SYLLABUS

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

ಪಠ್ಯಕ್ರಮ

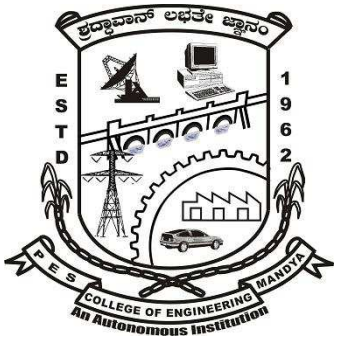
(ಶೈಕ್ಷಣಿಕವರ್ಷ 2013–14)
ಫಲಿತಾಂಶ ಆಧಾರಿತ ಶಿಕ್ಷಣ

VII and VIII 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.

ಪಿ.ಇ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ
ಮಂಡ್ಯ–571 401, ಕರ್ನಾಟಕ
(ವಿ.ಟಿ.ಯು, ಬೆಳಗಾವಿ ಅಡಿಯಲ್ಲಿನ ಸ್ವಾಯತ್ತ ಸಂಸ್ಥೆ)

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Preface

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

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

Our Higher Educational Institution has adopted the 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.

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

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

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

VII Semester B.E Mechanical Engineering **Scheme of Teaching and Examination**

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	P13ME71	Automatic Control Engineering	Mechanical	3:2:0:5	4	50	50	100	3
2	P13ME72	Hydraulics & Pneumatics	Mechanical	4:0:0:4	3	50	50	100	3
3	P13ME73	Management & Entrepreneurship	Mechanical	4:0:0:4	4	50	50	100	3
4	P13ME74	Production Management	Mechanical	4:0:0:4	4	50	50	100	3
5	P13ME75	Elective-II	Mechanical	4:0:0:4	4	50	50	100	3
6	P13ME76	Elective-III	Mechanical	4:0:0:4	4	50	50	100	3
7	P13MEL77	Design Lab	Mechanical	0:1:2:3	1.5	50	50	100	3
8	P13MEL78	Simulations Lab	Mechanical	0:1:2:3	1.5	50	50	100	3
				Total	**26**	**400**	**400**	**800**	

Elective-II

Sl. No.	Course Code	Course title
01	P13ME751	Industrial Automation
02	P13ME752	Non Destructive Testing
03	P13ME753	Theory of Plasticity
04	P13ME754	I. C. Engines

Elective-III

Sl. No.	Course Code	Course title
01	P13ME761	Computer Integrated Manufacturing
02	P13ME762	Maintenance Engineering
03	P13ME763	Experimental Stress Analysis
04	P13ME764	Gas Turbines

VIII Semester B.E Mechanical Engineering **Scheme of Teaching and Examination**

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	P13ME81	Industrial Robotics	Mechanical	4:0:0:4	3	50	50	100	3
2	P13ME82	Operations Research	Mechanical	4:0:0:4	3	50	50	100	3
3	P13ME83	Elective-IV	Mechanical	4:0:0:4	3	50	50	100	3
4	P13ME84	Elective-V	Mechanical	4:0:0:4	3	50	50	100	3
5	P13ME85	Project Work	Mechanical	0:0:20:6	10	100	100	200	
6	P13ME86	Industrial Visit and Seminar	Mechanical	0:0:4:3	2	50	--	50	
				Total	**24**	**300**	**300**	**650**	

Elective-IV

Sl. No.	Course Code	Course title
01	P13ME831	Organizational Behaviour
02	P13ME832	Foundry &Welding Technology
03	P13ME833	Renewable Energy Sources
04	P13ME834	Computational Fluid Dynamics

Elective-V

Sl. No.	Course Code	Course title
01	P13ME841	Project Management
02	P13ME842	Additive Manufacturing Techniques
03	P13ME843	Power Plant Engineering
04	P13ME844	Tribology

Seventh Semester

Course Title: Automatic Control Engineering			
Course Code: P13ME71	**Sem: 07**	**L –T-P-H: 3:2:0:5**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13MA21	Engineering Mathematics II	P13ME71	Automatic Control Engineering	P08ME71	Automatic Control Engineering
2	P13MA31	Engineering Mathematics III				
3	P13ME62	Mechanical Vibrations				

Course objective: The course aims at strengthening the ability of students in design and analysis of linear continues-time control systems to improve their static and transient behaviour.

Course Content

Unit - 1

Introduction and Mathematical Models of Physical Systems: Concept of automatic controls, open and closed loop control systems, concepts of feedback control systems, requirement of an ideal control system. Examples of control systems - Speed control system, Human body temperature control system, Home heating system, Traffic control system, Liquid level control system. Definition of Laplace transformation, Transfer function models, mathematical models of mechanical systems, models of electrical circuits, models of DC and AC motors, models of hydraulic systems and models of thermal systems. Analogous Systems- Force-voltage analogy and force-current analogy. **10 hrs**

Unit- 2

Block Diagrams & Signal Flow Graphs and Time Response Analysis: Transfer functions definition, block representation of system elements, reduction of block diagrams with single and multiple inputs. Signal flow graphs- Signal flow graph terminology, signal flow graph from block diagram, Manson's gain formula. **10 hrs**

Unit -3

Time Response Analyses: Time response analysis - Introduction, transient and steady state response of control system, standard test inputs – step, ramp, parabolic and impulse inputs. First order system response to step and ramp inputs, concepts of time constant and its importance in speed of response. Second order system response to step input, transient response specifications. Stability definition, mathematical concept of stability, characteristic root locations and stability, Routh's stability criterion, special cases of Routh's criterion. Steady-state error analysis- control system type, steady-state error constants- static position error constant, static velocity error constant and static acceleration error. **10 hrs**

Unit - 4

Frequency Response Analysis: Polar plots, relative stability- concepts phase margin and gain margin. Nyquist Stability Criterion, Stability analysis using Nyquist plot. Frequency response analysis using bode plot: Bode attenuation diagrams, stability analysis using Bode plots. **12 hrs**

Unit -5

Root Locus and State-Space Analyses: Root locus analysis- Introduction, definition of root loci, general rules for constructing root loci, root locus analysis of control systems. State-space analysis- introduction, definitions, state-space equations, transformation matrix, controllability and observability. **10 hrs**

Text books

1. Katsuhiko Ogata, **Modern Control Engineering,** Phi Learning Pvt Ltd, 5th Edition, 2010, ISBN: 9788120340107.
2. Rao V Dukkipati, **Control Systems,** Narosa Publishing House, 2008, ISBN: 978-8173195549.
3. Joseph J. Distefano, Allen R. Stubberud and Avan J. Williams, **Feedback and Control Systems**, Schaum's Outlines series, Tata McGraw Hill, New Delhi, 2nd Edition, 2003, ISBN: 978-0070582880.

References

1. I. J. Nagarath & M. Gopal, **Control systems,** New age International publishers, 4th Edition, 2006, ISBN: 978-8122417753.
2. F. Golnaraghi and B.C. Kuo, **Automatic Control Systems**, John Wiley & Sons, 9th Edition, 2009, ISBN: 978-0470048962.
3. **Control Systems:** Ashfaq Husain and Haroon Ashfaq, Dhanpat Rai & Co., 2015, ISBN: 978-8177000276.

Course Outcomes

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

1. **Identify** and **classify** the different types of control systems. **Develop** mathematical model for the mechanical, electrical, servo mechanism and hydraulic systems.
2. **Represent** the systems consisting of number of components in the form of block diagrams and signal flow graphs and **Develop** mathematical models using reduction technique of these block diagrams and signal flow graphs.
3. **Obtain** the time response and steady-state error of the system**. Determine** stability of the various control systems by **applying** Routh's stability criterion.
4. **Obtain** frequency response and **Determine** stability of control system **applying** Nyquist stability criterion and **using** Bode plot.
5. **Construct** root loci from open loop transfer functions of control systems and **Analyze** the behavior of roots with system gain. **Analyze** complex systems having multi inputs and multi outputs using state-space method.

Topic Learning Objectives (Unit wise)

Unit I

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

1. **Identify** and **distinguish** the different systems as open loop and closed loop control systems.
2. **Describe** the fundamental concept of feedback control systems.
3. **Develops** mathematical modeling of physical components and systems.
4. **Develops** transfer function model of physical components and systems
5. **Construct** electrical analogy of physical systems.

Unit II

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

6. **Represent** control systems in the form of block diagrams and signal flow graphs.
7. **Apply** various methods for reducing complicated block diagrams to simpler forms so that they can be used to analyze the control system.
8. **Obtain** transfer function of control system using block diagram reduction technique.
9. **Write** signal flow graph from block diagram.
10. **Obtain** transfer functions from signal flow graphs.

Unit III

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

11. **Apply** fundamentals to **predict** time response of 1^{st} order and 2^{nd} order dynamic systems subjected to step and ramp inputs.
12. **Predict** response time of the system under step and ramp inputs.
13. **Predict** system type and steady-state error of the systems.
14. **Analyze** system stability using Routh's stability criterion.

Unit IV

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

15. **Sketch** polar plot for open loop or closed loop transfer function of the system, **determine** its gain margin and phase margin and **predict** its stability using these gain and phase margins.
16. **Sketch** Nyquist plot for open loop or closed loop transfer function of the system and **discover** its stability.
17. **Sketch** Bode plot for open loop or closed loop transfer function of the system, **determine** its gain margin and phase margin and **predict** its stability using these gain and phase margins.

Unit V

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

18. **Sketch** root locus for open loop or closed loop transfer function of the system.
19. **Predict** variation of root loci with system gain parameter.
20. **Predict** limiting values of system gain for the system to be stable.
21. **Write** state-space equation for the system.
22. **Apply** state-space method to **analyze** complex systems having multi inputs and multi outputs.

Review Questions

1 Differentiate between open loop and closed loop control systems. Give examples for each.

2 List the advantages and disadvantages of closed loop control system over open loop control system.

3 What are the general requirements of a control system? Explain them.

4 With the help of block diagrams, explain the following:

i) Speed control system ii) Temperature control system

iii) Traffic control system iv) Human body temperature control system

v) Liquid level control system

5 Derive the transfer function for a first order mechanical/electrical systems.

6 Obtain the transfer function of armature/field controlled D. C. Motor and hence write the differential equation.

7 For the mechanical system shown in Fig. Q7, write down the differential equations of motion and electrical analogous circuit based on force-voltage and force-current analogy.

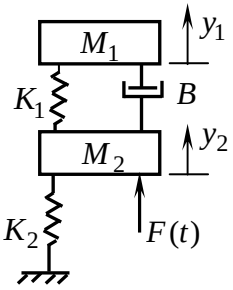

Fig. Q7.

8 Reduce the block diagram shown in Fig. Q 8 into canonical form and obtain its closed loop transfer function.

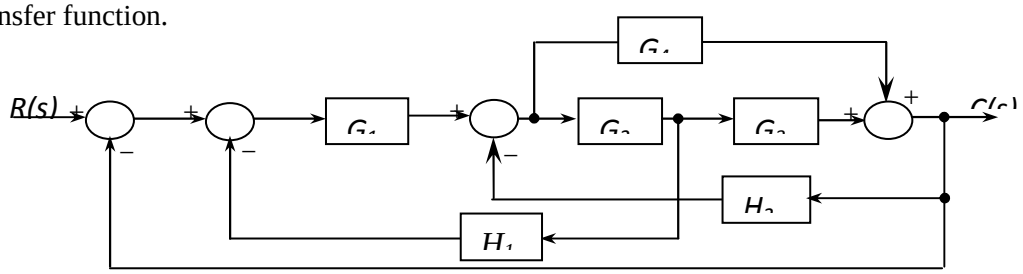

Fig. Q 8.

9 Obtain the output C(s) of multi input system shown in Fig. Q 9.

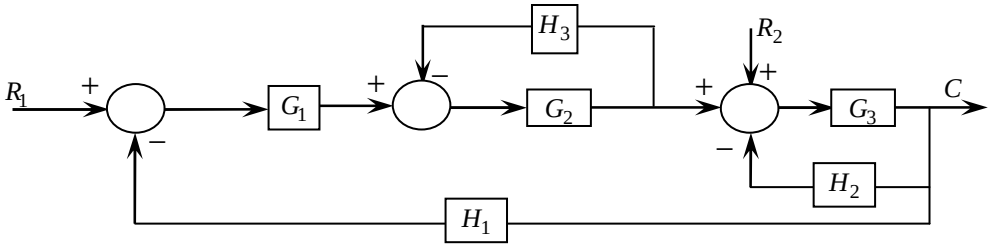

Fig. Q 9

10 For the system shown in Fig. Q 8, draw signal flow graph and obtain C(s)/R(s) using Mason's gain formula.

11 Determine CLTF for the signal flow graph shown in Fig. Q 11 using Masons gain formula.

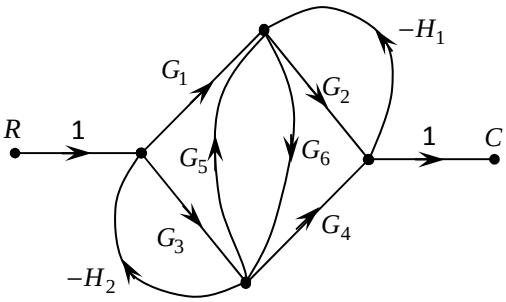

Fig. Q 11

12 Sketch the polar plot for a system whose open loop transfer function is given by

$G(s)H(s) = \frac{K}{1-\tau s}$.

13 With the help of polar plot, briefly explain the concept of gain margin and phase margin for both stable and unstable systems.

14 Sketch the Nyquist plot for a system with $G(s)H(s) = \frac{10(s+3)}{s(s-1)}$. Comment on its closed loop stability.

15 The open loop transfer function of a unity feedback control system is

$G(s) = \frac{10}{s(1+0.5s)(1+0.1s)}$. Draw Bode plot and find gain margin, phase margin, gain crossover frequency and gain crossover frequency. Also ascertain the stability of system.

16 Sketch the Bode plot for the system with $GH(s) = \frac{250K}{s(s+5)(s^2+5s+121)}$ and find the value of K for (i) gain margin of 40db and (ii) phase margin of 45^o.

17 Using necessary steps and calculations, sketch the Root locus plot for an unity feedback system having OPLT

$G(s) = \frac{K}{s(s+2)(s+6)}$ and determine the value of K for the system to be stable.

18 A feedback system has the closed loop transfer function

$\frac{Y(s)}{U(s)} = \frac{8}{s^3+3s^2+7s+9}$. Construct a state model.

19 Determine the transfer function of the system having the state model

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}-2 & -3\\ 4 & 2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}3\\ 5\end{bmatrix}u(t);\ y = \begin{bmatrix}1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

20 A control system is described by

$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}u(t);\ Y(t) = \begin{bmatrix}1 & 2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$. Determine the controllability and observability of the system.

Lesson Plan

Unit I

1. Concept of automatic controls, open and closed loop control systems, concepts of feedback control systems
2. Requirement of an ideal control system. Examples of control systems - Speed control system, Human body temperature control system.
3. Home heating system, Traffic control system, Liquid level control system.
4. Definition of Laplace transformation, Transfer function models,
5. Mathematical models of mechanical systems, models of electrical circuits
6. Models of DC and AC motors
7. Models of hydraulic systems and models of thermal systems
8. Models of thermal systems.
9. Analogous Systems- Force-voltage analogy and force-current analogy.
10. Example problems on analogous systems.

Unit II

11. Transfer functions definition, block representation of system elements
12. Reduction of block diagrams with single inputs.
13. Problems on reduction of block diagrams with single input.
14. Problems on reduction of block diagrams with single input.
15. Reduction of block diagrams with multiple inputs. Problems on reduction of block diagrams with multi inputs.
16. Signal flow graphs- Signal flow graph terminology.
17. Signal flow graph from block diagram, ason's gain formula.
18. Problems on signal flow graphs.
19. Problems on signal flow graphs.
20. Problems on signal flow graphs.

Unit III

21. Time response analysis - Introduction, transient and steady state response of control system, Standard test inputs – step, ramp, parabolic and impulse inputs.
22. First order system response to step and ramp inputs.
23. Concepts of time constant and its importance in speed of response. Second order system (under damped) response to step input.
24. Second order system (critically and over damped) response to step input. Transient response specifications.
25. Problems on first order and second order system responses.
26. Problems on transient response specifications.
27. Stability definition, mathematical concept of stability, characteristic root locations and Routh's stability criterion.
28. Problems on Routh's stability criterion, special cases of Routh's criterion.
29. Steady-state error analysis- control system type, steady-state error constants- static position error constant
30. Static velocity error constant and static acceleration error.

Unit IV

31. Definition of frequency response, introduction to polar plots.
32. Problems on Polar plots.
33. Problems on Polar plots.
34. Relative stability- concepts of phase margin and gain margin
35. Nyquist Stability Criterion, drawing of Nyquist plot.
36. Problems on stability analysis using Nyquist plot.
37. Problems on stability analysis using Nyquist plot.

38. Problems on stability analysis using Nyquist plot.
39. Frequency response analysis using bode plot and determination of Magnitude ratio and phase angle.
40. Problems on Bode plot.
41. Problems on Bode plot.
42. Problems on Bode plot.

Unit V

43. Root locus analysis- Introduction and definition of root loci.
44. General rules for constructing root loci.
45. Problems on root locus analysis of control systems.
46. Problems on root locus analysis of control systems.
47. Problems on root locus analysis of control systems.
48. State-space analysis- introduction, definitions of state, state-space, state variable, state vector, state variable equation.
49. State-space equations and transformation matrix.
50. Problems on writing state-space equations.
51. Controllability and observability.
52. Problems on controllability and observability.

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Identify and **classify** the different types of control systems. **Develop** mathematical model for the mechanical, electrical, servo mechanism and hydraulic systems.	H	H	M	L								
2. **Represent** the systems consisting of number of components in the form of block diagrams and signal flow graphs and **Develop** mathematical models using reduction technique of these block diagrams and signal flow graphs.	H	H	M		H							
3. **Obtain** the time response and steady-state error of the system**. Determine** stability of the various control systems by **applying** Routh's stability criterion.	H	H	H		M	M	M					
4. **Obtain** frequency response and **Determine** stability of control system by **applying** Nyquist stability criterion and **using** Bode plot.	H	H	H		H	M	M					
5. Construct root loci from open loop transfer functions of control systems and **Analyze** the behavior of roots with system gain. **Analyze** complex systems having multi inputs and multi outputs using state-space method.	H	H	H		H	L	L					

Course Title: Hydraulics and Pneumatics			
Course Code: P13ME72	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P08ME56	Mechatronics and Microprocessor	P13ME72	Hydraulics and Pneumatics	P08ME72	Hydraulics and Pneumatics
2	P13ME53	Turbomachines				

Course objective: The course aims at understanding and strengthening knowledge of the Hydraulic and Pneumatic basics, circuit diagram and circuit symbol, actuators, motors, valves and maintenance of hydraulic systems to students by exposing them to understand for different machines that are commonly used in industries.

Course Content

Unit - 1

INTRODUCTION TO HYDRAULIC POWER: Pascal's law and problems on Pascal's law. Structure of Hydraulic Control System. The Source of Hydraulic Power: Pumps, Pumping theory, pump classification, gear pumps, vane pumps, piston pumps, pump performance, pump selection. Variable displacement pumps and Numericals.

HYDRAULIC ACTUATORS AND MOTORS: Linear Hydraulic Actuators [cylinders], Hydraulic Rotary Actuators, Gear motors, vane motors, piston motors, Hydraulic motor theoretical torque, power and flow rate, hydraulic motor performance. **10 Hrs**

Unit- 2

CONTROL COMPONENTS IN HYDRAULIC SYSTEMS: Directional Control Valves Symbolic representation, Constructional features, pressure control valves, direct and pilot operated types, flow control valves.

HYDRAULIC CIRCUIT DESIGN AND ANALYSIS: Control of single and double acting Hydraulic cylinder, regenerative circuit, pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application. Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve, cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, accumulators and accumulator circuits. **10Hrs**

Unit -3

MAINTENANCE OF HYDRAULIC SYSTEMS: Hydraulic oils Desirable properties, general type of fluids, sealing devices, reservoir system, filters and strainers, problem caused by gases in hydraulic fluids, wear of moving parts due to solid particle contamination, temperature control, troubleshooting.

