) Initial gap between the full length and graduated leaves.
8 A steel tube 240 mm external diamater is shrunk on another steel tube of 80 mm internal diameter. After shrinking, the diameter at the junction is 160 mm. Before shrinking, the difference of diameters at the junction was 0.08 mm. If the Young's modulus for steel is 200 GPa, find [1] tangential stress at the outer surface of the inner tube; [2] tangential stress at the inner surface of the outer tube ; and [3] radial stress at the junction.
9 A cast iron cylinder of inside diameter 160 mm in subjected to a pressure of 15 N/mm^2. The permissible working stress for the cast iron may be taken as 25 MPa. If the cylinder is closed by a flat head cast integral with the cylinder walls, find the thickness of the cylinder wall and the flat head.
10 Explain briefly the uniform pressure theory and uniform wear theory as applicable to friction clutches and brakes.
11 Explain the significance of Bearing Characteristic Number in the design of sliding contact bearings.
12 Derive Petroff's equation for coefficient of friction in jurnal bearings
13 Determine the power loss in a Journal bearing 100 mm in diameter and 150 mm long. The radial clearance is 0.05 mm. Speed of the journal is 1000 rpm. SAE10 oil is used. Operating temperature is 60°C.
14 A 6203 single row deep grove ball bearing is subjected to a radial load of 1350N and axial load of 1260N. What is the rated life of the bearing?

Lesson Plan

Unit I

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 II
1	Introduction, types of springs, terminology
2	Derivation of equations for stress induced in helical springs and deflection
3	Design of springs under static and dynamic loads
4	Numerical problems
5	Numerical problems
6	Numerical problems
7	Laminated springs - equations for stress induced and deflection
8	Pre-stressing of leaf springs, equalized stresses
9	Numerical problems
10	Numerical problems
	Unit III
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 IV
1	Introduction, working principle, types of clutches
2	Uniform pressure theory, Uniform wear theory
3	Design of single plate clutch.
4	Design of multi plate clutch
5	Design of cone clutch.
6	Numerical problems
7	Introduction to brakes, classification of brakes.
8	Design of block brakes
9	Design of band brakes
10	Numerical problems
	Unit V
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	Rolling contact bearings - types of bearings, static equivalent load, dynamic load rating, bearing life.
8	Method of selection of rolling element Bearings
9	Numerical problems
10	Numerical problems

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
1. **Design** spur, helical, bevel and worm gears	M	M	L									
2. **Design** helical and leaf springs.	M	M	L									
3. **Determine** stresses in cylindrical pressure vessels with different types of fits.	M	M	L									
4. **Design** simple clutches and brakes	M	M	L									
5. **Design** sliding and rolling contact bearings.	M	M	L									

Course Title: Mechanical Vibrations			
Course Code: P13ME62	L-T-P-H : 4-0-0-4	Semester: VI	Credits: 4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13PH12	Engineering Physics	P13ME62	Mechanical Vibrations	P08ME62	Mechanical Vibrations
2	P13CV13	Engineering Mechanics				
3	P13ME33	Mechanics of Materials				

Course Objectives: 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.

10hrs

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. **Mechanical vibrations:** G.K. Grover, Nem Chand & brothers, Roorkee.
2. **Mechanical Vibrations:** V.P. Singh, Dhanpat Rai & Company Pvt. Ltd.

References

1. **Mechanical Vibrations**: S.S. Rao, Pearson Education Inc, 4th Edition, 2003.
2. **Mechanical Vibrations:** S. Graham Kelly, Schaum's Outline Series, Tata McGraw Hill, Special Indian edition, 2007.
3. **Theory & Practice of Mechanical vibrations:** J.S. Rao & K. Gupta, New Age International Publications, New Delhi, 2001.
4. **Elements of Vibrations Analysis:** Leonanrd Meirovitch, Tata McGraw Hill, Special

Indian edition, 2007.
5. **Mechanical Vibrations:** Austin H Church, John Wiley & Sons.

Course Outcomes

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

1. **Formulate** mathematical models of single degree of freedom, free, undamped and damped vibrating systems and **determine** their natural frequencies. **Formulate** mathematical models for damped free vibratory systems.
2. **Determine** 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. **Compute** harmonics of general forcing functions using Fourier series.
4. **Formulate** mathematical models and **Solve** vibration problems related to Two degrees of freedom. **Determine** influence coefficients.
5. **Solve** multi degree of freedom systems using Rayleigh and Dunkerley, Stodola, Holzer and Matrix iteration methods.

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1	**Classify** the vibratory systems.
2	**Formulate** the governing differential equations of motion for the single degree of freedom undamped-free vibrating systems using Newton's second law or Energy methods and **Express** their natural frequencies.
3	**Sketch** an equivalent spring-mass vibratory system for a single dof system having multi masses and springs.
4	**Formulate** governing differential equations of motion to the single dof damped-free vibratory systems and **Express** their solutions.
5	**Use** logarithmic decrement curve to **Estimate** the actual damping present in the vibratory system.

Unit II

By the end of the topic, student will be able to

1	**Formulate** the expression for transient and steady state vibration of a system subjected to harmonic excitation or excitation due to unbalanced force.
2	**Determine** force and motion transmissibility of vibratory system.
3	**Estimate** the spring stiffness and damping coefficients to minimize force and/or motion transmissibility of the system.
4	**Estimate** the frequency ratios to minimize steady state amplitude of vibration and/or force and motion transmissibility of the system.

Unit III

By the end of the topic, student will be able to

1	**Explain** the working principle of vibrometer, velocity pick up and accelerometer.
2	**Determine** whirling speed of shaft and its maximum deflection under whirling or operating speeds.
3	**Estimate** dynamic force transmitted from the vibrating shaft to bearings.
4	**Estimate** maximum and minimum bending stress developed in the shaft due to its deflection.
5	**Compute** harmonics of general forcing functions using Fourier series.

Unit IV

By the end of the topic, student will be able to

1	**Formulate** governing differential equations of motion for Two degree of freedom systems.

2 **Solve** governing differential equations of motion of free vibration of two dof systems in terms of initial conditions and **Express** their equation of motion.

3 **Estimate** natural frequencies and corresponding mode shapes of two degree of freedom systems having rectilinear and angular modes as well as combined rectilinear and angular modes.

4 **Design** undamped vibration absorber.

5 **Determine** influence coefficients of mechanical systems.

Unit V

By the end of the topic, student will be able to

1 **Estimate** fundamental natural frequency of multi degree freedom systems using Rayleigh's, Dunkerley's and stodola's numerical methods.

2 **Estimate** all natural frequencies and corresponding mode shapes of multi degree freedom systems using Holzer's numerical method.

3 **Formulate** equation of motion using influence coefficients and **Estimate** natural frequencies of multi degree freedom systems from matrix iteration method.

Review Questions

1 Define the following:
(a) Free vibrations (b) Forced vibration (c) Damped vibration
(d) Degrees of freedom (e) Critical damping (f) Coulomb damping
(g) Viscous damping (h) Solid damping (i) Logarithmic damping
(j) Natural frequency (k) Damped natural frequency

2 Distinguish between the followings:
(i) Natural frequency and damped natural frequency
(ii) Free and forced vibrations (iii) Damped and undamped vibrations.