INTRODUCTION TO PNEUMATIC CONTROL: Choice of working medium,
Characteristics of compressed air. Structure of Pneumatic control system cylinder working end position cushioning, seals, mounting arrangements applications. Rod less cylinders types, working advantages. Rotary cylinder types construction and application. Design parameters selection **11 Hrs**

Unit - 4

DIRECTIONAL CONTROL VALVES: Symbolic representation as per ISO1219 and ISO 5599. Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve. Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling use of quick exhaust valve. **10 Hrs**

Unit -5

MULTI-CYLINDER APPLICATIONS: Coordinated and sequential motion control. Motion and control diagrams Signal elimination methods. Cascading method principle. Practical application examples (up to two cylinders) using cascading method (using reversing valves).Compressed air: Production of compressed air compressors, preparation of compressed air-Driers, Filters, Regulators. Lubricators, Distribution of compressed air-Piping layout. **11 Hrs**

Text books

Anthony Esposito Fluid Power with applications:, 5th edition pearson education, Inc. 2000, ISBN: 9780130102256

Andrew Parr Pneumatics and Hydraulics: Jaico Publishing Co. 1st Edition, 2000, ISBN: 9788172241896

References

S.R Majumdar Oil Hydraulic Systems Principles and Maintenance: 2002, Tata McGraw Hill publishing company Ltd. 2001, ISBN: 9780071406697

S.R.Majumdar Pneumatic systems by, Tata McGraw Hill publishing Co, 1995, ISBN: 9780071359658

Pippenger Hicks Industrial Hydraulics: McGraw Hill, New York, 2nd Edition, 1980, ISBN: 9780070664777

Course Outcomes

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

1. **Derive** Pascal's law. **Explain** Linear Hydraulic Actuators [cylinders], Hydraulic Rotary Actuators and hydraulic motor performance.
2. **Explain** Cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, accumulators and accumulator circuits **Discuss**: Double pump Hydraulic system, Counter Balance Valve application, Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve
3. **Explain** Hydraulic oils Desirable properties, general type of fluids, sealing devices, reservoir system. **Describe** the choice of working medium, characteristics of compressed air. Structure of Pneumatic control system cylinder working end position cushioning, seals, mounting arrangements applications.
4. **Explain**: poppet valves, slide valves spool valve, suspended seat type slide valve. **Describe**: Direct and indirect actuation of pneumatic cylinders, Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling use of quick exhaust valve.
5. **Describe** Cascading method principle. Practical application examples (up to two cylinders) using cascading method (using reversing valves). Production of compressed air compressors, preparation of compressed air-Driers, Filters, Regulators. Lubricators, Distribution of compressed air-Piping layout.

Topic Learning Objectives (Unit wise)

Unit I

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

1. **Explain**: Pascal s law and problems on Pascal s Law,
2. **Discuss**: Structure of Hydraulic Control System.
3. **Describe:** Control System. The Source of Hydraulic Power
4. **Discuss**: Linear Hydraulic Actuators [cylinders]. Hydraulic Rotary Actuators
5. **Explain:** Hydraulic motor theoretical torque, power and flow rate, hydraulic motor performance.

Unit II

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

1. **Explain**: Directional Control Valves Symbolic representation, Constructional features, pressure control valves direct and pilot operated types, flow control valves.
2. **Describe**: Control of single and Double acting Hydraulic cylinder, regenerative circuit, pump unloading circuit
3. **Discuss**: Double pump Hydraulic system, Counter Balance Valve application, Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve
4. **Explain**: Cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, accumulators and accumulator circuits

Unit III

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

1. **Explain**: Hydraulic oils Desirable properties, general type of fluids, sealing devices, reservoir system
2. **Discuss**: Filters and strainers, problem caused by gases in hydraulic fluids, wear of moving parts due to solid particle contamination, temperature control, troubleshooting
3. **Describe:** Choice of working medium, characteristics of compressed air. Structure of Pneumatic control system cylinder working end position cushioning, seals, mounting arrangements applications
4. **Explain**: Rod less cylinders types, working advantages. Rotary cylinder types construction and application. Design parameters selection

Unit IV

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

1. **Explain**: Symbolic representation as per ISO1219 and ISO 5599. Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control
2. **Describe**: Direct and indirect actuation pneumatic cylinders, use of memory valve. Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling use of quick exhaust valve
3. **Explain**: poppet valves, slide valves spool valve, suspended seat type slide valve. Compressed air Production of compressed air compressors
4. **Discuss**: use of memory valve and quick exhaust valve

Unit V

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

1. **Explain**: Coordinated and sequential motion control. Motion and control diagrams Signal elimination methods

2. **Describe**: Cascading method principle. Practical application examples (up to two cylinders) using cascading method (using reversing valves).
3. **Explain**: Use of relay and contactors Control circuitry for simple single cylinder applications. Compressed air Production of compressed air compressors
4. **Discuss**: Preparation of compressed air-Driers, Filters, Regulators, Lubricators, Distribution of compressed air-Piping layout.

Review Questions

1. State pascal's law, explain briefly its applications
2. List broad classifications of hydraulic motors
3. Explain with a neat sketch the principle and working of a direct acting pressure relief valve, draw graphical symbol for the value
4. Explain with a neat circuit diagram sequencing of two cylinders using sequence valve for the operation of clamping of a job and machining it.
5. What are various important locations of filter in a typical hydraulic system? And explain with diagram.
6. What are the adverse effects of entrained gasses in oil used as an operating medium in a hydraulic system?
7. Explain with a neat diagram the construction and working of a 4/2 poopet valve
8. What are the stages of air preparation for use in a pneumatic system? Explain them
9. Explain with a neat circuit diagram the working of locking cylinder using pilot operated check valve.
10. Explain viscosity index, demulsibility and oxidation stability of the fluid.
11. Explain direct and indirect actuation pneumatic cylinders, use of memory valve.
12. List out the characteristics of compressed air
13. Explain with a neat diagram structure of a pneumatic control system
14. List along with symbols any six actuation methods for directional control valves

Lesson Plan

Unit I

1. Pascal s law and problems on Pascal s Law
2. Structure of Hydraulic Control System
3. Control System. The Source of Hydraulic Power
4. Linear Hydraulic Actuators [cylinders]
5. Hydraulic Rotary Actuators
6. Hydraulic motor theoretical torque, power and flow rate, hydraulic motor performance
7. The Source of Hydraulic Power: Pumps Pumping theory,
8. Pump classification, gear pumps, vane pumps,
9. Piston pumps pump performance, pump selection. Variable displacement pumps
10. Piston pumps, pump performance
11. Pump selection. Variable displacement pumps

Unit II

12. Directional Control Valves Symbolic representation,
13. Constructional features, pressure control valves direct and pilot operated types, flow control valves.
14. Control of single and Double acting Hydraulic cylinder,
15. Regenerative circuit, pump unloading circuit,
16. Double pump Hydraulic system, Counter Balance Valve application
17. Hydraulic cylinder sequencing circuits.

18. Locked cylinder using pilot check valve,
19. Cylinder synchronizing circuits,
20. Speed control of hydraulic cylinder, speed control of hydraulic motors,
21. Accumulators and accumulator circuits

Unit III

22. Hydraulic oils Desirable properties, troubleshooting.
23. General type of fluids, sealing devices.
24. Reservoir system, filters and strainers.
25. Problem caused by gases in hydraulic fluids, wear of moving parts due to solid particle contamination, temperature control
26. Introduction to pneumatic control: Choice of working medium
27. Characteristics of compressed air. Structure of Pneumatic control system cylinder
28. Working end position cushioning, seals.
29. Mounting arrangements applications. Rod less cylinders types
30. Working advantages. Rotary cylinder types construction and application.
31. Design parameters selection

Unit IV

32. Directional control valves: Symbolic representation as per ISO1219 and ISO 5599.
33. Design and constructional aspects, poppet valves
34. Slide valves spool valve, suspended seat type slide valve.
35. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, , practical applications
36. Use of memory valve. Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling use of quick exhaust valve.

Unit V

37. Multi-cylinder applications: Coordinated and sequential motion control.
38. Cascading method principle. Practical application examples (up to two cylinders) using cascading method (using reversing valves).
39. Compressed air: Production of compressed air compressors,
40. Preparation of compressed air-Driers
41. Filters
42. Regulators, Lubricators
43. Distribution of compressed air-Piping layout

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Derive: Pascal's law. **Explain:** Linear Hydraulic Actuators [cylinders], Hydraulic Rotary Actuators and hydraulic motor performance.	**M**			**L**						**M**		
Explain: Cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, accumulators and accumulator circuits **Discuss:** Double pump Hydraulic system, Counter Balance Valve application, Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve	**L**		**H**				**M**					
Explain: Hydraulic oils Desirable properties, general type of fluids, sealing devices, reservoir system. **Describe** the choice of working medium, characteristics of compressed air. Structure of Pneumatic control system cylinder working end position cushioning, seals, mounting arrangements applications.			**L**		**H**				**M**			
Explain: poppet valves, slide valves spool valve, suspended seat type slide valve. **Describe:** Direct and indirect actuation of pneumatic cylinders, Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling use of quick exhaust valve.		**L**				**H**		**M**				
Describe: Cascading method principle. Practical application examples (up to two cylinders) using cascading method (using reversing valves). Production of compressed air compressors, preparation of compressed air-Driers, Filters, Regulators. Lubricators, Distribution of compressed air-Piping layout.	**L**			**H**							**M**	

Course Title: Management & Entrepreneurship			
Course Code: P13ME73	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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			P13ME73	Management & Entrepreneurship	P08ME64	Management & Entrepreneurship
2						

Course objective: The course helps students to apply skills pertinent to the management and entrepreneurial management of both existing and emerging technologies. Understand engineering safety, strategies, and life cycle properties of a project. Be able to plan, organize staff and schedule in both small and large organizations with an engineering context.

Course Content

Unit - 1

MANAGEMENT: Introduction Meaning nature and characteristics of Management, Scope and functional areas of management, Management as a science, art or profession Management & Administration Role of Management, Levels of Management, Development of Management Thought early management approaches Modern management approaches.
PLANNING: Nature, importance and purpose of planning process objectives Types of plans (Meaning only) Decision making Importance of planning, steps in planning & planning premises Hierarchy of plans. 12hrs

Unit- 2

Organising and Staffing: Nature and purpose of organization, principles of organization Types of organization,Committees Centralization V/s Decentralization of authority and responsibility Span of control, MBO and MBE (Meaning only), Nature and importance of Staffing Process of Selection & Recruitment (in brief).
Directing and Controlling: Meaning and nature of directing Leadership styles, Motivation Theories, Communication Meaning and importance. Coordination meaning and importance and Techniques of Co-ordination. Meaning and steps in controlling Essentials of a sound control system Methods of establishing control (in brief). 12hrs

Unit -3

Entrepreneur: Meaning of Entrepreneur, Evolution of Concept, Functions of Entrepreneur, Types of Entrepreneur, Evolution of Entrepreneurship, Development of Entrepreneurship, Stages in entrepreneurial process, Role of Entrepreneurs in Economic development entrepreneurship in India, entrepreneurship - its barriers 08hrs

Unit - 4

Small Scale Industry: Definition; Characteristics; Need and rationale: Objectives, Scope, role of SSI in Economic Development. Advantages of SSI. Steps to start an SSI Government policy towards SSI, Different Policies of SSI, Government Support on SSI during 5 year plans. Impact of Liberalization, Privatisation, Globalization on SSI. Effect of WTO / GATT Supporting Agencies of Government for SSI Meaning. Nature of support; Objectives; Functions; Types of Help; Ancillary Industry and Tiny Industry (Definition only)

Institutional Support: Different Schemes, TECKSOK, KIADB; KSSIDC; KSIMC; DIC Single Window Agency; SISI, NSIC, SIDBI, KSFC. 12hrs

Unit -5

Preparation of Project: Meaning of Project, Project Identification, Project Selection, Project Report, Need and significance of Report, Contents, formulation, Guidelines by Planning Commission for Project Report, Network Analysis, Errors of Project Report, Project Appraisal.

Identification of Business Opportunities: Market Feasibility Study: Technical Feasibility Study, Financial Feasibility Study & Social Feasibility study. 08hrs

Text books

1. Principles of Management, P.C. Tripathi, P.N. Reddy, Tata McGraw Hill, 5th Edition, 27 January 2012, ISBN: 9780071333337
2. Dynamics of Entrepreneurial Development & Management, Dr. Vasant Desai Himalaya Publishing House, 2011, ISBN: 9789350244548
3. Entrepreneurship Development Small Business Enterprises, Poornima M. Charantimath Pearson Education , 2nd Edition, 2013, ISBN: 9788131762264

References

1. Management Fundamentals Concepts, Application, Skill Development Robert N Lussier , Cengage Publisher, 1st September 2012, ISBN: 9788131518267
2. Entrepreneurship Development , S S Khanka , S Chand & Co,1st Revised Edition 1 December 2007, ISBN : 9788121918015
3. Management ,Stephen Robbins Pearson Education / PHI 10th Edition, 2009, ISBN: 9788131727201

Course Outcomes

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

1. **Identify** Nature and characteristics of management, early management & modern management approaches. Hierarchy of plans, importance & purpose of plans, planning and planning premises
2. **Distinguish** Types of organizations, authority & responsibility, leadership styles, methods of sound control, techniques of co- ordination.
3. **Structure** Different types of entrepreneurs, stages in entrepreneurial process**,** role of entrepreneur in economic development.
4. **Structure** Objectives, Scope and role of SSI in Economic Development, Different Policies of SSI, Impact of Liberalization, Privatisation, and Globalization on SSI, Ancillary Industry and Tiny Industry. Different institutional support to start SSI**.**
5. **Analyse** Need and significance of project report, Market Feasibility Study: Technical Feasibility Study, Financial Feasibility Study & Social Feasibility study.

Topic Learning Objectives (Unit wise)

Unit I

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

1. Discuss Meaning nature and characteristics of Management
2. Explain Scope and functional areas of management, Management as a science, art or profession
3. Explain Role of Management, Levels of Management and Development of Management Thought early management approaches Modern management approaches.

4. Define Nature, importance and purpose of planning process and types of plans
5. Explain Decision making Importance of planning, steps in planning & planning premises Hierarchy of plans.

Unit II

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

6. Discuss Nature and purpose of organization, principles of organization Types of organization
7. Define Committees Centralization V/s Decentralization of authority and responsibility Span of control
8. Explain Nature and importance of Staffing Process of Selection & Recruitment
9. Discuss Meaning and nature of directing Leadership styles, Motivation Theories, Communication Meaning and importance
10. Discuss and Explain Meaning and steps in controlling Essentials of a sound control system Methods of establishing control

Unit III

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

11. Explain Meaning of Entrepreneur, Evolution of Concept, Functions of Entrepreneur, Types of Entrepreneur
12. Discuss Evolution of Entrepreneurship, Development of Entrepreneurship
13. Explain Stages in entrepreneurial process, Role of Entrepreneurs in Economic development
14. Discuss entrepreneurship in India, entrepreneurship - its barriers

Unit IV

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

15. Define Characteristics; Need and rationale: Objectives, Scope, role of SSI in Economic Development. Advantages of SSI
16. Explain Steps to start an SSI Government policy towards SSI, Different Policies of SSI, Government Support on SSI during 5 year plans
17. Discuss Impact of Liberalization, Privatisation and Globalization on SSI. Effect of WTO / GATT Supporting Agencies of Government
18. Define and Explain Functions; Types of Help; Ancillary Industry and Tiny Industry
19. Discuss Different Schemes, TECKSOK, KIADB; KSSIDC; KSIMC; DIC Single Window Agency; SISI, NSIC, SIDBI, KSFC.

Unit V

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

20. Discuss Meaning of Project, Project Identification, Project Selection, Project Report, Need and significance of Report, Contents, formulation
21. Define and Explain Guidelines by Planning Commission for Project Report, Network Analysis Errors of Project Report, Project Appraisal
22. Discuss Identification of Business Opportunities
23. Explain Market Feasibility Study: Technical Feasibility Study, Financial Feasibility Study & Social Feasibility study.

Review Questions

1. Explain Different Characteristics of Management
2. Distinguish between Management and Administration
3. Explain functional areas of Management

4. Briefly Explain each component of Planning Characteristics
5. Explain Principles of Organization
6. Define Leadership. Explain basic styles of Leadership
7. Explain steps involved in Controlling
8. Explain Functions of Entrepreneur with suitable Examples
9. Explain how small scale industries help in Economic Development of India
10. Explain Objectives and Functions of WTO
11. Discuss SIDBI. Explain need for institutional support for SSI
12. What are functions of KSFC and TECSOK
13. Differentiate between PERT and CPM
14. Define and Explain Steps followed in Project Appraisal

Lesson Plan

Sl.No.	Unit I
1	Introduction Meaning nature and characteristics of Management
2	Scope and functional areas of management
3	Management as a science, art or profession Management
4	Administration Role of Management Levels of Management,
5	Development of Management Thought
6	Early management approaches Modern management approaches.
7	Nature and importance of planning process
8	Purpose of planning process and objectives of planning
9	Types of plans
10	Decision making Importance of planning
11	Steps in planning & planning premises
12	Hierarchy of plans.
	Unit II
1	Nature and purpose of organization, principles of organization
2	Types of organization
3	Committees
4	Centralization V/s Decentralization of authority and responsibility
5	Span of control, MBO and MBE
6	Nature and importance of Staffing Process of Selection & Recruitment
7	Meaning and nature of directing Leadership styles,
8	Motivation Theories, Communication Meaning and importance
9	Coordination meaning and importance
10	Techniques of Co-ordination.
11	Meaning and steps in controlling
12	Essentials of a sound control system Methods of establishing control
	Unit III
1	Meaning of Entrepreneur, Evolution of Concept
2	Functions of Entrepreneur
3	Types of Entrepreneur
4	Evolution of Entrepreneurship
5	Development of Entrepreneurship
6	Stages in entrepreneurial process
7	Role of Entrepreneurs in Economic development
8	Entrepreneurship in India, entrepreneurship - its barriers
	Unit IV
1	Definition, Characteristics of SSI

2 Need, rationale and Objectives of SSI
3 Scope, Role of SSI in Economic Development. Advantages of SSI.
4 Steps to start an SSI, Government policy towards SSI, Different Policies of SSI
5 Government Support on SSI during 5 year plans.
6 Impact of Liberalization, Privatisation, Globalization on SSI.
7 Effect of WTO / GATT Supporting Agencies of Government for SSI Meaning.
8 Nature of support, Objectives, Functions, Types of Help
9 Ancillary Industry and Tiny Industry
10 Different Schemes, TECKSOK, KIADB
11 KSSIDC, KSIMC, DIC Single Window Agency
12 SISI, NSIC, SIDBI, KSFC.

Unit V

1 Meaning of Project, Project Identification
2 Project Selection, Project Report, Need and significance of Report
3 Contents, Formulation
4 Guidelines by Planning Commission for Project Report
5 Network Analysis, Errors of Project Report
6 Project Appraisal Identification of Business Opportunities
7 Market Feasibility Study: Technical Feasibility
8 Study, Financial Feasibility Study & Social Feasibility study.

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Identify: Nature and characteristics of management, early management & modern management approaches. Hierarchy of plans, importance & purpose of plans, planning and planning premises	L							**M**			**H**	
Distinguish: Types of organizations, authority & responsibility, leadership styles, methods of sound control, techniques of co- ordination						**L**	**M**			**H**		
Structure: Different types of entrepreneurs, stages in entrepreneurial process**,** role of entrepreneur in economic development						**H**	**H**	**L**			**M**	
Structure: Objectives, Scope, role of SSI in Economic Development, Different Policies of SSI, Impact of Liberalization, Privatisation, and Globalization on SSI, Ancillary Industry and Tiny Industry. Different institutional support to start SSI						**H**	**H**					**M**
Analyze: Need and significance of project report, Market Feasibility Study: Technical Feasibility Study, Financial Feasibility Study & Social Feasibility study.									**M**	**L**	**H**	

Course Title: Production Management			
Course Code: P13ME74	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME73	Management & Entrepreneurship	P13ME74	Production Management	P08ME76	Production Management

Course objective: The course aims at enabling the students to understand the basic concepts of production, forecasting, and various scheduling techniques related to manufacturing.