3 What are the different methods used to determine the expressions for natural frequency of a spring-mass system? Explain them.

4 Determine the natural frequency of the system shown in Fig. 1 using (i) Newton's second law method (ii) Energy method.

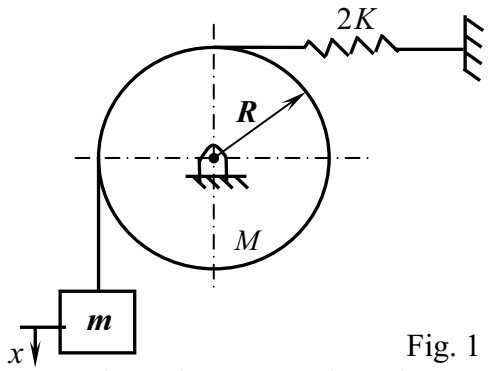


Fig. 1

5 A 20 kg mass is resting on a spring of 750 N/m and dash pot of 50 N-sec/m. If a velocity of 2 m/sec is applied to the mass at rest position, what will be its displacement at the end of 1 sec.

6 Derive an expression for the logarithmic decrement.

7 A body of mass 70 kg is suspended from a spring which deflects 2 cm under the load. It is subjected to a damping effect adjusted to a value 0.23 times that required for critical damping. Find the natural frequency of the undamped and damped vibrations and ratio of successive amplitudes for damped vibrations.

8 A vibrating system is defined by the following parameters:
$m = 3kg, k = 100N/m, C = 3N - \sec/m$.
Determine,
(i) the damping factor (ii) the natural frequency of damped vibration (iii) logarithmic decrement (iv) the ratio of two consecutive amplitudes and (v) the number of cycles after which the original amplitude is reduced to 20 percent.

9 The mass M of a machine is mounted on an elastic foundation modelled as a spring of stiffness k in parallel with a viscous damper of damping coefficient C. The machine is subjected to a harmonic excitation of $F_o \sin \omega t$. **Derive** the differential equation governing the machine's displacement and **Express** its steady-state amplitude.

10 An electric motor is supported on a spring and a dashpot. The spring has the stiffness 6.4 N/mm and the dashpot offers resistance of 500 N at velocity of 250 mm/sec. The unbalanced mass of 0.5 kg rotates at 50 mm radius and the total mass of vibratory system is 20 kg. The motor runs at 400 rpm. Determine (a) damping factor (b) amplitude of vibration and phase angle (c) force exerted by the spring and dashpot on the motor.

11 Explain the principles of operation of vibrometer and accelerometer.

12 The static deflection of the vibrometer mass is 20 mm. The instrument when attached to a machine vibrating with a frequency of 125 cpm records a relative amplitude of 0.3mm. find out for the machine, (i) Amplitude of vibration.
(ii) Maximum velocity of vibration and
(iii) Maximum acceleration.

13 A rotor of mass 14 kg is mounted at mid point of a steel shaft of 25 mm diameter supported between two bearings which are 40 cm apart. The rotor has an unbalance of 0.25 kg-cm. If the rotor runs at 6000 rpm, determine: (1) critical speed of the shaft (2) The maximum and minimum stress developed in the shaft (3) the dynamic load transmitted on each bearing. Take $E= 210\ Gpa$ and density of shaft material $\rho = 8 gm/cc$.

14 Define the following (i) Generalized and principle coordinates (ii) Principla mode and normal mode of vibrations.

15 Determine the natural frequencies and the corresponding modes of vibration of the system shown in Fig. 2. The string is stretched with a large tension T. Also draw the mode shapes.

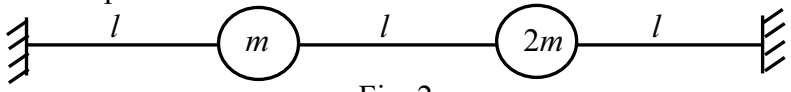


Fig. 2

16 With the derivation of necessary expressions, explain the principle of vibration absorber.

17 Determine the influence coefficients of the triple pendulum shown in Fig.3.

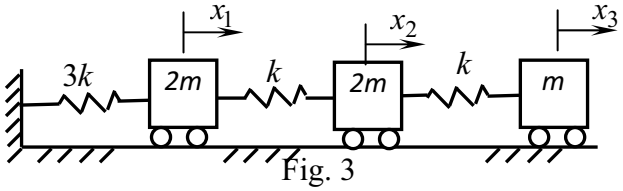


Fig. 3

18 Determine the fundamental natural frequency of transverse vibration of the system shown in Fig. 4 using Rayleigh's method and verify it using Dunkerley's method. Take $EI = 8\times10^4\ Nm^2$. $m_1 = 100$ Kg $m_2 = 50$ Kg

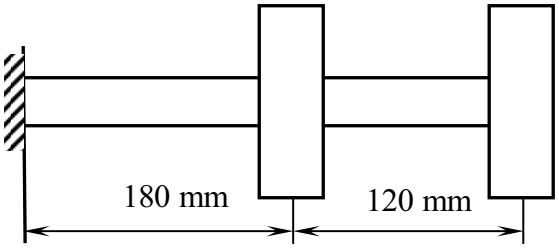


Fig. 4

19 Determine the natural frequencies of the system shown in Fig. 3. Use Holzer's method

20 Using matrix iteration method, determine first two natural frequencies of the system shown in Fig. 3

Lesson Plan

	Unit I
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 II
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 III
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 IV
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 V

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											
	1	2	3	4	5	6	7	8	9	10	11	12
Formulate mathematical models of single degree of freedom, free, undamped and damped vibrating systems and **determine** their natural frequencies. **Formulate** equation of motion for damped free vibratory systems.	M	H	M									
Determine the response of simple single degree of freedom systems subjected to forced vibration. **Design** mechanical systems with vibration isolation.	H	H	H									
Explain the working principle of vibration measuring instruments. **Determine** the whirling speed of shafts. **Compute** harmonics of general forcing functions using Fourier series.	L	M	H									
Formulate mathematical models and **Solve** vibration problems related to Two degrees of freedom. **Determine** influence coefficients.	M	H	H									
Solve multi degree of freedom systems using Rayleigh and Dunkerley, Stodola, Holzer and Matrix iteration methods.	H	L	L									

Course Title: HEAT AND MASS TRANSFER			
Course Code: P13ME63	Semester: VI	L-T-P-H : 4-0-0-4	Credits: 4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	**Prerequisites Course 2013-14**		**Course of Regulations 2013-14**		**Equivalent Course for 2008-09**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P13ME35	Basic Thermodynamics	P13ME63	Heat And Mass Transfer	P08ME63	Heat And Mass Transfer
2	P13ME45	Fluid Mechanics				
3	P13MA31	Engineering Mathematics				

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

UNIT –I Conduction

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. **12Hrs**

UNIT –II :

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 –III

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 –IV

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. **10hrs**

UNIT –V

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). **10hrs**

Text books

1. **Heat Transfer**- A Basic approach by M Necati Ozisik Mc-Graw Hill International ed 1988
2. **Principles of Heat Transfer** by Kreith Thomas learning 2001