Course Content

Unit – 1

INTRODUCTION: Introduction, meaning and concepts of production management, area of production management, relationship of PM, tools and techniques of PM, evolution of PM, PM, a system view point, PM today, productivity improvement, future of PM. product strategies, the product life cycle, productive system types, process focussed system, product focussed system, production to stock or order, productive system positioning strategies, process line technology, interdependent product lines, organization of the operations functions-process focussed organisation, product focussed organisation structure, difference between process and product focussed **10 hrs**

Unit- 2

FORECASTING: Types and uses of forecasting moving average Exponentially weighed moving averages. Trend model with seasonal variation. Delphi technique. **11 hrs**

Unit -3

FACILITIES LOCATION AND LAYOUT: Introduction, general procedure for location, factors affecting location, locational analysis- cost analysis, quantitative method, weight method, Rankine method, objectives of plant layout, factors affecting plant layout, material flow pattern, layout **10 hrs**

Unit - 4

SCHEDULING: Master scheduling, scheduling sequence operation standard scheduling techniques. Johnson s rule for 2 machines, 3 machines, and n machines. Graphical method for 2 machines and n jobs **11 hrs**

Unit -5

MACHINE LOADING TECHNIQUES: Indexing method, machine loading and follow up by use of Gantt Charts, Schedule boards and other commercial techniques.

PRODUCTION CONTROL: Despatching and Expediting the orders. Centralized and Decentralized dispatching process order control. Follow up and progress reporting, rescheduling and priority rules **10 hrs**.

Text books

1. Buffa and Sarin, Modern Production/Operations Management, Wiley India Pvt. Ltd.-New Delhi, 8th Edition , 23 August 2007, 9788126513727
2. Samuel Eilon, Elements of Production Planning and Control, Universal Publishing Corporation, 1991, ISBN: 9788185027098
3. S.K.Hajra Choudhury, Nirjhar Roy, A.K. Hajra Choudhury, Production Management,

Media Promotors & Pub. Pvt. Ltd., 1998, ISBN: 978-8185099255.

References

1. Barry Shore, Operations Management, McGraw-Hill Inc., USA, 1st January 1973, ISBN: 9780070570450
2. R. Panneerselvam, Production and Operations Management, PHI Publishers , 3rd Edition,2006, ISBN: 9788120345553

Course Outcomes

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

1. **Define** Production management, product life cycle, process focussed system, product focussed system
2. **Analyze** Productive system types, organization of the operations functions-process focussed organisation, product focussed organisation structure
3. **Describe** cost analysis.
4. **Compare** Types of forecasting moving average Exponentially weighed moving averages. Trend model with seasonal variation. Delphi technique.
5. **Discuss** Scheduling, standard scheduling techniques. Machine loading and follow up by use of Gantt Charts. Despatching and Expediting

Topic Learning Objectives (Unitwise)

Unit I

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

1. Explain concepts of production management, tools and techniques of PM,
2. Describe evolution of PM, PM today, productivity improvement, future of PM.
3. Relate process focussed system, and product focussed system.
4. Distinguish product focussed and process focussed organisation structure.
5. Explain product life cycle.

Unit II

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

6. List types and uses of forecasting methods.
7. Calculate moving average, and exponentially weighed moving averages. Trend model with seasonal variation. Delphi technique.
8. Interpret trend models.
9. Explain the Delphi technique.

Unit III

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

10. Summarise general procedure for location, and factors affecting location. layout
11. Analyse locational analysis.
12. List objectives of plant layout.
13. Write the factors affecting plant layout.

Unit IV

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

14. Name different scheduling techniques.
15. Analyse Johnson's rule for 2 machines, 3 machines, and n machines.
16. Interpret graphical method for 2 machines and n jobs.

Unit V

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

17. Define Indexing method
18. Illustrate machine loading and follow up by use of Gantt Charts
19. Explain Schedule boards and other commercial techniques

20. Describe despatching and expediting the orders
21. Compare Centralized and Decentralized dispatching.

Review Questions

1. Explain concepts of production management
2. Describe evolution of PM
3. Explain product life cycle.
4. List types of forecasting methods.
5. Calculate moving average of the given data.
6. Summarise general procedure for location
7. Interpret graphical method for 2 machines and n jobs.
8. Name different scheduling techniques
9. Explain Schedule boards
10. Describe despatching and expediting the orders

Lesson Plan

Unit I

1. Introduction, meaning and concepts of production management,
2. area of production management.
3. tools and techniques of PM, evolution of PM, PM, a system view point,
4. PM today, productivity improvement, future of PM. product strategies,
5. the product life cycle, productive system types,
6. process focussed system, product focussed system,
7. production to stock or order, productive system positioning strategies,
8. process line technology, interdependent product lines,
9. organization of the operations functions-process focussed organisation,
10. product focussed organisation structure, difference between process and product focussed

Unit II

11. Introduction, types of forecasting
12. uses of forecasting
13. Moving average forecasting.
14. Moving average forecasting.
15. Exponentially weighed moving averages.
16. Exponentially weighed moving averages.
17. Trend models
18. Trend models
19. Trend models
20. Trend models
21. Delphi technique

Unit III

22. Introduction,
23. general procedure for location,
24. factors affecting location, locational analysis- cost analysis,
25. factors affecting location, locational analysis- cost analysis,
26. quantitative method, weight method,
27. quantitative method, weight method,
28. Rankine method,
29. objectives of plant layout,
30. factors affecting plant layout,

31. material flow pattern, layout

Unit IV

32. Master Scheduling,
33. Scheduling sequence operation standard scheduling techniques.
34. Scheduling sequence operation standard scheduling techniques.
35. Scheduling sequence operation standard scheduling techniques.
36. Johnson s rule for 2 machines,
37. Johnson s rule for 2 machines,
38. Graphical method for 2 machines and n jobs
39. Graphical method for 2 machines and n jobs
40. Graphical method for 2 machines and n jobs
41. 3 machines, and n Jobs
42. m machines, and n Jobs

Unit V

43. Indexing method,
44. machine loading and follow up by use of Gantt Charts,
45. machine loading and follow up by use of Gantt Charts,
46. Schedule boards and other commercial techniques.
47. Schedule boards and other commercial techniques.
48. Schedule boards and other commercial techniques.
49. Centralized and Decentralized dispatching process order control.
50. Centralized and Decentralized dispatching process order control.
51. Follow up and progress reporting, rescheduling and priority rules.
52. Follow up and progress reporting, rescheduling and priority rules.

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Define: Production management, product life cycle, process focussed system, product focussed system	L											
Analyze: Productive system types, organization of the operations functions-process focussed organisation, product focussed organisation structure	L		M									
Describe: cost analysis.					H							
Compare: Types of forecasting moving average Exponentially weighed moving averages. Trend model with seasonal variation. Delphi technique..					H							
Discuss: Scheduling, standard scheduling techniques. Machine loading and follow up by use of Gantt Charts. Despatching and Expediting					M							M

Course Title: Industrial Automation			
Course Code: P13ME751	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME65	CAD/CAM	P13ME751	Industrial Automation	P08ME743	Industrial Automation

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

Course Content

Unit - 1

INTRODUCTION: Production System Facilities, Manufacturing Support systems, Automation in Production systems, Automation principles & Strategies**.**

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

Unit- 2

HARDWARE COMPONENTS FOR AUTOMATION AND PROCESS CONTROL: Sensors, Actuators, Analog-to-Digital Converters, Digital-to-Analog Converters, Input/Output Devices for Discrete Data

AUTOMATED MANUFACTURING SYSTEMS: Components of Manufacturing systems, Classification of Manufacturing Systems, overview of Classification Scheme, Single Station Manned Workstations and Single Station Automated Cells. **12 hrs**

Unit -3

CELLULAR MANUFACTURING: Part Families, Parts Classification and coding, Production Flow Analysis, Cellular Manufacturing, Application of group technology, Quantitative analysis in cellular manufacturing.

FLEXIBLE MANUFACTURING SYSTEMS: Introduction to FMS, FMS Components, FMS Applications & Benefits, and FMS Planning & Implementation Issues. Quantitative analysis of flexible manufacturing systems. **10 hrs**

Unit - 4

QUALITY CONTROL SYSTEMS: Traditional and Modern Quality Control Methods, Taguchi Methods in Quality Engineering, Introduction to SQC tools.

INSPECTION TECHNOLOGIES: Automated Inspection, Coordinate Measuring Machines Construction, operation & Programming, Software, Application & Benefits, Flexible Inspection System, Inspection Probes on Machine Tools, Machine Vision, Optical Inspection Techniques & Non contact Non optical Inspection Technologies. **10 hrs**

Unit -5

MANUFACTURING SUPPORT SYSTEM: Process Planning, Computer Aided Process Planning, Concurrent Engineering & Design for Manufacturing, Advanced Manufacturing

Planning, lean production and waste in manufacturing, Just-in Time Production System, Autonomation, Worker involvement, Basic concepts of lean and Agile manufacturing, Comparisons of Lean & Agile Manufacturing. **10 hrs**

Text books

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

References

1. Amber G.H & P. S. Amber, Anatomy of Automation, Literary Licensing ,LLC 2012, ISBN: 9781258304256
2. Viswanandham, Performance Modeling of Automated Manufacturing Systems, PHI, 1st Edition, 2008, ISBN: 9788120308701
3. Krishna Kant, Computer Based Industrial Control, EEE-PHI **,** 1st Edition, 15 August 2004, ISBN: 9788120311237

Course Outcomes

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

1. **Identify:** Production System Facilities, Manufacturing Support systems, Automation in Production systems, Basic Elements of an Automated System, Forms of Computer Process Control
2. **Analyze:** Sensors, Actuators, Analog-to-Digital Converters, Digital-to-Analog Converters, Single Station Manned Workstations and Single Station Automated Cells.
3. **Describe:** Production Flow Analysis, Cellular Manufacturing, Application of group technology and FMS Planning & Implementation Issues.
4. **Explain:** Traditional and Modern Quality Control Methods, Taguchi Methods in Quality Engineering, Automated Inspection, Coordinate Measuring Machines Construction, Inspection Probes on Machine Tools, Machine Vision, and Optical Inspection Techniques.
5. **Discuss:** Process Planning, Computer Aided Process Planning, Concurrent Engineering & Design for Manufacturing, JIT production system, Basic concepts of lean and Agile manufacturing.

Topic Learning Objectives (Unit wise)

Unit I

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

1. **Explain** the Production System Facilities
2. **Discuss** Automation in Production systems
3. **Describe** Automation principles & Strategies
4. **Discuss** Basic Elements of an Automated System
5. **Explain** Advanced Automation Functions & Levels of Automation

Unit II

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

1. **Discuss** the common measuring devices used in automation
2. **Explain** the procedure for converting an analog signal into digital form
3. **Describe** the working of actuators
4. **Classify** the Manufacturing Systems

5. **Demonstrate** the Single Station Manned Workstations and Single Station Automated Cells.

Unit III

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

1. **Discuss** Cellular Manufacturing,
2. **Explain** the Application of group technology
3. **Describe** Quantitative analysis in cellular manufacturing
4. **Discuss** FMS Planning & Implementation Issues
5. **Describe** Quantitative analysis of flexible manufacturing systems

Unit IV

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

1. **Explain** Traditional and Modern Quality Control Methods
2. **Discuss** Taguchi Methods in Quality Engineering
3. **Describe** Automated Inspection
4. **Demonstrate** the working of Coordinate Measuring Machine
5. **Discuss** Inspection Probes on Machine Tools

Unit V

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

1. **Discuss** Computer Aided Process Planning
2. **Explain** Concurrent Engineering & Design for Manufacturing
3. **Discuss** Advanced Manufacturing Planning,
4. **Describe** Just-in Time Production System
5. **Compare** Lean & Agile Manufacturing

Review Questions

1. Explain manufacturing systems and how are they distinguished from production systems
2. Discuss the four functions included within the scope of manufacturing support systems
3. Discuss the difference between a continuous control system and a discrete control system
4. Explain polling and interrupt system in computer process control.
5. Describe an overview of the three basic categories of manufacturing systems.
6. Explain the procedure for converting an analog signal into digital form
7. Discuss the typical objectives in implementing cellular manufacturing.
8. Explain parts classification and coding systems
9. Discuss the functions of material handling and storage system in flexible manufacturing systems.
10. Explain flexible manufacturing systems planning and implementation issues
11. Explain the three capabilities that a manufacturing system must possess in order to be flexible.
12. Discuss the robust design and taguchi loss function of taguchi methods in quality engineering.
13. Describe Noncontact non optical inspection techniques.
14. With flow chart explain retrieval computer aided process planning (CAPP) systems
15. Discuss the comparison of mass production and lean production.

Lesson Plan

Unit I

1. Introduction to Production System Facilities
2. Manufacturing Support systems
3. Automation in Production systems
4. Automation principles
5. Automation Strategies
6. Basic Elements of an Automated System
7. Advanced Automation Functions & Levels of Automation
8. Continuous versus Discrete control
9. Computer Process control
10. Forms of Computer Process Control

Unit II

1. Introduction to Hardware Components for Automation and Process Control
2. Sensors
3. Actuators
4. Actuators
5. Analog-to-Digital Converters
6. Digital-to-Analog Converters
7. Input/Output Devices for Discrete Data
8. Introduction to Automated Manufacturing Systems
9. Components of Manufacturing systems
10. Classification of Manufacturing Systems
11. overview of Classification Scheme,
12. Single Station Manned Workstations and Single Station Automated Cells.

Unit III

1. Introduction to Cellular Manufacturing
2. Part Families, Parts Classification and coding
3. Production Flow Analysis, Cellular Manufacturing
4. Application of group technology
5. Quantitative analysis in cellular manufacturing
6. Introduction to FMS
7. FMS Components
8. FMS Applications & Benefits
9. FMS Planning & Implementation Issues
10. Quantitative analysis of flexible manufacturing systems.

Unit IV

1. Introduction to Quality Control Systems
2. Traditional and Modern Quality Control Methods
3. Taguchi Methods in Quality Engineering
4. Introduction to SQC tools
5. Automated Inspection
6. Coordinate Measuring Machines Construction, operation & Programming
7. Software, Application & Benefits, Flexible Inspection System
8. Probes on Machine Tools
9. Machine Vision, Optical Inspection Techniques
10. Non contact Non optical Inspection Technologies

Unit V

1. Introduction to Manufacturing Support System
2. Process Planning
3. Computer Aided Process Planning
4. Concurrent Engineering & Design for Manufacturing
5. Advanced Manufacturing Planning
6. lean production and waste in manufacturing
7. Just-in Time Production System
8. Autonomation, Worker involvement
9. Basic Concepts of lean and Agile Manufacturing
10. Comparisons of Lean & Agile Manufacturing

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
1. **Identify:** Production System Facilities, Manufacturing Support systems, Automation in Production systems, Basic Elements of an Automated System, Forms		L			M				L			
2. **Analyze:** Sensors, Actuators, Analog-to-Digital Converters, Digital-to-Analog Converters, Single Station Manned Workstations and Single Station	M	L	L		M				M			
3. **Describe:** Production Flow Analysis, Cellular Manufacturing, Application of group technology and FMS Planning & Implementation Issues.		L	M		L							
4. **Explain:** Traditional and Modern Quality Control Methods, Taguchi Methods in Quality Engineering, Automated Inspection, Coordinate Measuring Machines Construction, Inspection Probes on Machine Tools, Machine Vision, and	M	M	L						M			
5. **Discuss:** Process Planning, Computer Aided Process Planning, Concurrent Engineering & Design for Manufacturing, JIT production system, Basic concepts of lean and Agile manufacturing.		L	L		M				L			

Course Title: Non Destructive Testing			
Course Code: P13ME752	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME664	Non-Traditional Machining	P13ME752	Non Destructive Testing	P08ME841	Non Destructive Testing

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

Course Content

Unit - 1

INTRODUCTION TO NDT: Introduction to NDT, types of Flaw, methods for the detection of surface and interior flaws, Visual inspection, Types of Boroscopes, special features and illumination.

LIQUID PENETRANT INSPECTION: Principles, Penetrant methods, procedure, materials used and applications. **12hrs**

Unit – 2

MAGNETIC PARTICLE INSPECTION: Principle of MPI, general procedure, advantages & limitation, applications, magnetic field generation methods, magnetic particles & suspending liquids examples and applications.

RADIOGRAPHIC INSPECTION: Principles, X-ray sources, working procedure of X-ray Radiography, Gamma - Ray radiography, Gamma -ray sources, real time radiography, radiation hazard, application examples. **10hrs**

Unit - 3

OPTICAL HOLOGRAPHY: Optical Holography: Principles, applications, holographic recording, reconstruction, interferometric techniques of inspection.

EDDY CURRENT INSPECTION: Principles of operation, procedure, advantages & limitations, operating variables: coil impedance, lift off factor and edge effects, skin effect, inspection coils, eddy current instruments, application examples. **10hrs**

Unit -4

ULTRASONIC INSPECTION: Principles of ultrasonic inspection, basic equipment, advantages & limitations, applicability, major variables in ultrasonic inspection, transducers & couplants, basic inspection methods: pulse echo method, industrial applications.

COMPUTED TOMOGRAPHY (CT): Principles, working and equipments, capabilities, industrial computed tomography applications. **10hrs**

Unit -5

ACOUSTIC EMISSION INSPECTION: introduction, Acoustic emission waves & propagation, instrumentation principles, application examples.

THERMAL INSPECTION: Principles, equipment, inspection methods and applications.

FUNDAMENTALS OF IMAGE PROCESSING METHODS: digital image enhancement

system, image capture & acquisition system, image processing & image enhancement principles. **10hrs**

Text books

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

References

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

Course Outcomes

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

1. **Review** On NDT and Its Methods. Liquid Penetrate Inspection Techniques
2. **Discuss** On Magnetic Particle Inspection And Radiographic Inspection**.**
3. **Explain** Optical Holography And Eddy Current Inspection.
4. **Summarize** Ultrasonic Inspection And Computed Tomography**..**
5. **Describe** Thermal Inspection And Acoustic Emission Inspection.

Topic Learning Objectives (Unit wise)

Unit I

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

1. Classification of NDT process
2. Explain Types of flows
3. Write the Principle Of Liquid Penetrant Inspection.
4. Summarise The Liquid Penetrant Methods

Unit II

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

1. Explain the Principle and methods of Magnetic Particle Inspections.
2. Discuss Advantages, limitation & applications of Magnetic Particle Inspection.
3. Explain the Principle and methods of Radiographic Inspection.
4. Discuss on X-ray Radiography process.

Unit III

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

1. Explain the Principle Of Optical Holography
2. Describe interferometric techniques of inspection
3. Describe Eddy Current Inspection
4. Analyzing operational variables Eddy Current Inspection

Unit IV

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

1. Discuss the Principle and method of ultrasonic inspection.
2. Explain major variables of ultrasonic inspection.
3. Discuss the Principle and methods of computed tomography.
4. Summarise the Applications of computed tomography.

Unit V

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

1. Discuss Acoustic emission waves generation & propagation
2. Explain Principle of Acoustic emission inspection.
3. Discuss on Thermal Inspection process
4. Describe image enhancement principles

Review Questions

1. Classification of different types of NDT process
2. Explain Types of flows and explain method of detection of flow.
3. Write a note on Principle Of Liquid Penetrant Inspection.
4. Explain The Liquid Penetrant Methods with sketch
5. Principle and methods of Magnetic Particle Inspections.
6. List out Advantages, limitation & applications of Magnetic Particle Inspection.
7. Explain Principle and method of Radiographic Inspection.
8. Explain X-ray Radiography process with neat sketch
9. Explain Principle Of Optical Holography
10. Explain interferometric techniques of inspection
11. Discuss Acoustic emission waves generation & propagation
12. Explain Principle of Acoustic emission inspection.
13. Discuss on Thermal Inspection process
14. Explain image enhancement principles
15. Explain Principle and method of ultrasonic inspection.
16. Explain major variables of ultrasonic inspection.
17. Explain Principle and methods of computed tomography.
18. List out advantages disadvantages and Applications of computed tomography.

Lesson Plan

Unit I

1. Introduction To NDT ,Types ,Recent Developments Of NDT
2. Types Of Flaw
3. Methods For The Detection Of Surface Flaws
4. Methods For The Detection Of Flaws
5. Visual Inspection Method
6. Types Of Boroscopes
7. Special Features And Illumination Used In Visual Inspection
8. Principles Of Liquid Penetrant Inspection
9. Penetrant Methods Of Liquid Penetrant Inspection
10. Procedure Of Liquid Penetrant Inspection
11. Materials Used
12. Applications.

Unit II

13. Principle Of Magnetic Particle Inspection
14. General Procedure
15. Advantages & Limitation, Applications
16. Magnetic Field Generation Methods
17. Concept Of Magnetic Particles Examples And Applications
18. Concept Of Suspending Liquids Examples And Applications
19. Principles And Source Of Radiographic Inspection, Working Of X-Ray Radiography
20. Working Of Gamma - Ray Radiography

21. Working Of Real Time Radiography
22. Radiation Hazard, Application Examples

Unit III

23. Optical Holography: Principles, Applications.
24. Working Procedure Of Optical Holography
25. Holographic Recording And Reconstruction
26. Interferometric Techniques Of Inspection
27. Eddy Current Inspection: Principles Of Operation
28. Procedure Of ECI
29. Advantages & Limitations
30. Operating Variables: Coil Impedance, Lift Off Factor And Edge Effects
31. Skin Effect, Inspection Coils, Eddy Current Instruments
32. Application Examples

Unit IV

33. Principles Of Ultrasonic Inspection
34. Basic Equipment And Working Of Ultrasonic Inspection
35. Advantages & Limitations, Applicability
36. Major Variables In Ultrasonic Inspection
37. Transducers & Couplants
38. Basic Inspection Methods: Pulse Echo Method
39. Industrial Applications Of Pulse Echo Inspection
40. Computed Tomography (Ct): Principles
41. Working And Equipments, Capabilities of CT
42. Industrial Computed Tomography Applications.

Unit V

43. Acoustic Emission Inspection: Introduction
44. Acoustic Emission Waves & Propagation
45. Instrumentation Principles, Application Examples
46. Thermal Inspection: Principles
47. Equipment and Applications of TI
48. Inspection Method of TI
49. Fundamentals of Image Processing Methods
50. Digital Image Enhancement System
51. Image Capture & Acquisition System
52. Image Processing & Image Enhancement Principles.

Course Articulation Matrix

Sl No.	Course Outcomes	Program Outcomes											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Review** On NDT And Its Methods. Liquid Penetrate Inspection Techniques	**M**				**H**							**L**
2	**Discuss** On Magnetic Particle Inspection And Radiographic Inspection**.**	**M**	**M**			**H**							**L**
3	**Explain** Optical Holography And Eddy Current Inspection.	**M**	**L**			**H**		**L**					**L**
4	**Summarize** Ultrasonic Inspection And Computed Tomography.	**M**	**M**			**H**							**M**
5	**Describe** Thermal Inspection And Acoustic Emission Inspection.	**M**				**H**		**L**					**L**

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	P13ME664	Non-Traditional Machining	P13ME752	Non Destructive Testing	P08ME841	Non Destructive Testing

Course Title: Theory of Plasticity			
Course Code: P13ME753	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME664	Theory of Elasticity	P13ME753	Theory of Plasticity	P08ME753	Theory of Plasticity
2	P13ME31	Engg. Mathematics				

Course objective: To provide a basic understanding of the plasticity theory as applied to metalworking processes and their analysis for improved quality and productivity.

Course Content

Unit – 1.

Fundamental of elasticity: Concept of stress, Equilibrium equation stress transformation laws, spherical and deviator stress tensors, octahedral stresses. Concept of strain, compatibility equations, deviator and spherical strain tensors, strain transformation laws, octahedral strains, elastic strain energy, theories of strength, Numerical. **10hrs**

Unit- 2.

Principal stresses and Strain:? Principal stresses and strains, true stresses and strains, cubical dilation, representation strain, engineering and natural strains.

Plastic deformation of metals: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth, flow figures (Luder's lines). **10hrs**

Unit -3.

Stress- Strain relations: Introduction, types of materials, empirical equations, theories of plastic flow, experimental verification of St Venant's theory of plastic flow, the concept of plastic potential, the maximum work hypothesis. **Yield Criteria:** Introduction, yield or plasticity conditions Tresca and Von-Mises criteria, experimental evidence for yield criteria (a) Lode's experiment (b) Quinney's experiment. The Haigh-Westergaard stress space. Traces of the yield surfaces in 2D stress space. **10hrs**

Unit – 4.

Slip Line Field Theory: Introduction, basic equations for incompressible two dimensional flow, continuity equations(Geiringer equation), stresses in conditions of plain strain, convention for slip lines, solutions of plastic deformation problem, geometry of slip line filed, properties of slip lines, construction of slip line nets. **10hrs**

Unit -5.

Bending of Beams: Introduction, analysis of stresses, Non-linear stress-strain curve, shear stress distribution, Residual stresses in plastic bending, Numerical.

Torsion of bars: Introduction, plastic torsion of a circular bar, Elastic- perfectly - plastic material, Elastic work hardening material, Residual stresses and Numerical. **12hrs**

Text books

1. Sadhu Singh, Theory of Plasticity & Metal Forming Processes, Khanna Publishers, 3rd Edition ,2015, ISBN: 9788174090509
2. R. A. W. Slater, Engineering Plasticity: Theory and Application to Metal Forming Processes , McMillan Press Ltd, 1st Edition, 1977, ISBN: 9780333157091

References

1. J. Chakraborty, Theory of plasticity, Butter-Heinemann publisher, 3rd Edition, 20 August 2007, ISBN: 9789380931715
2. Jacob Lubliner, Plasticity Theory **,** Dover publications Inc, 1st Edition, 2008, ISBN:9780486462905
3. Avitzur, B., Metal Forming Processes and Analysis, McGraw-Hill, 1st Edition,1968 , ISBN : 9780070025103
4. L. M. Kachanov**,** Fundamentals of the Theory of Plasticity , Dover Publication,1st Edition,2004 **,** ISBN: 9780486435831

Course Outcomes

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

1. **Derive** the equation for stress transformation, spherical, deviator, octahedral stresses and strains, and **calculate** the same.
2. **Explain** factors affecting plastic deformation, strain hardening, recovery, recrystallization, cubical dilation, and true stress and strain. **Calculate** principal stress and strain
3. **Explain** St Venant's theory of plastic flow; **derive** Von Mises and Tresca equations.
4. **Derive** basic equation for incompressible two dimensional flows, continuity equation and **explain** geometry of slip line field, properties of the slip lines.
5. **Explain** non linear stress strain curve, shear stress distribution, residual stresses in plastic bending, and plastic torsion of circular bar and **calculate** residual stresses.

Topic Learning Objectives (Unit wise)

Unit I

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

1. Describe the stress and strain.
2. Explain the equilibrium equation.
3. Describe the spherical, deviator and octahedral stresses.
4. Calculate the spherical, deviator and octahedral stress and strain.
5. Explain the theories of strength.

Unit II

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

6. Calculate the principal stress and strain.
7. Define the representative, engineering and natural strain.
8. Identify the crystalline structure in metals.
9. Describe the mechanism of plastic deformation.
10. Discuss the factors affecting plastic deformation.

Unit III

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

11. Classify the materials.
12. Demonstrate the experimental verification of St Venant's theory of plastic flow.

13. Describe the Tresca and Von-Mises yield criteria.
14. Demonstrate the Lode's and Quinney's experiments and Haigh-Westergaard stress space.

Unit IV

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

15. Identify the basic equation for incompressible 2D flow.
16. Describe the Geiringer equation.
17. Solve the plastic deformation problems.
18. Construct the slip line nets.

Unit V

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

19. Sketch the non-linear stress strain curve.
20. Analyse the shear stress distribution.
21. Calculate the residual stresses in plastic bending.
22. Describe the plastic torsion of a circular bar.
23. Calculate the residual stresses.

Review Questions

1. What are the basic assumptions of elasticity?
2. Derive the invariants of the deviator stresses in terms of invariants of stress tensors.
3. What is meant by octahedral stress? Derive the expression for octahedral stress, in terms of principal stress.
4. Obtain the expression for the cubical dilation.
5. Stress components are given by $\sigma_x=\sigma_y=\sigma_z=1,\tau_{xy}=2$,$\tau_{xz}=,\tau_{zy}=1$.Determine the principal stresses, deviatoric stress, effective stress.
6. Stain components are given by $\varepsilon_X=0.001$, $\varepsilon_Y=0.002$, $\varepsilon_Z= 0.001$, $\gamma_{xy}= 0.005$, $\gamma_{yz=}$ 0.001, $\gamma_{xz}=0.002$. Determine octahedral shear strain, principal strain, representative strain and effective strain.
7. Define the following: i) True stress ii) True strain iii) Natural strain iv) Engineering strain.
8. Discuss the factors affecting plastic deformation.
9. Explain the strain hardening. and Luder's lines.
10. Explain the Luder's lines.
11. Derive the Prandtl-Reuss stress-strain relations for plastic flow.
12. Explain the experimental verification of St Venant's theory of plastic flow.
13. Enumerate the various types of materials encountered in practice, from plastic flow point of view. Also sketch the corresponding mechanical model.
14. Explain the experimental verification of Prandtl Reuss equation.
15. Explain the convexity of yield locus.
16. Explain the experimental verification of yield criteria, using Taylor and Quinney's experiment.
17. The state of stress at a point in a material is $\sigma_x=150$MPa, $\sigma_y=100$MPa, $\gamma_{xy}=60$MPa. If the yield strength of the material is 150MPa, determine whether yielding of the material will occur or not according to the Tresca's and Mise's yield criteria.
18. Explain Haigh-Westergaard stress space representation of yield criteria.
19. Derive the Prandtl-Reuss stress-strain relations for plastic flow.
20. Explain the experimental verification of St Venant's theory of plastic flow.
21. Enumerate the various types of materials encountered in practice, from plastic flow point of view. Also sketch the corresponding mechanical model.
22. Explain the properties of slip lines.

23. What do you understand by slip lines? Explain three methods of drawing slip line nets.
24. Derive Geiringer's continuity equation.
25. Explain the geometry of the slip –line field.
26. A bar of rectangular cross section is subjected to a pure bending moment; the elastic stress distribution is linear. Derive the relation for bending moment i) Incipient yielding ii) Elastic-Plastic yielding iii) Fully plastic yielding iv) shape factor.
27. A beam of length L, simply supported at the ends carries a concentrated load W at midspan. If the stress-strain curve for the beam is given by $\sigma=H\varepsilon^{n,}$ determine the deflection of the beam under the load.
28. A cantilever beam of length L carries an end load W. The stress-strain curve for the beam material is given by $\sigma=H\varepsilon^{n,}$ determine the end deflection.
29. A rectangular beam 8cm wide and 10cm deep is 2m long is simply supported at the ends. The yield strength for the beam material is 250MPa. Determine the value of the concentrated load applied at the beam midspan if (a) the outermost fibres of the beam just start yielding (b) the outer shell up to 3cm depth yields and (c) whole of the beam yields. Assume linear stress-strain idealized curve for the beam material.
30. A cantilever beam 10cm wide 12cm deep is a4m long and is subjected to an end load of 5KN. If the stress-strain curve for the beam material is given by $\sigma=700\varepsilon^{0.2}$, determine the maximum stress induced in the beam and its radius of curvature.
31. Draw the shear stress distribution in a rectangular beam of width 8cm and depth 12cm at a cross section where the shear force is 5000N and the stress-strain curve for the beam material is given by $\sigma=700\varepsilon^{0.25}$
32. A rectangular beam having linear stress-strain behaviour is 6cm wide and 8cm deep. It is 3m long, simply supported at the ends and carries a uniformly distributed load over the whole span. The load is increased so that the outer 2cm depth of the beam yields plastically. If the yield stress for the beam material is 240MPa, plot the residual stress distribution in the beam.
33. A solid circular shaft of 8cm radius is subjected to a twisting couple so that the outer 3cm deep shell of the shaft yields plastically. If the yield stress in shear for the shaft material is 150MPa, determine the value of twisting couple applied and the associated angle of twist. $G=0.84x10^5N/mm^2$.
34. A hollow circular shaft of inner radius 5cm and outer radius 10cm is subjected to a twisting couple of 5000N-m. If the shear stress-strain diagram for the shaft material is given by $\tau=350\gamma^{0.3}$, determine the maximum shear stress induced in the shaft and the angle of twist per unit length.

A hollow circular shaft of inner radius 2cm and outer radius 5cm is subjected to a twisting couple so that the outer 1cm deep shell yields plastically. The yield stress in shear for the shaft material is 175MPa and it is made of a non-linear material whose shear stress-shear strain train curve is given by $\tau=280\gamma^{0.25}$. If this twisting moment is now released, determine the residual stress distribution in the shaft and associated residual angle of twist. $G=0.84x10^5N/mm^2$.

Lesson Plan

Unit I

1. Fundamental of Elasticity, concept of stress, equilibrium equation.
2. Stress transformation and problems.
3. Spherical and Deviatoric stress and problems.
4. Concept of strain, compatibility equation.
5. Spherical and Deviatoric strain and problems.
6. Strain transformation and problems.
7. Octahedral stress and problems.
8. Octahedral strain and problems.
9. Elastic strain energy.
10. Theories of strength.

Unit II

11. Principal stress and problems.
12. Principal stress and problems.
13. Principal strain and problems.
14. Principal strain and problems.
15. Cubical dilation, Representative strain.
16. Engineering and Natural strain, Plastic deformation of metals.
17. Crystalline structure in metals, mechanism of plastic deformation.
18. Factors affecting plastic deformation.
19. Strain hardening, recovery.
20. Recrystallization and grain growth, flow figures (Luder's Lines).

Unit III

21. Introduction, Types of materials.
22. Empirical equations, theories of plastic flow.
23. Experimental verification of St Venant's theory of plastic flow.
24. Concept of plastic potential.
25. Tresca yield criteria.
26. Von-Mises yield criteria.
27. Lode's experiment.
28. Taylor and Quinney's experiment.
29. Haigh-Westergaard stress space.
30. Problems.

Unit IV

31. Introduction, Basic equation for incompressible 2D flow.
32. Continuity equation (Geiringer).
33. Stresses in condition of plain strain.
34. Convention for slip lines.
35. Solutions of plastic deformation problems.
36. Geometry of slip lines field.
37. Properties of slip lines.
38. Construction of slip line nets.
39. Problems.
40. Problems.

Unit V

41. Introduction, Analysis of stresses.
42. Non-linear stress-strain curve.
43. Shear stress distribution, Residual stresses in plastic bending.
44. Problems.

45. Problems.
46. Plastic torsion of a circular bar.
47. Problems
48. Elastic-perfectly-Plastic material, Elastic work hardening material.
49. Residual stresses.
50. Problems.
51. Problems.
52. Problems.

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Derive the equation for stress transformation, spherical, deviator, octahedral stresses and strains, and **calculate** the same.	**H**	**M**										
Explain factors affecting plastic deformation, strain hardening, recovery, recrystallization, cubical dilation, and true stress and strain. **Calculate** principal strain.	**H**	**M**			**L**							
Explain St Venant's theory of plastic flow; **derive** Von Mises and Tresca equations.	**H**	**M**	**L**									**L**
Derive basic equation for incompressible two dimensional flows, continuity equation and **explain** geometry of slip line field, properties of the slip lines.	**H**	**M**	**M**	**M**	**L**							**L**
Explain non linear stress strain curve, shear stress distribution, residual stresses in plastic bending, and plastic torsion of circular bar and **calculate** residual stresses.	**H**	**H**	**M**	**H**	**M**				**L**			**M**

Course Title: I C ENGINES			
Course Code: P13ME754	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME754	I.C Engine	P08ME751	I.C Engines
2	P13ME42	Applied thermodynamics				

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

Course Content

Unit – 1

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

FUELS: Hydro carbons ; structure of petroleum – paraffin, olefin, napthene; aromatic series; requirements of an ideal gasoline; effect of volatility engine performance; knock rating on SI engine fuels- octane number; research & motor octane number; performance number; knock rating of diesel fuels - cetane number; diesel index; aniline point API gravity and specific gravity; Alternative fuels – alcohols ; vegetable oils; bio gas as Diesel engine fuels.

12 Hr

Unit- 2

CARBURATION AND COMBUSTION PROCESS IN S.I. ENGINES: Carburettor; types of carburettors and its limitations. Knock free and knocking combustion- stages of combustion process in S.I. engines. Features of different types of combustion chambers system for S.I. engine. I-head, F-head combustion chambers. Effect of engine variables on ignition lag; effect of variables on flame propagation. Detonation; effect of detonation; control of detonation. HUCR values. Anti Knock agents – Pre ignition – Post ignition

10 Hr

Unit -3

C. I. ENGINES:

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

COMBUSTION CHAMBERS:. C.I. engine combustion chambers; methods of generating air swirl; induction air swirl and open combustion chambers; turbulent swirl chambers; M. type combustion chamber. **10 Hr**

Unit-4

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

Unit -5

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

EMISSION REGULATION AND CONTROL SYSTEMS: Mechanism of pollutant formation. Total emission control package thermal reactor package-cata**l**ytic converter package - control of NOx -Exhaust gas recirculation; chemical method. **10 Hr**

Text books

1. M.L. Mathur and R.P. Sharma, Course in I.C. Engines, Dhanpat Rai Publication 1 st Edition, 2010, ISBN: 9788189928469
2. Ganeshan V, Internal Combustion Engine Tata McGraw Hill, 2nd Edition, 2003, ISBN: 0070494576
3. Colin R. Ferguson C. , Internal Combustion Engines, John Wiley & sons, 1st Edition, 1986, ISBN: 9780471837053

References

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

Course Outcomes

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

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

Topic Learning Objectives (Unitwise)

Unit I

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

1. Understand Fuel- Air cycle & Effect of variables
2. Write the structure of petroleum and understand the knock rating of diesel fuels & knock rating on SI engine fuels
3. Know the importance of Alternative fuels

Unit II

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

4. Know about Carburettor and there importance
5. Understand Features of different types of combustion chambers system for S.I. engine.

6. Explained the Detonation; effect of detonation & control of detonation

Unit III

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

7. Understand Ricardo's three stages of combustion process in C.I. engines & Delay period & factors affecting delay period.
8. Explained the Diesel knock- Methods of controlling diesel knock
9. Explained the methods of generating air swirl; induction air swirl
10. Know the principals of turbulent swirl chambers; M. type combustion chamber

Unit IV

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

11. Understand the Diesel injection systems; types of injection systems.
12. Know the working principals of Electronic fuel injection system. MPFI system;
13. Understand the Various factors affecting piston temperature in an engine.
14. Know the importance of Cooling system & Radiators.