References

1. **Heat transfers a practical approaches** by Yunus A Cengel Tata Mc-Graw Hill 2002.
2. **Heat Transfer** by sucec, Jaico Book house 2002
3. **Heat & Mass Transfer** by Rajuputh
4. **Heat & Mass Transfer** by P.K. Nag Tata Mc-Graw Hill 2002
5. **Fundamentals of Engg. Heat & Mass Transfer** by R.C.Sachdeva
6. **Heat Transfer** by J.P. Holman

Course Outcomes

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

1. **understand** and **formulate** to solve problems in fundamentals of three heat transfer modes using basic thermal properties such as thermal conductivity, heat capacity and thermal diffusivity
2. **understand** and **apply** basics of heat conduction: steady and unsteady one-dimensional conduction, special applications to extended surfaces with focus on fin design
3. **understand** and **apply** concepts of convection heat transfer with both analytical and empirical approaches.
4. **understand** and **demonstrate** fundamentals of radiation heat transfer: explaining concepts and application to radiations in engineering problems.

understand and **demonstrate** the design and applications of heat exchangers

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1	develop an appreciation for the fundamental concepts and principles of different modes or mechanisms of heat transfer for practical engineering applications.
2	develop, from basic principles, the general *heat conduction equation*, which governs the temperature distribution in a medium
3	develop the mathematical formulation of boundary conditions with insulation, constant heat flux, surface convection, and specified changes in surface temperature.
4	determine expressions for the temperature distribution and heat transfer rate in common geometries (planar, cylindrical, and spherical)
5	introduce the concept of thermal resistance and to show how thermal circuits may be used to model heat flow
6	obtain temperature distribution and rate of heat loss or gain from extended surfaces, also called *fins*, and use them in typical applications.

Unit II

By the end of the topic, student will be able to

1	obtain steady-state temperature distributions in simple conducting geometries with heat generation in slab
2	obtain steady-state temperature distributions in simple conducting geometries with out heat generation and variable thermal conductivity in slab
3	apply the concept of lumped capacitance in transient heat transfer.
4	develop procedures for determining the time dependence of the temperature distribution within a solid during a transient process,
5	Use charts for transient heat conduction to obtain temperature distribution as a function of time in simple geometries.

Unit III

By the end of the topic, student will be able to

1. Understand the concept of a boundary layer and thermal layer in convection heat transfer.
2. obtain analytical solutions for typical laminar flow boundary layer equations.
3. perform dimensionless analysis for free and forced convection heat transfer
4. present methods correlations for computing the coefficients associated with forced convection in external and internal flow configurations
5. present methods correlations for computing the coefficients associated with free convection in external and internal flow configurations
6. apply the analogy between momentum and heat transfer to solve turbulent flow convection problems.

Unit IV

By the end of the topic, student will be able to

1. employ radiation properties such as emissivity, absorptivity, and transmissivity in heat transfer analysis,
2. define different laws of radiation
3. define and use blackbody and gray body assumptions
4. express the relation between radiation intensity and emissive power
5. evaluate a radiation heat transfer between different surfaces.

Unit V

1. classify different types of heat exchangers
2. set up the thermal resistance network for the overall heat transfer coefficient
3. develops methods for designing and evaluating the performance of heat exchangers using the log mean temperature difference (or LMTD)
4. determine heat exchanger effectiveness and to evaluate the thermal performance by the effectiveness-NTU method
5. appreciate the physical conditions associated with boiling and condensation

Review Questions

1. Define thermal conductivity,thermal diffusivity and what is its physical significance.
2. By writing an energy balance for a differential volume element, derive the three dimensional, time dependent heat conduction equation for isotropic material with internal heat generation.
3. Describe the boundary conditions of three kinds.
4. Explain the physical significance of critical radius of insulation and hence Derive the condition for critical thickness of insulation for hallow sphere
5. Derive expression for temperature distribution in terms of Biot and Fourier numbers
6. Explain the use of Heisler Chart solution
7. Discuss temperature effect on thermal conductivity in slab
8. Explain the concept of Hydrodynamic boundary layer and Thermal boundary layer
9. Using dimensional analysis obtain a relation for the dimensionless number as applied to forced convection
10. Explain the physical significance of the following dimensionless numbers Reynold's number ii) Prandtl number iii) Nusselt number and iv) Stanton number
11. State Kirchoff's law, Lambert's Cosine Law, Stefan-Boltzman's law
12. Derive an expression for radiation heat exchange between two parallel plates, with radiation shielding
13. Discuss LMTD methods of analysis of heat exchangers
14. Discuss effectiveness- NTU methods of analysis of heat exchangers
15. Explain different regimes of pool boiling

Lesson Plan

Unit I

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 Equation for long fin, short fin with end insulated, short fin with free convection
10	Numerical Problems
11	Numerical Problems
12	Numerical Problems

Unit II

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 III

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 IV

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 V

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											
	1	2	3	4	5	6	7	8	9	10	11	12
understand and **formulate** to solve problems in fundamentals of three heat transfer modes using basic thermal properties such as thermal conductivity, heat capacity and thermal diffusivity	**M**	**L**										
understand and **apply** basics of heat conduction: steady and unsteady one-dimensional conduction, special applications to extended surfaces with focus on fin design	**H**	**M**	**M**									
understand and **apply** concepts of convection heat transfer with both analytical and empirical approaches.	**H**	**M**										
understand and **demonstrate** fundamentals of radiation heat transfer: explaining concepts and application to radiations in engineering problems.	**H**	**M**										
understand and **demonstrate** the design and applications of heat exchangers	**H**	**M**	**M**									

Course Title: FINITE ELEMENT METHODS			
Course Code: P13ME64	Semester: VI	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	**Prerequisites Course 2013-14**		**Course of Regulations 2013-14**		**Equivalent Course for 2008-09**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P13MA11/21	Engineering Mathematics – I & II	P13ME73	Finite Element Methods	P08ME73	Finite Element Methods
2	P13ME33	Mechanics of Materials				

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. **12 hrs**

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. **10 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. **Introduction to the Finite Element Method:** C. S. Desai and J.F. Abel, EWP an East-West

Edition

2. **Introduction to Finite Elements in engineering:** T R Chandrupatla and A D Belegundu, PHI.
3. **The Finite Element Method in engineering:** S S Rao, Elsevier.

References

1. **The FEM its basics and fundamentals**: O.C.Zienkiewicz, Elsevier, 6e.
2. **Finite Element Method**: J.N.Reddy, McGraw –Hill International Edition.
3. **Finite Element Methods:** by Daryl. L. Logon, Thomson Learning 3rd edition.
4. **Fundamentals of Finite Element Analysis:** David V. Hutton,–Tata McGraw Hill
5. Publishing Co. Ltd, New Delhi.

Course Outcomes

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

1. **Explain** the concept of finite element method as well as finite element discretization process. **Apply** Gauss elimination algorithm to **solve** linear algebraic equations and Gauss quadrature technique for numerical integration.
2. **Develop** interpolation models for different types of elements that satisfy convergence criteria and geometric isotropy. **Use** isoparametric concept in the finite element analysis.
3. **Formulate** element stiffness matrices and load vectors for different elements by **applying** variational principle.
4. **Use** developed finite element models in the **determination** of stresses, strains and reactions of axially loaded bars, trusses and transversely loaded beams.