Unit V

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

15. Know the recent technologies developed in IC engines
16. Understand the various emission controlling methods.

Review Questions

1. Explain structure of petroleum
2. Describe knock rating of diesel fuels
3. Define diesel index; aniline point, API gravity and specific gravity
4. Differentiate Knock free and knocking combustion
5. Describe Effect of engine variables on ignition lag
6. Explain Detonation; effect of detonation
7. Explain Delay period & factors affecting delay period
8. Write a note on Electronic fuel injection system
9. Explain turbulent swirl chambers; M. type combustion chamber.
10. Explain thermal reactor package & cata**l**ytic converter package

Lesson Plan

Unit I

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

Unit II

13. Carburettor; types of carburettors and its limitations.
14. Knock free and knocking combustion; stages of combustion process in S.I. engines
15. stages of combustion process in S.I. engines.
16. Features of different types of combustion chambers system for S.I. engine
17. I-head, F-head combustion chambers. Effect of engine variables on ignition lag;
18. . Effect of engine variables on ignition lag;
19. effect of variables on flame propagation. Detonation;
20. effect of detonation; control of detonation. HUCR values
21. Anti Knock agents – Pre ignition – Post ignition
22. Revision for unit 2

Unit III

23. Ricardo's three stages of combustion process in C.I. engines
24. Delay period & factors affecting delay period
25. factors affecting delay period
26. ; Variables affecting delay period
27. Diesel knock- Methods of controlling diesel knock.
28. **:**. C.I. engine combustion chambers
29. methods of generating air swirl; induction air swirl and open combustion chambers
30. . induction air swirl and open combustion chambers
31. turbulent swirl chambers; M. type combustion chamber
32. Revision for unit 3

Unit IV

33. Diesel injection systems; types of injection systems
34. fuel pump; Nozzles of different types;
35. Petrol injection systems for S.I. engines;
36. Electronic fuel injection system. MPFI system
37. MPFI system; spark advance mechanisms;
38. Various factors affecting piston temperature in an engine
39. . Cooling system-Water cooling,
40. Air cooling ; Radiators
41. Radiators.
42. Revision for unit 4

Unit V

43. Turbo charging and super charging of I.C. engines
44. , Stratified charge engines (Lean burned SI engine)
45. Multi fuel engines. Two injector engines
46. Multi fuel engines. Two injector engines
47. ;Pilot ignition engine, all ceramic swirl chamber engines
48. Mechanism of pollutant formation.
49. thermal reactor package-cata**l**ytic converter package
50. cata**l**ytic converter package; ; chemical method.
51. control of NOx ;Exhaust gas recirculation
52. Revision for unit 5

Course Articulation Matrix

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

Course Title: COMPUTER INTEGRATED MANUFACTURING			
Course Code: P13ME761	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME65	CAD/CAM	P13ME761	CIM	P08ME751	CIM

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

Course Content

Unit - 1

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

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

Unit- 2

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

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

Unit -3

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

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

10hrs

Unit - 4

Automated Material Handling And Storage: Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system,

automated guided vehicle systems, automated storage/retrieval systems, carousel storage systems work in process storage, interfacing handling & storage with manufacturing.

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

Unit -5

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

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

10hrs

Text books

1. M.P.Groover **"**Automation, Production system & Computer Integrated manufacturing," PHI Publication, 2nd edition, 2007, ISBN: 9780132393218
2. S. Kant Vajpayee "Principles of Computer Integrated Manufacturing" Prentice Hall India, 1st Edition, 1998, ISBN: 9780024222411

Reference Books:

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

Course Outcomes

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

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

Topic Learning Objectives (Unitwise)

Unit I

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

1. **Explain** the Production System Facilities
2. **Discuss** Automation in Production systems
3. **Illustrate** Production concepts and Mathematical Models
4. **Explain** Transfer Mechanisms.
5. **Solve** problems on mathematical models.

Unit II

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

6. **Analysis** of transfer line with storage & without storage.
7. **Compare** different storage buffers.
8. **Solve** problems on different flow lines.
9. **Explain** manual & automated assembly lines.
10. **Solve** problems on methods of line balancing.

Unit III

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

11. **Explain** types of automated assembly system.

12. **Describe** parts feeding devices elements of parts delivery system.
13. **Analysis** of single station & multistation assembly systems.
14. **Discuss** Computer Aided Process Planning.
15. **Explain** Concurrent Engineering & Design for Manufacturing.

Unit IV

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

16. **Explain** types of material handling equipment.
17. **Analysis** of material handling systems.
18. **Discuss** different storage systems.
19. **Illustrate** different control systems.
20. **Describe** PLC.

Unit V

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

21. **Discuss** automatic identification methods.
22. **Compare** other AIDC technologies.
23. **Describe** Automated Inspection
24. **Demonstrate** the working of Coordinate Measuring Machine
25. **Discuss** Inspection Probes on Machine Tools

Review Questions

1. Define Automation& Explain types of Automation.
2. Describe the mathematical model of product life cycle.
3. Sketch and explain different work part transfer mechanisms.
4. List the reasons for implementing storage buffers in a production line.
5. Discuss upper bound & lower bound approach.
6. Explain the terms used in line balancing.
7. Illustrate schematically & explain the elements of part delivery system.
8. Discuss retrieval CAPP system with a block diagram.
9. Discuss the fundamental concepts and input to the MRP systems.
10. Name types of material handling equipments.
11. Explain vehicle guidance methods used in AGV, for automated manufacturing systems.
12. Describe the components of a PLC schematically.
13. Explain radio frequency identification method.
14. Discuss other AIDC technologies.
15. Describe Noncontact non optical inspection techniques

Lesson Plan

Unit I

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

Unit II

12. Introduction to automated flow line.
13. Analysis of Transfer Line without storage & with storage.
14. Numerical problems on without storage & with storage.
15. Numerical problems on buffer storage & partial automation.
16. Numerical problems on flow line with two stages.
17. Line balancing & problems.
18. Precedence diagram
19. Balance delay methods of line balancing largest candidate rule.
20. Kilbridge and Westers method,
21. Ranked positional weight method.
22. Numerical problems.

Unit III

23. Introduction to automated assembly systems.
24. Design for automated assembly systems.
25. Types of automated assembly system.
26. Parts feeding devices elements of parts delivery systems.
27. Analysis of multi station assembly machine.
28. Analysis of single station assembly.
29. Introduction to Manufacturing Support System
30. Computer Aided Process Planning
31. Material requirement planning & its fundamentals.
32. Capacity planning.

Unit IV

33. Introduction to material functions & types of material handling equipment.
34. Analysis of material handling systems.
35. Automated guided vehicle system.
36. Automated storage/retrieval systems.
37. Carousel storage systems work in process storage.
38. Interfacing handling & storage with manufacturing.
39. Introduction to Industrial Control Systems.
40. Sensors & Actuators.
41. Other Control Systems.
42. Discrete Control using PLC.

Unit V

43. Overview of automatic identification methods.
44. Bar code technology.
45. Radio frequency identification.
46. Other AIDC technologies.
47. Introduction to automated Inspection.
48. Coordinate Measuring Machines Construction, operation & Programming.
49. Software, Application & Benefits, Flexible Inspection System.
50. Probes on Machine Tools.
51. Machine Vision, Optical Inspection Techniques.
52. Non contact Non optical Inspection Technologies.

Course Articulation Matrix

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

Course Title: Maintenance Engineering			
Course Code: P13ME762	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME62	Mechanical Vibration	P13ME762	Maintenance Engineering	P08ME845	Maintenance Engineering
2	P13ME73	Management & Entrepreneurship				

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

Course Content

Unit - 1

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

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

Unit- 2

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

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

Unit -3

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

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

Unit - 4

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

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

Unit -5

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

Text books

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

References

1. Frank Herbaty , Hand book of Maintenance Management , Noyes Publication, 2nd Edition, 1990, ISBN: 9780815512042
2. Hand book of Industrial Engg & management, W. Grant Larson Eugene L- Grant 2000
3. Herbert F. Lund, Industrial Pollution Control Handbook, McGraw-Hill Publication, 1st Edition,1971, ISBN: 9780070390959
4. H P Garg , Industrial Maintenance , S Chand & Co Ltd;3rd Edition, 1987, ISBN: 9788121901680
5. Keith Mobley, Lindrey Higgins, Darrin Wikoff , Maintenance engineering Hand book McGraw Hill, 7th Edition, 2008, ISBN: 9780071546461
6. William Staniar, Plant engineering hand book, McGraw-Hill Publication,1st Edition,1950, Digitized 2007.

Course Outcomes

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

1. **Discuss** scope, objective, functions and importance of maintenance systems, and **Explain** various types of maintenance systems.
2. **Recognize** the economics in maintenance, causes of machine failure, performance evaluation and complete overhauling of Machines tools.
3. **Explain** overhauling, maintenance planning, scheduling control. Estimation of maintenance work and Maintenance control.
4. **Describe** features and benefits of computer aided maintenance and application of computer to maintenance work. **Recognize** pollution control in industry.
5. **Recognize** the importance of industrial safety. **Analyse** accident Safety standards for Mechanical equipment and Electrical system.

Topic Learning Objectives (Unitwise)

Unit I

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

1. **Discuss** scope, objective, functions and importance of maintenance systems.
2. **Explain** various types of maintenance systems and condition monitoring.
3. **Solve** the Problems on selection of methods like preventive or breakdown maintenance.

Unit II

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

1. **Explain** economics in maintenance.
2. **Recognize** the causes of machine failure.
3. **Explain** overhauling, maintenance planning, scheduling control.

Unit III

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

1. **Explain** Maintenance planning and scheduling. Repair order control manpower requirement.
2. **Analyse** Maintenance job and spare parts control.
3. **Analyse** Planning of maintenance junctures man power allocation

4. **Recognize** Planning techniques and procedure.
5. **Analyse** Estimation of maintenance work and Maintenance control.

Unit IV

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

1. **Describe** features and benefits of computer aided maintenance.
2. **Recognize** Application of computer to maintenance work.
3. **Recognize** pollution control in industry

Unit V

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

1. **Recognize** safety in industry
2. **Analyse** accident Safety standards for Mechanical equipment and Electrical system.

Review Questions

1. Define Maintenance and mention different types of maintenance.
2. Explain the following: Break down maintenance, Preventive maintenance, Predictive maintenance and corrective maintenance.
3. Discuss the objectives of maintenance and benefits of maintenance.
4. Discuss the causes of machine failure.
5. Explain Repair cycle and repair complexity?
6. Explain the importance of Maintenance planning.
7. Write brief note on maintenance scheduling.
8. Explain in detail maintenance planning, scheduling, monitoring and controlling.
9. Explain how computers play an important role in maintenance.
10. Discuss the various benefits of computerising of maintenance system.
11. What are the types of safety organisations and explain in brief.
12. List out various causes for accidents.
13. What are the safety measures to be followed for exhaust systems?
14. What are the precautionary measures to be taken, when working on welding machine?
15. Write a note on noise control techniques.
16. Write a note on Vibration control techniques.

Lesson Plan

Unit I

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

Unit II

13. Repair for Machinery Maintenance
14. Replacement for Machinery Maintenance
15. Repair complexity in Maintenance of Machinery
16. Finding out most optimal preventive maintenance frequency

17. Numerical treatment required for machinery maintenance
18. Numerical treatment required for machinery maintenance
19. Causes of machine failure
20. Causes of machine failure
21. Performance evaluation
22. Complete overhauling of Machines tools

Unit III

23. Maintenance planning and scheduling
24. Repair order control and manpower requirement
25. Maintenance job analysis and spare parts control
26. Planning of maintenance junctures man power allocation
27. Long range planning and short range planning
28. Planning of maintenance junctures man power allocation
29. Long range planning and short range planning
30. Planning techniques and procedure
31. Estimation of maintenance work
32. Maintenance control

Unit IV

33. Features of Computer aided maintenance
34. Benefits of Computer aided maintenance
35. Application of computer to maintenance work
36. Application of computer to maintenance work
37. Economic importance of accidents
38. Dust control- Fiber collectors, mechanical dust collectors and wet type collectors
39. Electro static precipitators
40. Noise pollution Control –Noise measurement and control
41. Noise pollution Control –Noise measurement and control
42. Industrial vibration and its control

Unit V

43. Types of safety organizations
44. Analysis of accident records
45. Accident investigations
46. Analysis of accident Safety standards for Mechanical equipment
47. Analysis of accident Safety standards for Electrical system
48. Chemical hazards
49. material handling
50. Exhaust system and welding
51. plant house keeping-building, Aisles, Passages and floors
52. plant house keeping- tool cribs, washrooms and canteens

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Discuss scope, objective, functions and importance of maintenance systems, and **Explain** various types of maintenance	**L**	**L**	**H**									
Recognize the economics in maintenance, causes of machine failure, performance evaluation and complete overhauling of			**H**	**H**	**H**							
Explain maintenance planning, scheduling control. Estimation of maintenance work and Maintenance control.				**H**	**H**					**H**		
Describe features and benefits of computer aided maintenance and application of computer to maintenance work. **Recognize** the importance of pollution control in			**M**	**H**	**M**	**M**	**H**			**M**		**M**
Recognize the importance of industrial safety **Analyse** accident Safety standards for Mechanical equipment and Electrical system.			**H**	**M**		**L**	**M**					**M**

Course Title: Experimental Stress Analysis			
Course Code: P13ME763	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME43	Mechanical Measurements & Metrology	P13ME763	Experimental Stress Analysis	P08ME755	Experimental Stress Analysis
2	P13ME33	Mechanics of Materials.				

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

Course Content

UNIT-1

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

Unit – 2

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

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

Unit - 3

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

Unit -4

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

Unit -5

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

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

Text books

1. Sadhu Singh "Experimental Stress Analysis", Khanna publications, 5th Edition , 2015, ISBN: 9788174091826
2. R. S. Sirohi, H. C. Radha Krishna, "Mechanical measurements" New Age International Pvt. Ltd., New Delhi, 3rd Reprint 2016, ISBN: 9788122403831
3. Experimental Stress Analysis - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1st Edition, 1984, ISBN: 9780074519264
4. Holman, "Experimental Methods for Engineers" Tata McGraw-Hill Companies, Inc, New York, 7th Edition, 2007, ISBN: 9780071181655

References

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

Course Outcomes

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

1. Understand the basic aspects of measurement system
2. Set up the required technique of measurement
3. Choose the appropriate method of experiment to analyse the design parameters.
4. Compute the required parameters of design
5. Select the required methods for different techniques.

Topic Learning Objectives (Unit-wise)

Unit I

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

1. Understand the basic terminologies in measurement system.
2. Understand the experimental procedure.
3. Choosing the suitable statistical techniques
4. Understanding different statistical techniques
5. Consideration of data analysis

Unit II

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

Understanding the construction and working of strain gauges

Gaining the knowledge material used in strain gauge

Solving the problems on wheat stone bridge.

Understanding the different compensation techniques.

Unit III

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

1. Understanding the theory of light propagation
2. Gain the knowledge of construction of different polariscope
3. Analyse about different methods in compensation techniques
4. Acquire the knowledge of fringe separation methods.

Unit IV

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

1. Understanding the coating techniques in analysing the stresses.
2. Acquire the knowledge of Birefringent coating
3. Understanding the laws of failure of brittle coating
4. Understand the advantages and application of brittle coating methods.

Unit V

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

1. Understand the moire's fringe analysis technique.
2. Deriving the generalised moire's gap equation
3. Understanding the concept of holography
4. Acquire the knowledge of computer techniques and fringe analysis.

Review Questions

1. Explain with block diagram the generalised measurement system.
2. What are experimental errors? Explain each briefly.
3. Explain Chi-Square methods of goodness of fit.
4. What are strain gauges? Explain any two types of strain gauges.
5. What is gauge factor in strain gauges? Derive an expression for strain gauges.
6. With a neat sketch explain the working of wheat stone bridge in a strain gauge.
7. Explain the method of temperature compensation in strain gauges.
8. Explain the wave theory of light.
9. State and explain stress optic law.
10. With a neat sketch explain the concept of Tardy's compensation method.
11. Explain the sensitivity of Birefringent coating.
12. Explain isoclinics, isostatics and isoentatics,
13. What are the types of brittle coating? Explain briefly.
14. What are the required properties of stress cat materials?

Lesson Plan

Sl.No.	Unit I
1	Introduction: Basic terminologies, generalised measurement system
2	Experiment planning, Generalised experimental procedure
3	Preliminary, Intermediate and final stages of experimental programs
4	Causes and types of experimental errors, Error analysis
5	Statistical analysis of experimental data
6	Probability distribution, Histograms,
7	Chi-square test of goodness of fit
8	Method of least square. Curve fitting,
9	Types of curve fitting
10	General considerations in data analysis.
	Unit II
1	Introduction, Types of Strain gauges
2	Mechanical, Optical, Pneumatic, Acoustic strain gauges
3	Electrical Resistance Strain Gauges, Gauge factor
4	Properties of an ideal gauge material, backing material,
5	Adhesive material, protective coating;
6	Method of bonding strain gauges, strain gauges lead wire and connections
7	Numerical.
8	Strain gauge circuits, Wheatstone bridge,
9	Error due to input impedance of measuring instrument
10	Temperature compensation, multiple gauge circuits

11 Temperature compensation, multiple gauge circuits
12 Calibration of strain measuring system, load cells, Numerical.

Unit III

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

Unit IV

1 Introduction, Birefringence coating technique
2 Reflection polariscope
3 Sensitivity of Birefringent coating
4 Separation of principal stresses. Brittle coating:
5 Coating technique, laws of failure of brittle coating
6 Isostatics and isoentatics,
7 Properties of stress coat materials, crack pattern
8 Crack detection technique, Types of brittle coating,
9 Calibration of brittle coating materials, advantage of brittle coating,
10 Application of brittle coating.

Unit V

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

Course Articulation Matrix

Course Outcomes	**Program Outcomes**											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Introduction	L	L	M	H	M	H	M	H	H	M	M	M
2. STRAIN GUAGES	L	L	H	H	M	H	H	M	M	M	H	H
3. Two dimensional photoelasticity:	L	L	M	M	H	M	H	M	M	H	H	H
4. Coating methods	L	M	H	H	M	H	M	M	M	H	H	L
5. Moire's fringe methods:	M	M	L	H	H	M	L	H	H	M	H	M

Course Title: Gas Turbines			
Course Code: P13ME764	**Sem: 07**	**L –T-P-H: 4:0:0:4**	**Credit: 04**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME42	Applied Thermodynamics	P13ME764	Gas Turbines	---	---
2	P13ME45	Fluid Mechanics				
3	P13ME53	Turbomachines				

Course objective: The objectives of the course are to develop the students ability to understand the thermodynamics of each component, the linked system performance of all components in the Gas turbine engine and performance trends for each component which include compressors, burners, turbines regenerator.

Course Content

Unit – 1:

Ideal plant cycles: Introduction, Carnot cycle, Stirling cycle with regenerator, Ericsson cycle, Joule air cycle, Brayton cycle with regenerator, complex cycles, The closed cycle, Operating media other than air,

Performance of actual gas turbine cycle: Efficiency of compressor and turbine, Pressure or flow losses, Heat exchanger effectiveness, Effect of varying mass flow, Loss due to incomplete combustion, Mechanical loss, Effect of variable specific heat, Calculation of fuel consumption and cycle efficiency, Poly tropic efficiency, Performance of actual cycle, Jet propulsion, Specific thrust of the turbo-jet engine, Thermal efficiency of turbo jet engine, Propulsive efficiency, Effect of forward speed, Effect of altitude, Numerical examples.

10 Hrs

Unit- 2:

Centrifugal compressors: Components, Method of operation, Theory of operation, Ideal energy transfer. Actual energy transfer- Slip, Analytical method of finding slip factor, Power input factor, Pressure coefficient, Compressor efficiency. Inlet or inducer section- when the entrance is axial, sizing of inducer section, Pre whirl. Impeller passage- Effect of impeller blade shape on performance, The impeller channel. The compressor diffuser, Losses in centrifugal compressor, Compressor characteristic, Surging and choking

Axial flow compressor: Introduction, Description, Performance analysis. Momentum or filament analysis –Special velocity diagram, Symmetric stage, Non-symmetric axial inflow, Non-symmetric axial out flow, Actual energy transfer. Airfoil analysis - One dimensional ideal incompressible flow, Two dimensional flow with friction. Blading efficiency – Losses in terms of air angles and drag coefficient. Coefficient of performance- flow coefficient, Pressure coefficient, Work coefficient. Blade loading, Cascade characteristic, Blade angles, Reynolds and Mach number effects. Three dimensional flow analysis- Radial equilibrium theory, Free vortex blades, Constant reaction blades, Forced vortex or solid rotation blades, The general design. Three dimensional blade losses, Compressor stall and surge, overall performance, Compressor characteristics. Numerical examples **12Hrs**

Unit -3

Combustion systems: Introduction, Combustion mechanism, Pressure losses, Combustion intensity, Combustion efficiency, Requirement of Combustion chamber, Shape of the combustion chamber, Stabilizing or primary zone, Dilution and mixing, Combustion chamber arrangements, Fuel injection system

Regenerator: Introduction, Types of regenerator, Heat transfer in direct type exchangers- Exchanger heat transfer effectiveness, Number of exchanger heat transfer units, Capacity ratio, Relation between NTU and Stanton number, Relations between NTU and effectiveness(no derivation), Effect of flow arrangement, Effect of $C_{min}/C_{max}<1$ for regenerator, Log mean rate equation compared to effectiveness –NTU approach. Rotary heat exchanger- Effect of Mateix speed, Effect of longitudinal conduction, Core pressure drop. Some economics approach of heat exchanger design. Numerical examples **10 Hrs**

Unit-4

Axial flow gas turbines: Introduction, Turbine and nozzle efficiencies. Degree of reaction- Impulse turbine, Ideal impulse turbine, Impulse turbine with loss, Blade speed ratio, Velocity ratio and torque, Velocity compounded turbine. The reaction turbine- Reheat factor, Blade speed ratio for reaction turbine. Comparison of turbine types, Forces on blade, Cascade analysis, Three dimensional flow analysis – The free vortex blades, Constant angle nozzle stage. Turbine flow passage- Impulse blading, Reaction blading. Turbine characteristics **10 Hrs**

Unit -5

Performance of Gas turbine power plant: Non dimensional representation of compressor and turbine performance, Performance characteristics of compressor and turbines compressors, Matching of compressor and turbine in a self driving system, Equilibrium running of simple jet and propeller turbine engines, Simple jet unit, nozzle characteristic, Effect of adding a propelling nozzle to the compressor turbine combination, Variation of thrust with forward speed and rpm, Variation of specific fuel consumption with forward speed and rpm, Discussion on the equilibrium running diagram ,Propeller turbine engines(turboprop), Combined turbines.

Environmental consideration: Air pollution, Aircraft emission standards, Stationary engine emission standards, NO_x formation, NO_x reduction in stationary engines, Noise, Noise standards, Noise reduction. **10 Hrs**

Text books

1. P.R. Khajuria.and S. P. Dubey, Gas Turbines and Propulsive System, Dhanpat Rai Publication, 2012, ISBN: 9788189928483
2. V Ganeshan, Gas Turbines McGraw –Hill Publication, 3rd Edition, 2010,
3. ISBN: 9780070681927

References

1. H. I. H Saravanamutto, GFC Rogers, H Cohen, Gas Turbine Theory, Pearson Education, 5th Edition, 2001, ISBN: 9788178085340
2. Turbines Compressor and Fans, S. M. Yahya, Tata McGraw-Hill Publication, 4th Edition , 29 October 2010, ISBN: 9780070707023

Course Outcomes

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

1. Analyze and predict the cycle performance of gas turbine engines.
2. Solve the problem for aircraft propulsion systems, in particular gas turbine engines.
3. Analyze and predict the performance of compressors ,turbines, and combustion system.
4. Apply the dimensionless parameters involving different variables in predicting the performance of a gas turbine power plant.
5. Understand the environmental aspects of gas turbines.

Topic Learning Objectives (Unitwise)

Unit I

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

1. Explain the ideal Plant cycles, such as, Carnot cycle, Stirling cycle with regenerator, Ericsson cycle, Joule air cycle, Brayton cycle with regenerator.
2. Estimate efficiency and work done for ideal Plant cycles, such as, Carnot cycle, Stirling cycle with regenerator, Ericsson cycle, Joule air cycle, Brayton cycle with regenerator.
3. Analyze the effect of variable mass flow and specific heat on the performance of actual gas cycles
4. Estimate specific thrust, thermal efficiency and propulsive efficiency of turbojet engine
5. Analyze the effect of the forward speed and the altitude on turbo jet engine

Unit II

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

1. Explain the components and operation of centrifugal compressor.
2. Understand slip and determine the slip factor, power input factor, pressure coefficient and compressor efficiency of a centrifugal compressor.
3. Explain the losses in compressor and explain the surging and choking
4. Explain the arrangement and operation of an axial flow compressor
5. Analyze the performance of axial flow compressor
6. Explain the performance coefficients such as flow coefficient, pressure coefficient and work coefficient

Unit III

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

1. Explain the combustion mechanism and pressure losses in gas turbine combuster
2. Explain requirements and shape of the combustion chamber
3. Explain various combustion chamber arrangements.
4. Explain the fuel injection system
5. Analyze Heat transfer mechanism in direct type of heat exchangers

Unit IV

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

1. Analyze the nozzle efficiencies
2. Analyze the degree of reaction, blade speed ratio for impulse turbines and also analyze the velocity compounded turbine
3. Analyze the blade speed for a reaction turbine
4. Distinguish between Curtis stage, Rateau stage and Reaction stage
5. Analyze the forces acting on the turbine blades

Unit V

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

1. Demonstrate the non-dimensional representation of compressor and turbine performance.
2. Demonstrate the matching of compressor and turbine in a simple self driving system
3. Explain the effect of adding a propelling nozzle to compressor turbine combination
4. Explain the clean air standards established by the Environmental protection agency(EPA)
5. Explain the mechanism of formation and reduction of NO_x in gas turbines
6. Identify the various noise sources from gas turbine engines and Explain the methods of reducing the noise

Review Questions

1. Explain the following air cycles

a)Ericssion cycle b)Joule air cycle c)Broyton cycle with regenerator

2. Explain the following: a) Pressure or flow losses, b) effect of loss due to incomplete combustion, c) Mechanical losses d) Effect of Variable specific heat
3. A Turbojet engine inducts 45 kg of air per second and propels an aircraft with a uniform flight speed of 880 km/hr. The isentropic enthalpy change for the nozzle is 180 kj/kg, and its velocity coefficient is 0.96. The fuel air ratio is 0.012, the combustion efficiency is 0.95 and lower heating value of the fuel is 44000kj/kg. calculate a)the thermal efficiency of the engine b) the fuel flow rate in kg/hr and TSFC, c) the propulsion power. D) the thrust power e) The propulsive efficiency and f) the overall efficiency.
4. Develop an expression for the slip factor
5. With a neat diagram Describe the axial flow compressor
6. Develop an expression for the static pressure rise in the rotor of an axial flow compressor
7. Design an axial flow compressor for the following conditions:

Mass flow rate 20 kg/s, Pressure ratio 4, Static temperature at the inlet 288K, Static pressure at the inlet 1 atm, mean blade diameter 40 co, Axial velocity 130 m/s, and Degree of reaction 50% at all radii

8. Explain the combustion mechanism in gas turbine combustor
9. What are the basic requirements of the gas turbine combustion chamber

Lesson Plan

Sl.No.	Unit I
1	Introduction, Carnot cycle, Stirling cycle with regenerator, Ericsson cycle Joule air cycle.
2	Brayton cycle with regenerator, complex cycles, The closed cycle, Operating media other than air.
3	Efficiency of compressor and turbine, Pressure or flow losses, Heat exchanger effectiveness, Effect of varying mass flow
4	Loss due to incomplete combustion, Mechanical loss, Effect of variable specific heat, Calculation of fuel consumption and cycle efficiency,
5	Poly tropic efficiency, Performance of actual cycle
6	Jet propulsion, Specific thrust of the turbo-jet engine, Thermal efficiency of turbo jet engine,
7	Propulsive efficiency, Effect of forward speed, Effect of altitude,
8	Numerical examples.

9	Numerical examples.
10	Numerical examples
	Unit II
1	Components, Method of operation, Theory of operation, Ideal energy transfer.
2	Actual energy transfer- Slip, Analytical method of finding slip factor, Power input factor, Pressure coefficient, Compressor efficiency
3	Inlet or inducer section- when the entrance is axial, sizing of inducer section, Pre whirl. Impeller passage- Effect of impeller blade shape on performance.
4	The impeller channel. The compressor diffuser Losses in centrifugal compressor, Compressor characteristic, Surging and choking.
5	**Axial flow compressor** Introduction, Description, Performance analysis. Momentum or filament analysis Special velocity diagram, Symmetric stage
6	Non-symmetric axial inflow, Non-symmetric axial out flow, Actual energy transfer. Airfoil analysis - One dimensional ideal incompressible flow, Two dimensional flow with friction.
7	Blading efficiency – Losses in terms of air angles and drag coefficient. Coefficient of performance- flow coefficient, Pressure coefficient, Work coefficient
8	Blade loading, Cascade characteristic, Blade angles, Reynolds and Mach number effects.
9	Three dimensional flow analysis- Radial equilibrium theory, Free vortex blades, Constant reaction blades, Forced vortex or solid rotation blades, The general design. Three dimensional blade losses
10	Compressor stall and surge, overall performance, Compressor characteristics. Numerical examples
11	Numerical examples
12	Numerical examples
	Unit III
1	**Combustion systems** Introduction, Combustion mechanism, Pressure losses
2	Combustion intensity, Combustion efficiency, Requirement of Combustion chamber, Shape of the combustion chamber
3	Stabilizing or primary zone, Dilution and mixing, Combustion chamber arrangements
4	Fuel injection system **The regenerator** Introduction, Types of regenerator, Heat transfer in direct type exchangers- Exchanger heat transfer effectiveness, Number of exchanger heat transfer units
5	Capacity ratio, Relation between NTU and Stanton number, Relations between NTU and effectiveness(no derivation)
6	Effect of flow arrangement, Effect of $C_{min}/C_{max}<1$ for regenerator, Log mean rate equation compared to effectiveness –NTU approach.
7	Rotary heat exchanger- Effect of Mateix speed, Effect of longitudinal conduction
8	Core pressure drop. Some economics approach of heat exchanger design. Numerical examples
9	Numerical examples
10	Numerical examples
	Unit IV
1	**Axial flow gas turbines** Introduction, Turbine and nozzle efficiencies. Degree of reaction- Impulse turbine
2	Ideal impulse turbine, Impulse turbine with loss, Blade speed ratio, Velocity ratio and torque
3	Velocity compounded turbine. The reaction turbine- Reheat factor

4	Blade speed ratio for reaction turbine. Comparison of turbine types
5	Forces on blade, Cascade analysis
6	Three dimensional flow analysis The free vortex blades
7	Constant angle nozzle stage. Turbine flow passage-
8	Impulse blading, Reaction blading. Turbine characteristics
9	Numerical examples
	Unit V
1	**Performance of Gas turbine power plant** Non dimensional representation of compressor and turbine performance
2	Performance characteristics of compressor and turbines compressors
3	Matching of compressor and turbine in a self driving system
4	Equilibrium running of simple jet and propeller turbine engines, Simple jet unit, nozzle characteristic
5	Effect of adding a propelling nozzle to the compressor turbine combination, Variation of thrust with forward speed and rpm
6	Variation of specific fuel consumption with forward speed and rpm, Discussion on the equilibrium running diagram, Propeller turbine engines(turboprop),
7	Combined turbines. Torque characteristics of gas turbine plant **Environmental consideration** Air pollution
8	Aircraft emission standards, Stationary engine emission standards
9	NO_x formation, NO_x reduction in stationary engines
10	Noise, Noise standards, Noise reduction.

Course Articulation Matrix

Course Outcomes	**Program Outcomes**											
	1	2	3	4	5	6	7	8	9	10	11	12
Analyze and predict the cycle performance of gas turbine engines.	M	M	M							M		
Solve the problem for aircraft propulsion systems, in particular gas turbine engines.	M	M	M							M		
Analyze and predict the performance of compressors, turbines, and combustion system.	M	M	M							M		
Apply the dimensionless parameters involving different variables in predicting the performance of a gas turbine power plant	M	M	M							M		
Understand the environmental aspects of gas turbines.						M	M					

Course Title: Design Lab			
Course Code: P13MEL77	**Sem: 07**	**L –T-P-H: 0:1:2:3**	**Credit: 1.5**
Contact Period: Lecture: 36 Hrs, Exam: 3Hrs		**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	P13ME62	Mechanical Vibrations	P13MEL77	Design Lab	P08MEL77	Design Lab
2	P13ME33	Mechanics of Materials				
3	P13ME51	Dynamics of Machines				

Course Content

PART - A

1. Determination of natural frequency of single DOF undamped spring-mass free vibration system.
2. Determination of natural frequency of single DOF undamped equivalent spring-mass free vibration system.
3. Study of single DOF damped torsional free vibration system.
4. Study of forced vibration of single DOF equivalent spring - mass – damper system
5. Determination of natural frequency by Dunkerley's principle
6. Determination of critical speed of a rotating shaft.

PART - B

7. Determination of Fringe constant of Photoelastic material using a Circular disc subjected to diametral compression.
8. Determination of stress concentration using Photoelasticity for a circular disk with circular hole under compression
9. Performance study of governors.
10. Determination of a Pressure distribution in Journal bearing
11. Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes.
12. Determination of gyroscopic torque in a Gyroscope.

References

1. V.P. Singh**, Mechanical Vibrations,** Dhanpat Rai & Co (P) Ltd**., ISBN:** 1234567150209
2. S.S. Rattan, **Theory of Machines,** Tata McGraw-Hill, New Delhi, 4th edition, 2015, ISBN: 9789351343479.

Evaluation Scheme				
Scheme	**Weightage**	**Marks**	**Event Break Up**	
CIE	50%	50	**Test**	**Record**
			20	30
SEE	50%	50		

Scheme for Examination	
One Question from Part –A	20 Marks (05 write up +15)
One Question from Part -B	20 Marks (05 write up +15)
Viva – Voice	10 Marks
Total	**50 Marks**

Course Outcomes

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

1. **Apply** principles of vibration and **determine** vibration characteristics of simple single degree of freedom systems experimentally.
2. **Determine** critical speed of shaft experimentally.
3. **Demonstrate** the basic principles of photoelasticity**. Determine** experimentally, stress concentration using polariscope.
4. **Demonstrate** experimentally pressure distribution in journal bearings.
5. **Demonstrate** the working principles of Governors and Gyroscope.
6. **Determine** experimentally, stresses induced in a cantilever beam subjected to combined bending and torsion, using strain rosette.

DESIGN LAB P08MEL77		**COURSE ARTICULATION MATRIX**											
Sl No.	**Course Outcomes**	**Program Outcomes**											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Apply** principles of vibration and **determine** vibration characteristics of simple single degree of freedom systems experimentally.	**L**	**M**		**H**					**M**	**M**		
2	**Determine** critical speed of shaft experimentally.	**L**	**M**		**H**					**M**	**M**		
3	**Demonstrate** the basic principles of photoelasticity**. Determine** experimentally, stress concentration using polariscope.	**M**	**M**		**H**					**M**	**M**		
4	**Demonstrate** experimentally pressure distribution in journal bearings.		**M**		**H**					**M**	**H**		
5	**Demonstrate** the working principles of Governors and Gyroscope.		**M**		**H**					**L**	**L**		
6	**Determine** experimentally, stresses induced in a cantilever beam subjected to combined bending and torsion, using strain rosette.		**M**		**H**					**M**	**M**		

Course Title: Simulations Lab			
Course Code: P13MEL78	**Sem: 07**	**L –T-P-H: 0:1:2:3**	**Credit: 1.5**
Contact Period: Lecture: 36 Hrs, Exam: 3Hrs		**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	P13ME65	CAD/CAM	P13MEL78	Simulations Lab	P08MEL67	CAM Lab
2	P13ME71	Automatic Control Engineering				

Course Content

PART - A	**Hrs.**
1. Modeling of simple machine parts and generating machine codes for CNC production using standard CAM packages.	**21**
2. Simulation of Turning, Drilling, Milling / Cutting operations on a Computer using CAM packages	
3. Three typical simulations to be carried out using simulation packages like Master CAM, or any equivalent software	
PART – B	
4. Design and building of hydraulic circuits using single acting cylinder and double acting cylinder and its analysis.	**15**
5. Unit-step response plot of control system using MATLAB, for (i) its open loop transfer function and (ii) its state-space equation and to determine rise time, peak time, maximum overshoot and settling time in the unit-step response plot.	
6. Root locus plot, Bode plot and Nyquist plot of control systems using MATLAB, for (i) its open loop transfer function and (ii) its state-space equation.	

Course Outcomes

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

1. Create solid model of simple machine parts using Master CAM package.
2. Show simulation of Turning, Drilling, Milling using software
3. Develop MATLAB programs to plot step-response curve and determine transient response specifications.
4. Develop MATLAB programs to draw root locus, Nyquist and Bode plots of control systems.

References	
1	P.N. Rao, **CAD/CAM** Principles and Application, Tata McGraw Hill, 3rd edition, 2010, ISBN: *0070681937*.
2	Groover, **Computer Aided Design/Computer Aided Manufacturing**, Tata McGraw Hill. 2003.
3	Rao V Dukkipati, **Control Systems,** Narosa Publishing House, 2008, ISBN: 978-8173195549.

Evaluation Scheme				
Scheme	**Weightage**	**Marks**	**Event Break Up**	
CIE	50%	50	**Test**	**Record**
			20	30
SEE	50%	50		
Scheme for Examination				
One Question from Part –A			25 Marks (05 write up + 20)	
One Question from Part -B			15 Marks (05 write up + 10)	
Viva – Voice			10 Marks	
Total			**50 Marks**	

Simulations Lab		**Course Articulation Matrix**											
Sl No.	**Course Outcomes**	**Program Outcomes**											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Create solid model of simple machine parts using Master CAM package.**		**M**	**L**	**H**	**M**				**H**	**L**		**L**
2	**Show simulation of Turning, Drilling, Milling using software**		**M**		**L**	**M**				**M**	**L**		
3	**Develop MATLAB programs to plot step-response curve and determine transient response specifications.**	**L**	**M**	**H**		**L**				**M**	**M**		
4	**Develop MATLAB programs to draw root locus, Nyquist and Bode plots of control systems.**	**L**	**M**	**H**		**L**				**M**	**M**		

VIII Semester

Course Title: Industrial Robotics			
Course Code: P13ME81	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME81	Industrial Robotics	P08ME81	Industrial Robotics
2	P13ME65	CAD/CAM				

Course objective:

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

Course Content

Unit -1

INTRODUCTION: Automation and robotics, brief history of robotics, Classifications of robots, Geometrical configuration, Work Volume, wrist and its motions, links and joints. End Effectors: types of grippers, tools. Resolution, Accuracy and Repeatability, Problems **10Hrs**

Unit - 2

STRUCTURE OF ROBOTIC SYSTEM: Robot drive system: Hydraulic, electric and pneumatic drive system, advantages and disadvantages. Feedback components: position, velocity sensors, types of Actuators. internal State sensors, tactile sensors, - proximity sensing, range sensing, force-torque sensors **10Hrs**

Unit - 3

ROBOT ARM KINEMATICS: Kinematics- Introduction, direct and inverse Kinematics, rotation Matrix, composite rotation matrix, rotation matrix about an arbitrary axis, Euler angles representation, homogeneous transformations D-H representation. Applications of DH method:-Three axis robot arm, Three axis wrist. **10Hrs**

Unit -4

ROBOT PROGRAMMING: Introduction, manual teaching, lead through teaching, Robot programming languages:-Generations Robot programming Languages. Robot language elements and functions, Motion commands, End Effector and sensor commands, Program control and subroutines. Programs. **10Hrs**

Unit -5

APPLICATIONS OF ROBOTS IN MANUFACTURING: Material Transfer:- general considerations in robot material handling, pick and place, palletizing operations. Machine Loading & unloading: Die casting, Plastic moulding, Forging, machining and stamping press operations. Processing Operations:- spot and arc welding, features of arc welding robot, spray coating and other processing applications. Robotic assembly operation, Parts presentation methods, Assembly system configurations. **12Hrs**

Text books

1. Michell Grover, Mitchel weiss, Roger nagel **"Industrial Robots",** McGraw Hill 2012,India ,2ND edition, ISBN-13:9780070265097

2. K.S. Fu, R.C. Gonzales and Lee, **"Robotics"**. McGraw Hill Intl. India, 1ST edition, 2008 ISBN-13:9780070265103
3. Yoramn Koren, **"Robotics for Engineers"** Mc Graw hill Intl. Book Co., New Delhi 1987 ISBN-13:9780070353992

References

1. Robert J. Schilling, **"Fundamentals of Robotics"** PHI**, 1ST** edition-.2011, ISBN-13:9788120310476
2. Richard D. Klafter,C Thomas A, "**Robotic Engineering"** PHI,1993, ISBN-13:9788120308428
3. R.K. Mittal and J. Nagarath, **"Robotics and Control"** Tata Mc Graw Hill, DELHI,6TH edition 2007, ISBN:0070482934

Course Outcomes

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

1.Analyze work volume, resolution, and accuracy of various configuration of robots
2.Identify different types of end effectors and sensors required for specific applications
3.Calculate the forward kinematics of robots using DH method
4. Develop robot task program using robot language
5. Discuss requirements of robot systems for various industrial applications

Topic Learning Objectives (Unitwise)

Unit I

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

1. **Explain** classification of robots
2. **Discuss** geometrical configuration of robot
3. **Determine** work volume, resolution, accuracy and repeatability of robot
4. **Illustrate** wrist motions, links and joints
5. **Explain** types of end effectors and its applications

Unit II

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

6. **Explain** classification of robot drive system
7. **Discuss** Feedback components used in robots
8. **Identify** types of actuators used in robot
9. **Illustrate** internal state sensors of robots

Unit III

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

10. **Explain** direct and inverse Kinematics
11. **Discuss** composite rotation matrix, rotation matrix about an arbitrary axis
12. **Illustrate** Euler angles representation, homogeneous transformations
13. **Determine** D-H representation for Three axis robot arm.