Formulate finite element equations for heat transfer problems using Variational and Galerkin techniques and **apply** these models to conduction and convection heat transfer problems.

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1 Explain FEM, its advanatages, disadvanatages and applications.
2 Explain different types of elements.
3 Apply Gauss elimination method to solve system of algebraic equations.
4 Apply Gauss quadrature rule for numerical integration.
5 Explain principle of minimum potential energy and derive potential energy functional for a three dimensional elastic body.
6 Explain the concept of plane stress and plane strain.

Unit II

By the end of the topic, student will be able to

1 Explain the convergence criteria for interpolation functions.
2 Derive shape functions for bar elements, CST and QUAD elements.
3 Explain iso-parametric formulation and its advantage.
4 Explain the concept of Jacobian matrix.

Unit III

By the end of the topic, student will be able to

1 Derive strain-displacement, element stiffness matrices and load vectors for bar and CST elements.
2 Explain special characteristics of stiffness matrix.
3 Explain the treatment of boundary conditions by elimination and penalty approach.
4 Solve problems on axially loaded bars.

Unit IV

By the end of the topic, student will be able to

1 Explain the concept of local and global coordinate systems.
2 Derive stiffness matrix for truss element.
3 Derive shape functions, stiffness matrix and load vectors for beam element.
4 Solve problems on truss and beam elements.

Unit V

1 Derive governing FE equation for 1D heat transfer problem using functional approach. and

Galerkin's method.

2 Explain boundary conditions used in heat transfer problems.

3 Solve problems on 1D heat transfer.

Review Questions

1 List the advantages and disadvantages of FEM over other numerical methods.

2 Explain the steps involved in FEM

3 Giving suitable example, explain the following: (i) Essential and nonessential boundary conditions and (ii) Boundary value and initial value problems

4 Write note on node numbering scheme for the minimization of bandwidth of stiffness matrix

5 Solve the following system of simultaneous equation by Gaussian elimination method: $2x_1 + x_2 + 3x_3 = 10;\ 4x_1 + x_2 + x_3 = 5;\ 3x_1 + 2x_2 + x_3 = 3$

6 What is meant by body force and surface force? Give examples.

7 With examples explain Plane stress and Plane strain. Give stress-strain relations.

8 Derive equilibrium equation for a 3D body subjected to surface forces.

9 Evaluate $\int_{-1}^{+1}\int_{-1}^{+1}(\xi^2 + 2\xi\eta + \eta^2)d\xi d\eta$ using two-point Gauss quadrature formula.

10 Write a note on convergence criteria and explain Pascal's triangle for 2D polynomial

11 What are the properties of shape functions? Derive the shape functions for a quadratic bar element in terms of natural coordinate system

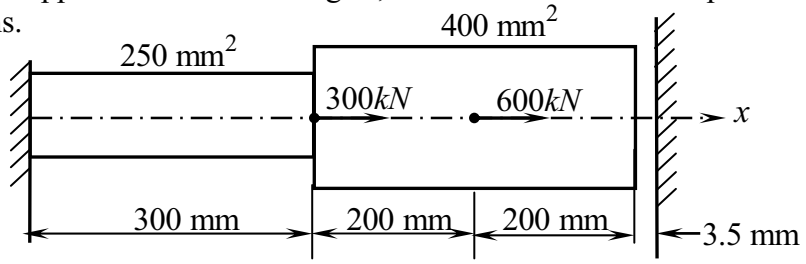
12 Derive strain-displacement matrix B for a quadratic bar element. If the length of the element is 30 mm, obtain B matrix at point P located at 1/4 of the element length.

13 With necessary proof, discuss elimination method used to apply boundary conditions.

14 Calculate the strain displacement matrix B and determine the *strains* $\varepsilon_x, \varepsilon_y$ and γ_{xy}, if the nodal displacements of a triangle are given by $u_i = 3mm; u_j = 4mm; u_k = 2mm;$ $v_i = 2mm; v_j = 3mm; v_k = 4mm$

Nodes i, j and k of the triangle are given by the coordinates (1,1), (4,1) and (1,5) respectively.

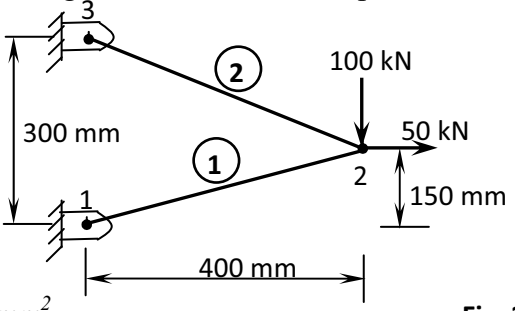
15 For the stepped bar shown in Fig. 1, determine the nodal displacement, stresses and support reactions.



E_1 = 70 GPa; E_2= 200 GPa

Fig. 1

16 For the two-bar truss member shown in Fig. 2, determine the displacement at load point and stresses in each member.



E=200 GPa, A_1=1500 mm², A_2=2000 mm²

Fig. 2

17 Explain the concept of Iso, Sub and Super Parametric elements.

18 The beam shown in Fig. 3, determine the unknown deflections and slopes. Also determine the

vertical deflection at the mid-point of the beam having distributed load of 12kN/m. Assume *E=200 GPa and* $I = 4 \times 10^6 mm^4$.

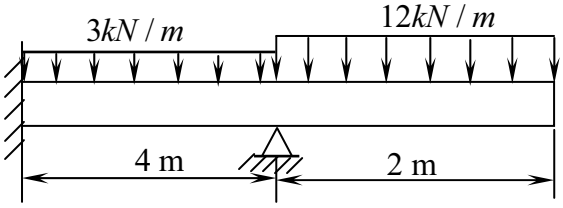


Fig. 3

19 Derive element conductivity and convection matrices for a 1D heat transfer problem using Galerkin's method.

20 The left surface of the plane wall of thickness 1.2 m is maintained at a constant temperature of 200°C and the right side surface is exposed to cold air at -15°C. The heat transfer coefficient associated with the outside surface is h=40W/m²°C. The thermal conductivity is $K_{xx} = 25W / m^oC$ and there is a uniform generation of heat inside the wall of $Q = 400W / m^3$. Determine the temperature distribution through the wall using two elements of equal length.