Unit IV

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

14. **Explain** various methods of robot teaching
15. **Discuss** Generations Robot programming Languages
16. **Illustrate** Robot language elements and functions
17. **Develop** robot program for palletizing and depalletizing operation.

Unit V

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

18. **Explain** general considerations in robot material handling
19. **Discuss** features of arc welding robot

20. Illustrate robotic assembly operation
21. Identify Parts presentation methods and assembly system configurations

Review Questions

1. Define Industrial robot according to RIA and state three laws of robots
2. Enumerate merits and demerits of Industrial robots
3. List out classification of robots
4. Sketch and explain geometrical configuration of robot with its work volume
5. Discuss resolution, accuracy and repeatability with the help of sketches.
6. The base joint of a cylindrical robot is driven by 12 bit memory controller has a swing of 360^0 the radial axis is driven by 8 bit memory controller, it has a horizontal reach of 300mm and a stroke of 200mm. The vertical motion has a drive of 10 bit memory controller with a vertical reach of 480mm and a stroke of 350mm. Compute the following:- i. Work volume, ii. Radial resolution, iii. Vertical resolution, iv. Minimum and maximum angular resolution.
7. Sketch and explain : Magnetic gripper, Two fingered mechanical gripper
8. List out the merits and demerits of pneumatic drive systems.
9. Describe DH convention used in robot kinematics
10. Obtain a transformation matrix for Three axis robot arm
11. What are the critical information required for task programming of robots
12. Write a task program for palletizing and depalletizing operation.
13. What are the features of arc welding robot
14. Discuss the problems associated with assembly robots and list guide lines to over come it.

Lesson Plan

Unit I

1. Automation and robotics, brief history of robotics
2. Classifications of robots
3. Classifications of robots
4. Geometrical configuration, Work Volume
5. Geometrical configuration, Work Volume
6. wrist and its motions, links and joints
7. End Effectors: types of grippers
8. types of grippers & tools
9. Resolution, Accuracy and Repeatability
10. Problems

Unit II

11. Robot drive system: Hydraulic drive system advantages and disadvantages
12. Electric and pneumatic drive system, advantages and disadvantages
13. Feedback components: position, velocity sensors, encoders
14. Feedback components: position, velocity sensors, encoders
15. Types of Actuators
16. Sensors: classification
17. Tactile Sensors
18. Proximity Sensing
19. Range Sensing
20. Force-Torque Sensors

Unit III

21. Introduction, direct and inverse Kinematics,
22. Rotation Matrix,

23. Composite Rotation Matrix, Rotation Matrix About An Arbitrary Axis,
24. Euler angles representation
25. Homogeneous Transformations
26. D-H representation
27. D-H representation
28. Applications of DH method:-Three axis robot arm
29. Three axis robot arm
30. Three axis wrist

Unit IV

31. Types of robot teaching
32. Manual Teaching, lead through teaching
33. Robot programming languages
34. Generations Robot programming Languages
35. Robot language elements and functions
36. Motion commands
37. End Effector and sensor commands
38. Program control and subroutines
39. Program control and subroutines
40. Robot Programs.

Unit V

41. General Considerations In Robot Material Handling
42. Pick And Place
43. Palletizing Operations
44. Machine Loading & unloading: Die casting
45. Plastic moulding
46. Forging
47. Machining and stamping press operations
48. Processing Operations:- spot and arc welding
49. Features of arc welding robot
50. Spray coating and other processing applications
51. Robotic assembly operation
52. Parts presentation methods, Assembly system configurations.

Course Articulation Matrix

Course Outcomes		Program Outcomes											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Analyze** work volume, resolution, and accuracy of various configuration of robots	**M**	**M**	**L**	**L**								
2	**Calculate** the forward kinematics of robots using DH method	**H**	**M**	**L**	**L**								
3	**Identify** different types of end effectors and sensors required for specific applications										**M**		**M**
4	**Develop** robot program using robot languages					**M**					**M**		**M**
5	**Discuss** various applications of industrial robot systems.					**L**					**M**		**M**

Course Title: Operations Research			
Course Code: P13ME82	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	Basic knowledge of mathematics, matrices.			Operations Research		Operations Research

Course objective: The course aims at enabling the students to understand the basic concepts of Operations Research. Identify and develop operation research models from the verbal description of real life and optimise the solutions.

Course Content

Unit -1

INTRODUCTION: Linear programming, Definition, scope of Operations Research (O.R) approach and limitations of OR Models, Characteristics and phases of OR Mathematical formulation of L.P. Problems. Graphical solution for maximization and minimization problems. Simplex method – slack, surplus and artificial variables. Degeneracy and procedure for resolving degenerate cases. **12hrs**

Unit - 2

LINEAR PROGRAMMING PROBLEMS: The Concept of duality relation between primal and dual problems, Big M method two phase method, dual simplex method. **10hrs**

Unit- 3

TRANSPORTATION PROBLEM: Formulation of transportation model, Basic feasible solution using different methods, Optimality Methods, Unbalanced transportation problem, maximization and minimization problems. Degeneracy in transportation problems, Applications of Transportation problems **10hrs**

Unit- 4

ASSIGNMENT PROBLEM: Formulation, balanced and unbalanced assignment problem-Hungarian method and penalty cost method, Travelling salesman problem. **10hrs**.

Unit -5

QUEUING THEORY: Queuing system and their characteristics. The M/M/1 Queuing system, Steady state performance analyzing of M/M/ 1 System.

GAME THEORY: Formulation of games, two people-Zero sum game, games with and without saddle point, Graphical solution (2 x n, m x 2 game) and dominance property. **10hrs**

Text books

1. Taha H. A **Operations Research and Introduction**,. Pearson Education edition
2. S.D. Sharma **Operations Research**, Kedarnath Ramnath & Co 2002.

References

1. **Operation reaseach** AM Natarajan, P. Balasubramani , A Tamilaravari Pearson 2005
2. **Introduction to operation research**. Hiller and liberman, Mc Graw Hill. 5th edition 2001
3. **Operations Research**, Principles and practice: Ravindran, Phillips & Solberg, Wiley

India lts, 2nd edition 2007.

4. **Operation Research**, Prem Kumar Gupta, D.S. Hira, S Chand Pub,New delhi.2007

Course Outcomes

- At the end of the course the students should be able to:
- **Identify** and develop operation research models from the verbal description of real life.
- **Analyse** the problem using mathematical tools and simple queue system.
- **Describe** the model and the solving technique to analyze the results and propose recommendation.
- **Solve** Transportation and Assignment problem using different methods.
- **Explain** the game theory with their characteristics and Solve problems.

Topic Learning Objectives (Unit wise)

Unit I

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

1. Define linear programming, describe characteristics and phase of OR model.
2. Explain scope of OR and list the limitations of OR model.
3. Mathematical formulate L.P. problems
4. Discuss Simplex algorithm
5. Define Degeneracy, solve degenerate cases
6. Describe and solve problem using different method.

Unit II

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

7. Define duality, concept of duality.
8. Illustrate relation between primal and dual problems.
9. Explain Big M method, two phase method
10. Explain dual simplex method
11. Solve problem using different methods.

Unit III

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

12. Define transportation problem
13. Formulate and solve transportation problem
14. Solve Basic feasible solution using different methods
15. Calculate maximization and minimization problems
16. Solve problem using different method

Unit IV

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

17. Define assignment problem, compare between transportation and LPP
18. Describe Hungarian method
19. Explain penalty cost method and travelling salesman problems
20. Formulate of mathematical model
21. Solve problem using different method

Unit V

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

22. Define queuing theory and list characteristics of queuing theory
23. Explain Kendall's notation and M/M/1 system
24. Analyze steady state performance of M/M/1 system
25. Define game theory, explain concept of game theory and describe type of game theory.
26. Define and explain Dominance property
27. Formulate graphical solution for 2 x n, m x 2 game
28. Solve problem using different method

Review Questions

1 Explain the main phases of OR.

2 Use the graphical method to solve the following L.P problem Maximize $Z = 2X_1+X_2$
Subject to, $X1 + 2X_2 \leq 10$, $X_1 + X_2 \leq 6$, $X_1 - X_2 \leq 2$, $X_1 - 2X_2 \leq 1$ and $X_1, X_2 \geq 0$

3 Solve the following LPP using simplex method. Maximize $Z = 3X_1 - X_2$ Subject to $2X_1 + X_2 \leq 2$, $X_1 + 3X_2 \geq 3$, $X_2 \leq 4$, X_1 and X_2 are positive.

4 Consider the following transportation problem

			To		
		1	2	3	Available
	A	7	3	4	2
From	B	2	1	3	3
	C	3	4	6	5
	Requirement	4	1	5	

The shipping clerk has worked out the following schedule: $X_{A2} = 1$, $X_{A3} = 3$, $X_{C1} = 4$, $X_{C3} = 1$

(i) Check if the above schedule is the optimum one.
(ii) If not, find the optimum schedule and cost.

5 An Airline operates 7 days a week and has a timetable shown below. Crew must have a minimum layover of 5 hrs between flights. Obtain the pairing of flights that minimizes layover time away from home assuming that the crew can be based at either of the 2 cities. The crew will be based at the city that results in smaller layover.

Delhi – Jaipur			Jaipur – Delhi		
Flight No.	Departure	Arrival	Flight No.	Departure	Arrival
1	7.00 AM	8.00 AM	101	8.00 Am	915 AM
2	8.00 AM	9.00 AM	102	8.30 AM	9.45 AM
3	1.30 PM	2.30 PM	103	12.00 PM	1.5 PM
4	6.30 PM	7.30 PM	104	5.30 PM	6.45 PM

6 Explain the Characteristics of Queuing system.

7 Cars arrive at a petrol pump, having one petrol unit, in Poisson fashion with an average of 10 cars per hour. The service time is distributed exponentially with a mean of 3 minutes. Find:

(i) Average number of cars in the system
(ii) Average waiting time in the queue
(iii) Average queue length
(iv) The probability that the number of cars in the system is 2.

8 A small maintenance project consists of the following jobs. The duration of each job in days is listed below:

	Activity Duration		
Jobs	t_0	t_m	t_p
1-2	3	5	7

1-3	1	2	3
2-5	6	8	12
3-4	8	12	17
4-5	0	0	0
5-8	5	7	9
4-6	6	9	12
6-9	1	2	3
8-9	3	6	8
4-7	4	6	8
7-10	8	15	20
9-10	2	4	6

9 Explain the following terms:

(i) Pure Strategy
(ii) Mixed Strategy
(iii) Pay off Matrix
(iv) Saddle Point

10 Solve the following Game:

Player - A		Player - B		
		Y_1	Y_2	Y_3
	X_1	6	4	3
	X_2	2	4	8

Lesson Plan

Unit I

1. Introduction: Linear programming, Definition and Characteristics, Phases of OR,
2. Scope of Operations Research (O.R), Limitations of OR Models,
3. Mathematical formulation of L.P. Problems and Graphical solution,
4. Formulation and Graphical solution,
5. Graphical solution to problems having alternate solutions and no- solutions,
6. Graphical solution for maximization and minimization problems, unbounded solutions.
7. Formulation, simplex method- slack variables, surplus and artificial variables.
8. Simplex algorithm.
9. Degeneracy, degenerate solutions and non- degenerate solutions.
10. Simplex method for L.P. Problems with no- solutions,
11. Simplex method for L.P. Problems with unbounded solutions,
12. Simplex method for L.P. Problems with alternate solutions,

Unit II

13. Duality, Concept of duality, Relation between primal and dual problems.
14. Writing Dual problem.
15. Big M method,
16. Big M method,
17. Two phase method.
18. Two phase method,
19. Dual simplex method.
20. Dual simplex method.
21. Writing the dual, solving the dual.
22. Interpreting primal and dual solutions.

Unit III

23. Transportation Problem**:** Introduction to Transportation Problem.
24. Basic feasible solution using different methods, LCM, NWC, VAM,
25. Optimality Method: MODI method.
26. Optimality Method: Stepping stone method.
27. Degeneracy in transportation problems and resolving.
28. Unbalanced problem.
29. Maximization problem.
30. Formulation of Transportation Problem and solving,
31. Formulating special cases as Transportation Problem,
32. Formulation of special cases.

Unit IV

33. Assignment Problem: introduction, comparison of transportation and LPP.
34. Balanced assignment problem- Hungarian method.
35. Unbalanced assignment problem.
36. Penalty cost method, Advantage of penalty cost method,
37. Formulation and solutions.
38. Formulation and solutions.
39. Formulation of additional cases.
40. Formulation of additional cases.
41. Introduction to Travelling salesman problem and solution.
42. Problem on Travelling salesman,

Unit V

43. Queuing Theory: Queuing system and their characteristics, kendall's notation.
44. The M/M/1 Queuing system,
45. Steady state performance analyzing of M/M/ 1 System and problems,
46. Problems on Steady state system.
47. Game Theory: introduction to game theory, related definition of game theory.
48. Two people-Zero sum game, games with saddle point, type of strategies.
49. Games without saddle point, Dominance property.
50. Solving games without saddle point.
51. Formulation of game.
52. Graphical method.

Course Articulation Matrix

Course Outcomes	**Program Outcomes**											
	1	2	3	4	5	6	7	8	9	10	11	12
Identify and develop operation research models from the verbal description of real life.	**H**			**H**	**H**							
Analyse the problem using mathematical tools and simple queue system.	**M**											
Describe the model and the solving technique to analyse the results and propose recommendation.					**H**							
Solve Transportation and Assignment problem using different methods.					**M**							
Explain the game theory with their characteristics and Solve problems.					**M**							

Course Title: Organizational Behaviour			
Course Code: P13ME831	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	---	---	P13ME831	Organisational Behaviour	P08ME831	Organisational Behaviour
2	---	---				

Course objective: The course aims at understanding the behaviour of individual, groups, and structure of the organisations.

Course Content

Unit – 1

INTRODUCTION: Definition of Organizational Behaviour and Historical development, Environmental context (Information Technology and Globalization, Diversity and Ethics, Organisational culture, Reward Systems).
THE INDIVIDUAL: Foundations of individual behaviour, Ability.
LEARNING: Definition, Theories of Learning, Individual Decision Making, classical conditioning, operant conditioning, social learning theory, continuous and intermittent reinforcement **10 hrs**

Unit- 2

VALUES, ATTITUDES: Definition, values, attitudes: Types of values, job satisfaction, job involvement, professional Ethics, Organizational commitment, cognitive dissonance. Personality and its traits. **11 hrs**

Unit -3

MOTIVATION: Maslow's Hierarchy of Needs, Mc-Gregor's theory X and Y, Herzberg's motivation Hygiene theory, David Me-Cleland theory needs, Goal-setting theory, Victor vroom s expectancy theory of motivation. **10 hrs**

Unit - 4

THE GROUPS: Definition and classification of groups, Factors affecting
group formation, stages of group development, Norms, Hawthorne studies, group processes, group tasks, group decision making and group decision making techniques. **11 hrs**

Unit -5

PERCEPTION: Definition, Factors influencing perception, attribution theory, selective perception, projection, stereotyping, Halo effect.
CONFLICT MANAGEMENT: Definition of conflict, functional and dysfunctional conflict, stages of conflict process.
LEADERSHIP: Definition, Behavioural theories Blake and Mounton managerial grid, Contingency theories Hersey Blanchard's situational theory, Leadership styles characteristics, Transactional, transformation leaders. **10 hrs**

Text books

1. Stephen P Robbins, TIMOTHY A . JUDGE, "**Organizational Behaviour"** , Pearson Education Publications ,17th Edition, ISBN:9780134103983
2. Fred Luthans, "**Organizational Behaviour**", Mc Graw Hill International Edition, 12th Edition ,2010, ISBN:9780073530352

References

3. John W Newstrom, Keith Davis, "**Organizational Behaviour (Human behaviour at work**)" Mc graw hill higher education,11th new Edition,2003, ISBN:97800701110488
4. Paul Henry and Kenneth.H. Blanchard, "**Management of Orgnizational Behaviour",**

pearson publication, 10th edition, 2012, ISBN:9780132556408 .

Course Outcomes

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

1. **Define** and **Recognise** Organizational Behaviour.
2. **Describe** various theories of Learning.
3. **Analyse** different theories of Motivation.
4. **Identify** Factors affecting group formation, and stages of group development
5. **Judge and Solve** conflicts in organizations.

Topic Learning Objectives (Unit wise)

Unit I

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

1. Define Organizational Behaviour and Globalization, Diversity and Ethics.
2. Analyse individual behaviour, Ability.
3. Compare different theories of Learning.
4. Apply continuous and intermittent reinforcement.

Unit II

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

5. Define values, and attitudes.
6. Classify types of values
7. Analyse job satisfaction, job involvement, and professional Ethics.
8. Identify Personality and its traits.

Unit III

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

9. Define motivation.
10. State various theories of motivation.
11. Use various theories of motivation.
12. Compare different theories of motivation.

Unit IV

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

13. Define groups, and norms.
14. List factors affecting group formation.
15. Identify stages of group development.
16. Analyse Hawthorne studies.
17. Identify group tasks, and group decision making techniques.

Unit V

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

18. Define perception, conflict, and leadership.

19. Name factors influencing perception.
20. Analyse selective perception, projection, stereotyping, and Halo effect.
21. Explain functional and dysfunctional conflict, and stages of conflict process.
22. Analyse various behavioural theories.

Review Questions

1. Define Organizational Behaviour.
2. Compare different theories of Learning.
3. Classify types of values.
4. Analyse job satisfaction, and job involvement.
5. List Personality traits.
6. Define motivation.
7. State various theories of motivation.
8. Compare different theories of motivation
9. Analyse Hawthorne studies.
10. Explain functional and dysfunctional conflict, and stages of conflict process.

Lesson Plan

Unit I

1. Introduction to Organizational Behaviour and Historical Development.
2. Environmental context :Information Technology and
3. Globalization, Diversity and Ethics
4. Organizational Culture, Reward Systems.
5. Foundations of individual behaviour.
6. Ability
7. Theories of Learning
8. Theories of Learning
9. Individual Decision Making
10. Social learning theory.
11. Continuous and intermittent reinforcement

Unit II

12. VALUES, ATTITUDES: Introduction, values, and attitudes.
13. Types of values.
14. Job satisfaction.
15. Job involvement.
16. Professional Ethics.
17. Organizational commitment.
18. Organizational commitment.
19. Cognitive dissonance.
20. Personality and its traits.
21. Personality and its traits.
22. Personality and its traits.

Unit III

23. Introduction to needs, and motivation
24. Introduction to theories of needs and motivation
25. Maslow's Hierarchy of Needs.
26. Mc-Gregor's theory X and Y.
27. Herzberg's motivation Hygiene theory.
28. Herzberg's motivation Hygiene theory.
29. David Me-Cleland theory needs.

30. Goal-setting theory.
31. Victor vroom s expectancy theory of motivation
32. Victor vroom s expectancy theory of motivation

Unit IV

33. Introduction to groups.
34. Classification of groups.
35. Factors affecting group formation.
36. Stages of group development.
37. Group Norms.
38. Hawthorne studies.
39. Group processes.
40. Group tasks.
41. Group decision making.
42. Group decision making techniques.
43. Group decision making techniques.

Unit V

44. Introduction.
45. Factors influencing perception, attribution theory.
46. Selective perception.
47. Projection, stereotyping, Halo effect.
48. Introduction to conflict management
49. Functional and dysfunctional conflict, stages of conflict process.
50. Introduction to leadership.
51. Behavioural theories, Blake and Mounton managerial grid.
52. Contingency theories Hersey Blanchard's situational theory.
53. Leadership styles characteristics, Transactional, transformation leaders.