Lesson Plan

Unit I

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 II

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

Unit III

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
9 Treatment of boundary conditions- penalty method
10 Numericals
11 Numericals
12 Numericals

Unit IV

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 V

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											
	1	2	3	4	5	6	7	8	9	10	11	12
1. **Explain** the concept of finite element method as well as finite element discretization process. **Apply** Gauss elimination algorithm to **solve** linear algebraic equations and Gauss quadrature technique for numerical integration.	**H**									**H**		
2. **Develop** interpolation models for different types of elements that satisfy convergence criteria and geometric isotropy. **Use** isoparametric concept in the finite element analysis.	**H**	**H**										
3. **Formulate** element stiffness matrices and load vectors for different elements by **applying** variational principle.	**H**	**H**										
4. **Use** developed finite element models in the **determination** of stresses, strains and reactions of axially loaded bars, trusses and transversely loaded beams.	**H**	**H**										
5. **Formulate** finite element equations for heat transfer problems using Variational and Galerkin techniques and **apply** these models to conduction and convection heat transfer problems.	**H**	**H**										

Course Title: CAD/CAM			
Course Code: P13ME65	Semester: 06	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

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

Course Content

Unit -1

INTRODUCTION: Role of computers in design and manufacturing, Product cycle in conventional and computerized manufacturing environment, introduction to CAD and CAM, advantages and limitations of CAD/CAM. Latest display systems. 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. Introduction 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 , NC co-ordinate system , open loop & closed loop system (position controlled NC) NC motion control system, application of NC , Advantage & limitations of NC. Functions of CNC, CNC machining centers, CNC turning centers, high speed CNC machine tools. **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. **CAD/CAM Principles and application:** P.N. Rao, Tata McGraw Hill. 2002.
2. **CAD/CAM:** Groover, Tata McGraw Hill. 2003.

References

1. **Introduction to the Design and Analysis of Algorithms**: S.E. Goodman, S.T.Headetmiemi, McGraw Hill Book Company - 1988.
2. **Principles of interactive Computer Graphics**: Newman and Sproull, Tata McGraw Hill, 1995.
3. **NC Machine programming and software Design:** Chno-Hwachang, Michel.A.Melkanoff, Prentice Hall, 1989.
4. **Numerical control and CAM:** Pressman RS and Williams JE, Johnwiley. 2000.
5. **Computer Graphics**: Steven Harrington, McGraw Hill Book Co.2001.

CAD-CAM: Ibrahim Zeid, Tat McGraw Hill, 1999.

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. **Summarize** the functions of graphics package in CAD system.
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.

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1 **Define** CAD/CAM
2 **List role** of computers in design and manufacturing.
3 **Explain** latest display system types.
4 **Demonstrate** different input and output devices.

Unit II

By the end of the topic, student will be able to

1 **Identify** software configuration of graphic system. L4
2 **Illustrate** transformations of 2D graphics primitives. L3
3 **Compare** different drawing interchange files. L4
4 **Discuss** representation of curves and surfaces. L2

Unit III

By the end of the topic, student will be able to

1 **Discuss** components of nc systems. L2
2 **Differentiate** between different coordinate system, motion control system and feedback system. L4
3 **Compare** cnc machine centes and cnc turning centres. L4

Unit IV

By the end of the topic, student will be able to

1 **Explain** structure of cnc machine tools. L2
2 **Discuss** cutting tool materials. L2
3 **Describe** tooling system. L1
4 **Explain** work holding devices. L2

Unit V

1 **Explain** part programming fundamentals. L2
2 **Prepare** part programming for turning. L5
3 **Prepare** part programming for drilling. L5
4 **Prepare** part programming for milling. L5

Review Questions

1 Explain role of computers in product cycle.
2 Describe input/output devices used in CAD.
3 Describe the functions of graphics software.
4 A line (2, 5) and (5, 8) is rotated by an angle of 45^0.determine rotated line.
5 Explain configuration of DXF.
6 Sketch and explain cubic splines and B-splines.
7 Discuss NC procedure.
8 Differentiate coordinate system and motion control system.
9 Compare turning centre and machining centre.
10 Describe work holding devices.
11 Explain the principles of tool presetting.
12 Write a part program for drilling operations.
13 Write a part program for turning operations.
14 Write a part program for milling operations.

Lesson Plan

Unit I

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 II

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 III

1 Introduction to Numerical control (nc) and Basic components of NC
2 Explanation of NC procedure.
3 Systems 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 IV

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 V

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											
	1	2	3	4	5	6	7	8	9	10	11	12
Describe input and output devices used in CAD		**L**			**L**	**M**						
Summarize the functions of graphics package in CAD system.	**M**		**M**		**L**							
Discuss the basic components of NC system and the different NC motion control systems.	**L**		**M**		**M**							
Identify CNC machine components.	**L**	**M**		**M**								
Develop the manual part program for CNC machining of a different components, using ISO codes	**M**	**M**		**L**	**M**							

Course Plan

Course Title: Theory of Elasticity			
Course Code: P13ME661	Semester: 06	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50%; SEE:50%	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	**Prerequisites Course 2013-14**		**Course of Regulations 2013-14**		**Equivalent Course for 2008-09**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P13MA11/21	Engineering Mathematics – I & II	P13ME644	Theory of Elasticity	P08ME644	Theory of Elasticity
2	P13CV13	Engineering Mechanics				
3	P13ME33	Mechanics of Materials				

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, Mohr's stress circle and construction of Mohr Circle for 2D stress systems. **10 hrs**

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. **08 hrs**

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. **10 hrs**

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. **12 hrs**

Unit-5: General Equations in Cylindrical coordinate: Thick cylinder under uniform internal and / or external pressure, shrink fit.

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

Text books

1. **Theory of Elasticity:** Timoshenko and Goodier, McGraw Hill Book Company.
2. **Advanced Mechanics of Solids:** L S Srinath McGraw Hill Book Company.

References

1. **Theory of Elasticity:** Sadhu Singh, Khanna publisher
2. **Applied Elasticit:** Wang. C. T.
3. **Applied Elasticity:** T.G.Sitharam. Govindraju, Interline publishing.
4. **Advanced Mechanics of Materials:** Arthur P Boresi and Richard J Schmidt.

Course Outcomes

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

1. **Describe** and **calculate** the state of stress at a point and principal stresses and **construct** the Mohr's circle.
2. **Determine** state of a strain at a point and principal strains.
3. **Discuss** the stress and strain relations.
4. **Compute** and **analyze** bending and shear stresses and deflections induced in beams and torsional stresses of thin walled and multiple cell closed sections.

Determine stresses in thin and thick cylinders and **analyze** stress concentration.

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1	**Describe** the general theory of elasticity with assumptions and applications of linear elasticity
2	**Formulate** the State of stress at a point and 3D Equilibrium equation.
3	**Calculate** state of stress at a point and principal stresses.
4	**Describe** Mohr's stress circle and **construct** Mohr Circle for stress systems.

Unit II

By the end of the topic, student will be able to

1	**Define** the strain, state of strain at a point and Principal strain.
2	**Derive** and **Apply** strain –displacement relation.
3	**Determine** the Principal strain.
4	**Formulate** compatibility equation.

Unit III

By the end of the topic, student will be able to

1	**Derive** the Hooke's law in terms of engineering constants.
2	**Discuss** the principles; Saint venant, superposition, Kirchoff's law and boundary value problems.
3	**Derive** the thermo elastic stress strain relationship.

Unit IV

By the end of the topic, student will be able to

1	**Explain** the Plane stress and plane strain.
2	**Formulate** the expression for compatibility condition from strain component to stress components.
3	**Determine** the shearing stresses in beams.
4	**Discuss** Airy stress function.
5	**Derive** relation for Torsion of circular, elliptical and triangular bars.

Unit V

1	**Define** thick cylinder.
2	**Formulate** the Hoop's and Longitudinal stress for thick cylinder under external and internal pressure.
3	**Describe** the solid disk and disk with a hole.

Review Questions

1	Derive 3D differential equation of equilibrium subjected to body forces and surface tractions.
2	Derive an equation for state of stress at a point.
3	What is meant by stress invariants?
4	Derive strain –displacement relation.
5	Derive the compatibility relation of strain in a 3D elastic body. What is its significance?
6	State and explain Saint Venant's principle and principle of superposition.
7	Write short note on Hooke's law, methods of solution of elasticity problems.
8	Write short note on (i) Plane stress and plane strain (ii) Airy's stress function.
9	Derive the equation for stresses developed in an elliptical section of a bar subjected to torque.
10	Show that M_t=GJ in torsion of shafts with usual notations. Where G-modulus of rigidity, j-

polar moment of inertia and - angular twist for unit length.

11 Derive the equilibrium equation in cylindrical coordinates for 2D elastic body.

12 Derive the expression for radial and tangential stresses in a rotating disc of uniform thickness.

13 Derive the expression for radial and circumferential stresses for the thick walled cylinder subjected to uniform internal and external pressure.

Lesson Plan

Unit I

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 II

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 III

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.

Unit IV

1 General case of Plane stress and Plane strain.

2 Transformation of compatibility condition from strain component to stress components.

3 Relation between plane stress and plane strain

4 Airy stress function, Investigation for simple beam problems.

5 Bending of narrow cantilever under end load and problems.

6 Simply supported beam with uniform load and problems.

7 Simply supported beam with uniform load and problems.

8 Torsion of circular bar.

9 Torsion of elliptical cross section.

10 Torsion of triangular cross section.

11 Stress function, torsion of thin walled tubes.

12 Problems on torsion of thin walled tubes.

13 Torsion of multiple cell closed sections.

14 Problems Torsion of multiple cell closed sections.

Unit V

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											
	1	2	3	4	5	6	7	8	9	10	11	12
Describe and **calculate** the state of stress at a point and principal stresses. **Construct** the Mohr's circle	**M**	**M**	**L**		**M**	**M**						
Describe and **calculate** state of a strain at a point **and** principal strains.	**M**	**M**				**M**						
Discuss and compare the stress and strain relations.	**M**	**M**		**M**								
Compute and **analyze** bending and shear stresses and deflections induced in beams and torsional stresses of thin walled and multiple cell closed sections.	**M**	**M**	**L**	**M**								
Determine stresses in thin and thick cylinders **analyze** stress concentration.	**M**	**M**	**L**	**M**								

Course Title: Refrigeration & Airconditioning			
Course Code: P13ME662	Semester: VI	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	**Prerequisites Course 2013-14**		**Course of Regulations 2013-14**		**Equivalent Course for 2008-09**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P13ME35	Basic thermodynamics	P13ME662	Refrigeration & Air conditioning	P08ME756	Refrigeration & Air conditioning
2	P13ME63	Heat and Mass transfer				

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). **10 hrs**

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. **10 hrs**

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. **11 hrs**

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. **10 hrs**

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. **11 hrs**

Text books

1. **Refrigeration and Air-Conditioning:** C. P. Arora Tata McGraw Hill Publication, 2nd edition, 2001.
2. **Refrigeration and Air-Conditioning:** Manohar prasad

Reference books

1. **Refrigeration and Air-conditioning:** Ballaney P.L., , Khanna Publisher, New Delhi 13th ed,
2. **Refrigeration and Air-conditioning:** R.S Khurmi& J.K.Guptha, , S.Chand & company ltd New Delhi 3rd ed.
3. **Refrigeration and Air-conditioning:** Arora S.C. & Domkundwar S., , Dhanpat Rai &

Sons,New Delhi

Course Outcomes

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

1. **Interpret** the principles of various systems involved in refrigeration and **Analyze** the working of the different refrigeration cycle
2. Learn the **classification** of refrigerants, its properties and its effect on environment
3. **Appreciate** the Various Components: its working and design and **identify** about system balancing and Controls involved in Refrigeration units
4. **Appreciate** & **Analyze** the various Psychrometric processes and **Recognize** the importance of P-h , T-S and Psychrometric charts in air conditioning system
5. **Estimate** the cooling and heating load and **design** the Air-Conditioning systems

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1	Define refrigeration and refrigeration effect
2	Identify various natural and artificial methods of refrigeration
3	Describe about Reverse Carnot cycle & its limitations
4	Analyze and perform cyclic calculations for Carnot refrigeration cycle State the difficulties with Carnot refrigeration
5	Understand working of Steam Jet Refrigeration, vapour compression refrigeration, vapour absorption refrigeration and Solar refrigeration

Unit II

By the end of the topic, student will be able to

1	Analyze and perform calculations for standard vapour compression refrigeration systems using P –h and T-s diagrams
2	Show and discuss qualitatively the effects of evaporator and condensing pressures and temperatures on refrigeration effects, work of compression and on system COP
3	Discuss and evaluate the performance of single stage VCRS with subcooling and superheating on COP and Capacity.
4	Evaluate the COP of actual VCRS from condensing and evaporator temperatures, efficiency of motor and compressor
5	Explain the importance of refrigerant selection and List the criteria used in selecting refrigerants
6	Write the chemical formula of a refrigerant from its number and vice – versa

Unit III

By the end of the topic, student will be able to

1	Identify important components of a vapour compression refrigeration system
2	Classify refrigerant compressors based on their working principle and based on the arrangement of compressor motor/external drive
3	Draw the schematic of a reciprocating compressor and explain its working principle
4	Classify and describe refrigerant condensers based on the external fluid used,based on the external fluid flow and based on constructional aspects
5	Classify refrigerant evaporators and discuss the salient features of different types of evaporators
6	Explain the working principle and salient features of capillary tube, automatic expansion valve, thermostatic expansion valve

Unit IV

By the end of the topic, student will be able to

1	Define psychrometry and atmospheric air, dew point, adiabatic saturation and thermodynamic wet bulb temperature
2	Estimate various psychrometric properties given any three independent properties
3	Represent various psychrometric processes on psychrometric chart

4	Perform calculations for various psychrometric processes using the psychrometric charts and equations
5	Define sensible heat factor, by-pass factor, contact factor and apparatus dew point temperature

Unit V

By the end of the topic, student will be able to

1	Explain the differences between conventional cooling and heating load Calculations
2	Describe with sketches summer and winter air-conditioning systems
3	List commonly used methods for estimating cooling loads
4	Explain briefly the procedure for estimating heating loads
5	Explain the concepts of RSHF, GSHF and ESHF

Review Questions	
1	Define refrigeration and refrigeration effect and How is the effectiveness of a refrigeration system measured.
2	Explain the working principle of vapour compression refrigeration system with a neat diagram and also plot the same on a P-h and T-s diagram.
3	Draw the refrigeration cycle on T-s diagram when the refrigerant is dry and saturated at the end of compression and find an expression for the COP in terms of i. Temperature and entropies. ii. Enthalpies
4	What modifications are necessary in a simple absorption refrigeration system in order to improve the performance of the system?.
5	What is sub-cooling and super heating? Explain with the help of diagram, why is super heating considered to be good in certain cases
6	What are the parameters that effect the vapour compression refrigeration system and how
7	Explain the following terms: **a.** Inorganic refrigerants b. Hydro carbon refrigerants c. Azeotrope refrigerants d. Zeotrope refrigerants e. Secondary refrigerants
8	Discuss the nomenclature used for classifying refrigerants
9	List important components of a vapour compression refrigeration system
10	Classify refrigerant compressors based on their working principle and based on the arrangement of compressor motor/external drive
11	Compare air-cooled condensers with water-cooled condensers
12	Explain the working principle and salient features of capillary tube, automatic expansion valve, thermostatic expansion valve
13	Perform calculations for various psychrometric processes using the psychrometric charts and equations
14	Select suitable indoor design conditions based on comfort criteria Explain the method followed for selecting suitable outside design conditions
15	Explain briefly the procedure for estimating heating loads

Lesson Plan	
	Unit I
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 II
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 III
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.
	Unit IV
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 V
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

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Interpret the principles of various systems involved in refrigeration and **Analyze** the working of the different refrigeration cycle	**M**	**L**										
Learn the **classification** of refrigerants, its properties and its effect on environment	**L**	**L**					**L**					
appreciate the Various Components: its working and design and **identify** about system balancing and Controls involved in Refrigeration units	**M**	**L**	**M**									
appreciate & **Analyze** the various Psychrometric processes and **Recognize** the importance of P-h , T-S and Psychrometric charts in air conditioning system	**L**	**L**										
Estimate the cooling and heating load and **design** the Air-Conditioning systems	**H**	**L**	**M**									

Course Title: STATISTICAL QUALITY CONTROL			
Course Code: P13ME663	Semester: VI	L-T-P -H: 4-0-0-4	Credit: 04
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13ME41	Engineering Mathematics-IV	P13ME663	Statistical Quality Control	P08ME622	Statistical Quality Control

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, Concepts in quality management, quality measurement. 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, C_{pk}. 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. **Statistical Quality Control:** E.L. Grant and R.S. Leavenworth,Tata Mc Graw –Hill publishing Co. Ltd. New Delhi

References

1. **Statistical Quality Control:** R.C.Gupta, Khanna Publishers, Delhi
2. **Introduction to statistical Quality Control:** Montgomery Douglas C., John Wiley and Sons, Inc., Hoboken.
3. **Quality Planning & Analysis:** Juran Banks, TataMcGraw Hill

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

2. **Explain** measure of central tendency and measure of dispersion, various types of probabilities distribution, to solve numerical problem using statistical technique
3. **Perform** mathematical calculations using data collected and to plot a suitable control chart for further analysis and compute Cp and Cpk.
4. **Discuss** the concept of acceptance sampling, differentiate between acceptance sampling and 100% inspection, producers risk and consumers risk, OC curves.
5. **Describe** concept and meaning of reliability, reliability prediction, system reliability, redundancy and its uses, problem solving.

Topic Learning Objectives (Unit-wise)

Unit I

By the end of the topic, student will be able to

1	**Define** Basic concepts of quality
2	**Define** quality control, objectives of quality control
3	**List and Explain** Quality Characteristics
4	**Explain** Quality Costs, Quality of Design
5	**Explain** Quality of conformance, Optimum quality
6	**Define and Explain** Statistical Quality Control
7	**Explain** objectives of Statistical Quality Control
8	**Explain** Concepts in quality management,
9	**Explain** Quality Measurement.

Unit II

By the end of the topic, student will be able to

1	**Define** Concept of variation and its types
2	**Explain** Variables and Attributes
3	**Explain** Frequency distribution and its graphical representation
4	**Explain** Frequency Polygon, Histogram, and Ogive
5	**Explain** Central tendency and Measures of dispersion
6	**Solve** Numerical Problems on Mean, Median and Mode.
7	**Solve** Numerical Problems on Range and Standard deviation
8	**Explain** Theory of Probability and Types of Probability distributions
9	**Solve** Numerical Problems on Hypergeometric and Bi-nomial distributions.
10	**Solve** Numerical Problems on Poisson and Normal distributions.

Unit III

By the end of the topic, student will be able to

1	**Define** control charts
2	**Explain** Control charts for X – bar and R charts
3	**Solve** Numerical Problems on Type I and Type II errors.
4	**Define** Methods of calculating process capability
5	**Explain** Natural Tolerance limits, process capability index C_P, C_{pk}
6	**Solve** Numerical Problems on process capability index C_P, C_{pk}

Unit IV

By the end of the topic, student will be able to

1	**Define** Control charts for defects and defective
2	**Explain** p, np, c, and u charts and their applications
3	**List** differences between control chart for variables
4	**Explain** differences between p chart and c chart
5	**Solve** Numerical Problems on p chart and c chart

Unit V

By the end of the topic, student will be able to

1	**Explain** basic concepts Acceptance Sampling
2	**Explain** Sampling by attributes, single, double and multiple sampling plans

3 **Describe** use of sampling table
4 **Explain** Sequential sampling plan
5 **Explain** construction and use of Operating Characteristic curves
6 **Solve** Numerical Problems on Sampling

Review Questions

1 Define the term Statistical Quality Control, List any 6 benefits of SQC
2 Explain (i) Quality Characteristics (ii) Quality Costs (iii) Quality of Design (iv) Quality of conformance
3 Define and Explain Concepts in quality management and quality measurement
4 Explain Mean, Median, Mode with Suitable Examples
5 Tests have indicated that strength of certain Aluminium Alloys averages 1785 kg/cm^2 , with a Standard Deviation of 220 kg/cm^2. If the distribution is normal, What percentage of Castings will have
   (i) Tensile Strength Less than 1400 kg/cm^2
   (ii) More than 1500 kg/cm^2
6 What are control charts and explain its objectives.
7 A subgroup of 5 items each is taken from a manufacturing process at a regular interval. A certain quality characteristics is measured and x and r values computed After 25 subgroups it is found that $\sum x$=357.50 and $\sum$ r =8.80. If the specifications limit is 14.40 $\pm$*0.40*, and if the process is in statistical control, what conclusion can you draw about the ability of the process to produce item with specifications? (d = 2.326).
8 Write a brief note on (i) process capability (ii) defects and defectives
9 Determine Trial Control Limits for X-bar and R charts. If $\sum$X-bar is 357.50 and $\sum$R is equal to 9.90. Number of subgroups is 20. It is given A_2 = 0.18, D_3 = 0.41, D_4 = 1.59, and d_2 = 3.375. Assuming that the process is within the statistical control, indicate the calculated value son the graph.
10 Define sampling. Why it is needed? Draw an oc curve and describe consumer and producers risk.
11 Draw an OC curve for single sampling plan. Given that N = 10000, n = 150, C = 2, Determine producers Risk if (a) if AQL = 1% and consumer risk if (b) LTPD = 4%.
12 Explain single and double sampling plan

Lesson Plan

Unit I

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 II

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 III

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

Unit IV

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

Unit V

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

STATISTICAL QUALITY CONTROL (P13ME663)		COURSE ARTICULATION MATRIX											
Sl. No.	Course Outcomes	Program Outcomes											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Explain** the basic concepts of quality, optimum quality, quality control necessity and objectives of quality control and SPC						**M**	**L**					
2	**Explain** measure of central tendency and measure of dispersion, various types of probabilities distribution, to solve numerical problem using statistical technique	**L**				**M**							
3	**Perform** mathematical calculations using data collected and to plot a suitable control chart for further analysis and compute Cp and Cpk.	**L**				**L**					**M**		
4	**Discuss** the concept of acceptance sampling, differentiate between acceptance sampling and 100% inspection, producers risk and consumers risk, OC curves.					**L**					**M**		
5	**Describe** concept and meaning of reliability, reliability prediction, system reliability, redundancy and its uses, problem solving.	**L**				**L**					**M**		

Course Title: NON TRADITIONAL MACHINING			
Course Code: P13ME664	Semester: VI	L-T-P-H : 4-0-0-4	Credits:4
Contact Period: Lecture: 52 Hr; Exam: 3 Hrs		**Weightage: CIE:50; SEE:50**	

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

Course Content

Unit -1

Introduction to Mechanical Process: Need for nontraditional machining processes, Process selection- classification on-comparative study of different processes, comparison between conventional and Non-conventional machining process selection. Ultrasonic Machining-Definition-Mechanism of metal removal- elements of the process-Tool feed mechanism, theories of mechanics of causing 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 holding. 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, PAN parameters-process characteristics — type of torches, applications. Thermal & Non thermal type-Process characteristics —applications, safety issues. **10 hrs**

Text books

1. **Modern machining process:** PANDEY AND SHAH, TATA McGrawHill 2000
2. **New technology:** BHATTACHARAYA 2000

References

1. **Production Technology:** HMT TATA McGraw Hill. 2001
2. **Modern Machining Process:** ADITYA 2002
3. **Non-Conventional Machining:** P.K.Mishra The Institution of Engineers (India) Test book series, Narosa Publishing House 2005.

Sl. No.	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 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 PAM and LBM with the effect of parameters and process characteristics.

Topic Learning Objectives (Unitwise)

Unit I

By the end of the topic, student will be able to

1. **Explain** need for nontraditional machining processes.
2. **Distinguish** b/w conventional and non conventional machining processes.
3. **Describe** mechanism of USM.
4. **List** the applications of USM.

Unit II

By the end of the topic, student will be able to

1. **Explain** principles of abrasive jet machining.
2. **Discuss** advantages and disadvantages of AJM.
3. **Explain** electric discharge machining.
4. **Describe** mechanism of EDM.

Unit III

By the end of the topic, student will be able to

1. **Classify** ECM process.
2. **Explain** principle of ECM.
3. **Describe** electro chemical grinding.

Unit IV

By the end of the topic, student will be able to

1. **Explain** laser beam machining process.
2. **Discuss** types of lasers.
3. **Describe** mechanism of IBM.
4. **Explain** types of high velocity forming processes.

Unit V

1. **Explain** plasma arc machining process.
2. **Discuss** parameters of PAN.
3. **Describe** types of electron beam machining.
4. **List** applications of EBM.

Review Questions

1. Differentiate traditional and nontraditional machining processes.
2. Explain ultrasonic machining process along sketch.
3. Discuss the parameters used in AJM.
4. Describe at least three typical engineering applications of AJM.
5. Describe the chemistry involved in the ECM process.
6. Distinguish between chemical machining process and electrochemical machining process.
7. Explain laser beam machining process.
8. Discuss mechanism of metal removal rate in IBM.
9. Explain PAM parameters.
10. Explain generation and control of electron beam in EBM.

Lesson plan

Unit I

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 II

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 III

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 IV

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	Machining and associated equipment-process characteristics applications.
7	Introduction to 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 V

1	Introduction to 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

Sl No.	Course Outcomes	Program Outcomes											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Discuss** the difference between conventional and non conventional machining process.	L	L			M							
2	**Characterize** the USM and AJM with the effect of parameters and process characteristics.	L	L		L	M							
3	**Explain** the working principle ECM and CHM with the effect of parameters and process characteristics.	M	L		M	M							
4	**Discuss** about the working principle of EDM with the effect of parameters and process characteristics.	L	L		M	L							
5	**Describe** the working principle PAM and LBM with the effect of parameters and process characteristics.	L	L		L	M							

Course Title: Computer Aided Modelling & Analysis Lab			
Course Code: P13MEL67	Sem: VI	L-T-P-H: 0-0-3-3	Credits: 1.5
Contact Period: Practicals: 36 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	Prerequisites Course 2013-14		Course of Regulations 2013-14		Equivalent Course for 2008-09	
	Code	Title	Code	Title	Code	Title
1	P13ME33	Mechanics of Materials	P13MEL67	Computer Aided Modeling & Analysis Lab	P08MEL78	Computer Aided Modeling & Analysis Lab
2	P13ME35	Fluid Mechanics				
3	P13ME64	Finite Element Method				
4	P13ME63	Heat and Mass Transfer				

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.
Application of line elements: bars of constant cross section area, tapered cross section area, stepped bars. **3Hrs**

Exp-2
Application of line elements: Plane trusses, beams with point, uniform and variable loads. **3Hrs**

Exp-3
Application 2-D elements: Beams, Plate with hole, heat transfer (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. **Finite Element Analysis Theory and Application with ANSYS**, Saeed Moaveni, Pearson Education
2. **ANSYS 15** documentation.

Sl. No.	Course Outcome
	At the end of the course the students should be able to:
1	**Explain** the applications of commercial finite element analysis packages like ANSYS 15.
2	**Solve** structural engineering problems using ANSYS 15.
3	**Solve** thermal engineering problems using ANSYS 15.
4	**Validate** finite element results with analytical or experimental results.

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	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Explain the applications of commercial finite element analysis packages like ANSYS 15.										**H**		**H**
Solve structural engineering problems using ANSYS 15.	**H**	**H**		**M**	**H**							
Solve thermal engineering problems using ANSYS 15.	**H**	**H**		**M**	**H**							
Validate finite element results with analytical or experimental results.				**M**								

Course Title: Heat and Mass Transfer Laboratory			
Course Code: P13MEL68	Semester: VI	L-T-P-H : 0-0-3-3	Credits:1.5
Contact Period: Practicals: 36 Hr; Exam: 3 Hrs		Weightage: CIE:50; SEE:50	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	**Prerequisites Course 2013-14**		**Course of Regulations 2013-14**		**Equivalent Course for 2008-09**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P13ME63	Heat and mass transfer	P13MEL68	Heat and Mass Transfer Laboratory	P08MEL68	Heat and Mass Transfer Laboratory

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.

Sl. No.	**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
6	Prepare and present clear and concisely written lab reports

Course Content

PART-A

Exp-1 **3Hrs**
Determination of thermal Conductivity of a Metal Rod.

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

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

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

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

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

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

PART-B

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

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

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

References

1 **Heat and mass transfer:** P.K. Nag, tata megraw-hill publications
2 **Heat and mass transfer:** R.K Rajput S.Chand, publications

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

	Program Outcomes											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1] Identify safe operating practices and requirements for laboratory experiments		**L**										
2] Analyze thermal and fluid systems.	**M**	**M**										
3] Understand basic thermal and fluid measurement techniques		**M**										
4] Perform one dimensional conduction, convection and radiation experiments	**M**	**M**		**M**								
5] Function effectively as a member of a team									**L**			
6] Prepare and present clear and concisely written lab reports										**M**		