Course Articulation Matrix

Course Outcomes	**Program Outcomes**											
	1	2	3	4	5	6	7	8	9	10	11	12
Define and **Recognise** Organizational Behaviour.					M							
Describe various theories of Learning.						M						
Analyse different theories of Motivation.	L		H									
Identify Factors affecting group formation, and stages of group development				M								
Judge and Solve conflicts in organizations.				H								

Course Title: Foundry & Welding Technology			
Course Code: P13ME832	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME32	Material Science And Metallurgy	P13ME832	**Foundry & Welding Technology**	P08ME832	Foundry Technology
2	P13ME34	Manufacturing processes - I				

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

Course Content

Unit – 1

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

METALLURGY OF CAST STEEL: Composition, structure, control of properties, macrostructure, microstructure, inclusions, Heat- treatment, annealing, normalizing, stress relief anneal, liquid quench and temper. Alloy steels, measurement of hardenability and its significance, production heat treating, **10 Hrs**

Unit- 2

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

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

Unit -3

CASTING DESIGN CONSIDERATIONS: functional design, mechanical strength, dimensional design factors, simplification of foundry practice, molding and coring, elimination of coring, metallurgical design,

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

10 Hrs

Unit - 4

WELDING PROCESSES: Classification of Welding and allied processes, cast weld processes: Thermit welding, Electroslag welding, Arc and Flame welding processes: Seam welding & Arc spot welding processes, Resistance welding processes: Spot welding, Seam welding, Zonal welding processes, Solid state welding processes: High heat input and Low heat input processes, Allied processes: Material joining processes, Thermal cutting processes, Modes of Welding: manual welding, semiautomatic welding, automatic welding, automated welding(flexible welding system), positions in welding.

CRACKS IN WELDING: introduction, classifications in weld cracks, Hot and Cold cracks, Nomenclature, Location & Orientation of weld cracks: Weld metal cracks, Base metal cracks, Factors contribution to weld Cracking, Specific weld cracks: Chevron cracks, lamellar cracks, reheat cracking, stress corrosion cracking **11 Hrs**

Unit -5

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

WELD INSPECTION AND QUALITY CONTROL: Introduction, visual inspection and measurement: equipment, visual inspection, Destructive tests, Non-Destructive tests(NDT): liquid penetrate testing, magnetic particle testing, eddy current testing, magnetographic test, radiographic testing, ultrasonic testing, acoustic emission testing, comparison of NDT methods, Pressure and Leak testing: kerosene test, hydrostatic pressure testing, air pressure or pneumatic testing, vacuum testing, halide testing, helium test. **11 Hrs**

Text books

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

References

1. John Campbell, **"Casting",** Butterworth heinnmann, 2nd edition, 2004, ISBN-13:9780750647915

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

Course Outcomes

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

1. **Explain** concept of solidification of metals- solidification of pure metals- nucleation, homogeneous or self nucleation, heterogeneous nucleation- growth- solidification of alloys**.**
2. **Describe** gating System- Requirements, purposes of functions of the gating system- pouring cups and basins- spruers- gates, their characteristics and different types- design of gating system, objectives achieved from good design, defects occurring due to improper design of gating system
3. **Explain** shakeout- modern developments, punchout machines, shakeout tables and decks, high frequency shakeouts, vibrating shakeout conveyors, rotary separators, robots and manipulators, - fettling(cleaning) and finishing of castings- removal of cores- cleaning of castings surfaces, hand methods and mechanical methods
4. **Describe** classification of Welding and allied processes, cast weld processes: Thermit welding, Electroslag welding, Arc and Flame welding processes: Seam welding & Arc spot welding processes, Resistance welding processes: Spot welding, Seam welding, Zonal welding processes
5. **Discus** Weld defects in other arc welding processes: Resistance welding defects, defects in friction welding, defects in welds of other welding processes. **Explain** , Non-Destructive tests(NDT): liquid penetrate testing, magnetic particle testing, eddy current testing, magnetographic test, radiographic testing

Topic Learning Objectives (Unit wise)

Unit I

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

1. **Understand** concept of solidification of metals- solidification of pure metals- nucleation, homogeneous or self nucleation, heterogeneous nucleation-
2. **Analyse** phase diagram, coring or segregation, types of segregation, solute distribution, - solidification phenomenon and grain structure
3. **Understand** formation and dendrite growth- solidification rate, time and chvorinov's rule- progressive,
4. **Design** directional solidification and control of solidification to obtain sound castings.
5. **Understand** Heat- treatment, annealing, normalizing, stress relief anneal, liquid quench and temper. Alloy steels, measurement of hardenability

Unit II

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

1. **Understand** Gating System- Requirements, purposes of functions of the gating system- pouring cups and basins- spruers- gates, their characteristics and different types- design of gating system.
2. **Analyse** objectives achieved from good design, defects occurring due to improper design of gating system, turbulence in gating system, metal flow rate and velocity calculations
3. **Explain** design criteria for pouring basin, design of sprue, pouring time

Unit III

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

1. **Explain** functional design, mechanical strength, dimensional design factors, simplification of foundry practice
2. **Discus** shakeout- modern developments, punchout machines, shakeout tables and decks, high frequency shakeouts, vibrating shakeout conveyors, rotary separators
3. **Describe** cleaning of castings surfaces, hand methods and mechanical methods,- blast cleaning- process control- blast cleaning abrasives
4. **Understand** chemical cleaning, removal of gates and riser- removal of fins and other unwanted projections from castings- finishing of castings- grinding castings

Unit IV

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

1. **Understand** classification of Welding and allied processes, cast weld processes: Thermit welding, Electroslag welding, Arc and Flame welding processes: Seam welding & Arc spot welding processes,
2. **Describe** resistance welding processes: Spot welding, Seam welding, Zonal welding processes, Solid state welding processes.
3. **Explain** classifications in weld cracks, Hot and Cold cracks, Nomenclature, Location & Orientation of weld cracks: Weld metal cracks,
4. **Discus** base metal cracks, Factors contribution to weld Cracking, Specific weld cracks: Chevron cracks, lamellar cracks, reheat cracking, stress corrosion cracking

Unit V

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

1. **Explain** classification of weld defects, General sources of weld defects, Arc welding defects: surface or visual defects, subsurface weld defects
2. **Discus** acceptance levels of arc welding defects, Weld defects in other arc welding processes: Resistance welding defects, defects in friction welding, defects in welds of other welding processes.
3. **Describe** Visual inspection and measurement, Non-Destructive tests(NDT): liquid penetrate testing, magnetic particle testing, eddy current testing, magnetographic test, radiographic testing, ultrasonic testing, acoustic emission testing
4. **Understand** Comparison of NDT methods, Pressure and Leak testing: kerosene test, hydrostatic pressure testing, air pressure or pneumatic testing
5. **Explain** Vacuum testing, halide testing, helium test.

Review Questions

1. Explain concept of solidification of metals
2. Explain nucleation with homogeneous and heterogonous nucleation
3. Explain dendritic growth
4. Explain progressive, directional solidification and control of solidification to obtain sound casting.
5. Explain modern developments in stakeout of castings
6. Explain different methods which are available for removing feeding and gating systems
7. Give broad classification of welding and allied processes.
8. With a neat diagram explain thermit welding process
9. With a neat diagram explain Arc and flame welding process
10. With a neat diagram explain shielded metal arc welding process
11. Explain hot cracks and cold cracks

12. Explain defects in arc welding process
13. Explain any two NDT methods for Welding
14. Explain any two Pressure and Leak testing methods in welding

Lesson Plan

Unit I

1. Solidification of castings: Introduction- concept of solidification of metals- solidification of pure metals
2. Nucleation, homogeneous or self nucleation, heterogeneous nucleation- growth- solidification of alloys, alloyed metal characteristics
3. Main types of alloys, solid solution alloys, their characteristics, and solidification, phase diagram, coring or segregation
4. Types of segregation, solute distribution, - solidification phenomenon and grain structure
5. mechanism of dendrite, formation and dendrite growth- solidification rate
6. Time and chvorinov's rule- progressive, directional solidification and control of solidification to obtain sound castings.
7. Metallurgy of cast steel: Composition, structure, control of properties,
8. macrostructure, microstructure, inclusions, Heat- treatment, annealing, normalizing,
9. Stress relief anneal, liquid quench and temper. Alloy steels,
10. measurement of hardenability and its significance, production heat treating

Unit II

11. Principles of gating: Gating System- Requirements, purposes of functions of the gating system- pouring cups and basins
12. Spruers- gates, their characteristics and different types- design of gating system, objectives achieved from good design, defects occurring due to improper design of gating system
13. Turbulence in gating system, metal flow rate and velocity calculations, design criteria for pouring basin, design of sprue
14. Pouring time, design of runner and gates, pressurized and unpressurized gating system, streamlining the gating system
15. Practical rules for gating practice, elimination of slag and dross for copper, ferrous and light metal alloys.
16. Principles of risering: Introduction- Functions of a riser- types of riser,
17. Open and blind risers- Riser and Directional solidification- increasing riser efficiency and promoting directional solidification
18. Insulating materials, exothermic materials, chills, padding etc. –Feeder Head (or riser system) Design
19. General principles, riser shape, riser size, Chvorinove's rule
20. Riser location and riser feeding distance- Risering practice for alloys- Heat loss from risers

Unit III

21. Casting design considerations: functional design, mechanical strength, dimensional design factors
22. Simplification of foundry practice, molding and coring,elimination of coring, metallurgical design
23. Shakeout/ cleaning/ finishing: shakeout- modern developments, punchout machines, shakeout tables and decks

24. High frequency shakeouts, vibrating shakeout conveyors, rotary separators, robots and manipulators, - fettling(cleaning) and finishing of castings
25. Removal of cores- cleaning of castings surfaces, hand methods and mechanical methods
26. Blast cleaning- process control- blast cleaning abrasives- air blasting- mechanical blast cleaning (wheelabrator system)
27. Hydroblasting- safety considerations when blast cleaning nonferrous casting, chemical cleaning
28. Removal of gates and riser- removal of fins and other unwanted projections from castings
29. finishing of castings- grinding castings, robots for grinding, manipulators, trim dies,
30. Abrasive products- surface treatment of castings

Unit IV

31. Welding & welding processes: Classification of Welding and allied processes, cast weld processes: Thermit welding,
32. Electroslag welding, Arc and Flame welding processes: Seam welding & Arc spot welding processes,
33. Resistance welding processes: Spot welding, Seam welding,
34. Zonal welding processes, Solid state welding processes: High heat input and Low heat input processes,
35. Allied processes: Material joining processes, Thermal cutting processes,
36. Modes of Welding: manual welding, semiautomatic welding,
37. Automatic welding, automated welding (flexible welding system), positions in welding.
38. Cracks in welding**:** introduction, classifications in weld cracks, Hot and Cold cracks
39. Nomenclature, Location & Orientation of weld cracks: Weld metal cracks
40. Base metal cracks, Factors contribution to weld Cracking
41. Specific weld cracks: Chevron cracks, lamellar cracks, reheat cracking, stress corrosion cracking

Unit V

42. Weld defects**:** Classification of weld defects, General sources of weld defects
43. Arc welding defects: surface or visual defects, subsurface weld defects, Acceptance levels of arc welding defects
44. Weld defects in other arc welding processes: Resistance welding defects, defects in friction welding
45. Defects in welds of other welding processes.
46. Weld inspection and quality control**:** Introduction, visual inspection and measurement
47. Equipment, visual inspection, Destructive tests,
48. Non-Destructive tests(NDT): liquid penetrate testing
49. Magnetic particle testing, eddy current testing
50. Magnetographic test, radiographic testing,
51. Ultrasonic testing, acoustic emission testing,
52. Comparison of NDT methods, Pressure and Leak testing: kerosene test, hydrostatic pressure testing
53. Air pressure or pneumatic testing, vacuum testing, halide testing, helium test.

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Explain Oxidation of liquid metals, gas dissolution in liquid metals, methods of degassing, fluidity, factors affecting fluidity, fluidity tests, hot tearing, shrinkage of liquid and metals**.**	**L**				**M**				**H**			
Describe Structure of castings - significance and practical control cast structure, grain shape and orientation, grain size, refinement and modification of cast structure			**H**			**M**		**L**				
Explain Need for risering, general considerations of risering, riser shapes, riser size and location. Requirements of riser. Sand, insulation, and exothermic materials used for risers												
Describe Classification of Welding and allied processes, cast weld processes: Thermit welding, Electroslag welding, Arc and Flame welding processes: Seam welding & Arc spot welding processes, Resistance welding processes: Spot welding, Seam welding, Zonal welding processes		**M**		**L**			**H**					
Discus Weld defects in other arc welding processes: Resistance welding defects, defects in friction welding, defects in welds of other welding processes. **Explain** , Non-Destructive tests(NDT): liquid penetrate testing, magnetic particle testing, eddy current testing, magneto graphic test, radiographic testing	**H**		**M**							**L**		

Eighth Semester

Course Title: Renewable Energy Sources			
Course Code: P13ME833	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**Weightage: CIE 50%, SEE: 50%**	

Prerequisites & Equivalents for Courses of 2013-14						
Sl. No.	**Prerequisites Course 2015-16**		**Course of Regulations 2015-16**		**Equivalent Course for 2013-14**	
	Code	**Title**	**Code**	**Title**	**Code**	**Title**
1	P13ME53	Turbomachines	P13ME833	RENEWABLE ENERGY SOURCES	P08ME835	Non-Conventional Energy Source
2	P13ME42	Applied Thermodynamics				

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 machines.

Course Content

Unit - 1

INTRODUCTION: Energy source, India's production and reserves of commercial energy sources, need for non-conventional energy sources, solar, photovoltaic, water power, wind, bio-mass, ocean temperature difference, tidal and waves, geothermal (Qualitative and Quantitative).

SOLAR RADIATION: Extra-terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam and global radiation, solar radiation data**.** **9hrs**

Unit- 2

SOLAR RADIATION MEASUREMENT: Pyranometer, shading ring, Pyrheliometer, sunshine recorder, schematic diagrams and principles of working. (no numericals)

SOLAR RADIATION GEOMETRY: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle, expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent motion of sun, day length and numerical examples. **10hrs**

Unit -3

SOLAR THERMAL CONVERSION: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid), sensible heat storage, latent heat storage, application of solar energy water

heating. Solar heating and cooling, active and passive systems, power generation, refrigeration. Distillation, solar pond, principle of working, operational problems.

GEOTHERMAL ENERGY CONVERSION: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. **11hrs**

Unit - 4

WIND ENERGY: Availability of wind energy in India, wind velocity and power from wind, major problems associated with wind power, wind machines: Types of wind machines and their characteristics, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor.

TIDAL POWER: Tides and waves as energy suppliers and their mechanics, harnessing tidal energy, limitations.

OCEAN THERMAL ENERGY CONVERSION: Principle of working, Rankine cycle, problems associated with OTEC. **10hrs**

Unit -5

ENERGY FROM BIO MASS: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, problems involved with bio-gas production, application of bio-gas in engines, advantages.

HYDROGEN ENERGY :properties of Hydrogen with respect to its utilization as a renewable form of energy sources, production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production and bio-chemical production**10hrs**.

Text books

1. G.D Rai K, "**Non conventional energy sources**", Khanna publishers.2004, ISBN:9788174090737
2. Subhas P.Sukhatme, J K Nayak, "**Solar energy**", Tata Mc Graw Hill,India 3rd Edition. 2009, ISBN: 9780070142961

References

1. N.K.Bansal, Manfred Kleeman and Mechael meliss, "**Renewable energy sources and conversion technology"**, Tata Mcgraw Hill, 2001. ISBN:9780074600238

John W.Twidell, Tony Weir, "**Renewable energy resources**" , Routledge, 4th edition, 2014, ISBN:9780415633581

Course Outcomes

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

1. **Identify** production and reserves of commercial energy sources in India and **Evaluate** the availability of solar radiation.
2. **Analyse** solar energy with the help of solar radiation measuring instruments and **Explain** the angles related to solar radiation geometry.
3. **Analyse** and **design** solar collectors for harnessing solar energy. **Discuss characteristics** of geothermal energy.
4. **Explain** different types of wind mills and their design principles. **Compute** coefficient of performance of wind mill. **Discuss characteristics** of tidal energy, ocean thermal energy.
5. **Discuss characteristics** of biomass energy and **Describe** the methods of production of hydrogen for utilization as a renewable form of source of energy.

Topic Learning Objectives (Unit wise)

Unit I

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

1. Current energy reserves in India.
2. Need for Non-conventional energy source.
3. Harnessing Solar energy.
4. Spectral distribution of extra-terrestrial radiation.
5. Solar radiation and Solar radiation data at the earth's surface.

Unit II

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

6. Solar radiation measuring instruments.
7. Principle and working of Pyranometer, Pyrheliometer and shading ring.
8. Declination angle, surface azimuth angle, hour angle, zenith angle.
9. Sun apparent angle between the incident beam and the normal to a plane surface.

Unit III

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

10. Thermal collection devices like Liquid flat plate collectors, Solar air heaters.
11. Thermal electric conversion by Solar pond.
12. Principle of working of Geothermal energy conversion.
13. Problems associated with geothermal conversion, scope of geothermal energy.

Unit IV

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

1. Availability of wind energy in India, types of wind machines.
2. Coefficient of performance of a wind mill rotor.
3. Tidal power and their mechanics, harnessing tidal energy.
4. Principle of working of ocean thermal energy conversion.

Unit V

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

1. Bio gas production from organic wastes by anaerobic fermentation.
2. Problems involved with bio-gas production, application of bio-gas in engines.

3. Properties of Hydrogen and its utilization as a renewable form of energy sources.
4. Thermo chemical production and bio-chemical production.

Review Questions

1. Write a descriptive note on the current energy scenario of conventional and non-conventional energy sources with respect to Indian Context.
2. Compare Renewable and Non-Renewable energy sources with their advantages and limitations.
3. With a neat sketch, explain spectral distribution of extra terrestrial radiation.
4. Describe the principle of energy conversion in a flat plate collector. With a neat labelled diagram discuss the function of each component of liquid flat plate collector.
5. With the help of neat diagram, explain the angles related to solar radiation geometry.
6. Explain sensible heat and latent heat storage with the applications of solar water heating.
7. With a neat diagram, explain the working principle of solar pond for the electricity generation.
8. With a neat labelled diagram, explain the working principle of horizontal axis wind machine.
9. Write down the elementary principles and derive the coefficient of performance of a wind mill rotor.
10. Explain the method of harnessing tidal energy using the double basin system.
11. With a neat sketch, explain Rankine cycle OTEC plant and discuss the problem associated with OTEC.
12. Differentiate Biomass and Biogas. Explain the principle of a KVIC biogas digester with a neat sketch.
13. Explain the production of hydrogen by thermal decomposition of water.
14. Why hydrogen is more versatile than fossil fuels? State merits and demerits of hydrogen energy.

Lesson Plan

Unit I

1. Introduction to energy source in India.
2. India's production and reserves of commercial energy sources.
3. Need for non-conventional energy sources.
4. Energy sources like solar, photovoltaic, water power.
5. Energy sources like wind, bio-mass, ocean temperature difference.
6. Energy sources like tidal and waves, geothermal.
7. Spectral distribution of extra-terrestrial radiation.
8. Solar radiation at the earth's surface.
9. Beam and global radiation**.**
10. Solar radiation data**.**

Unit II

11. Schematic diagram and principle of working of Pyranometer, Pyrheliometer
12. Schematic diagram and principle of working of shading ring, , sunshine recorder.
13. Solar radiation geometry flux on a plane surface.
14. Latitude, Declination angle, Solar azimuth angle.

15. Hour angle, zenith angle, solar altitude angle.
16. Expression for angle between the incident beam and normal to a plane surface.
17. Local apparent motion of sun, day length.
18. Numerical problems of the above topics.

Unit III

19. Introduction to solar radiation collectors.
20. Liquid flat plate collectors, solar air heaters.
21. Concentrating collectors (cylindrical, parabolic, paraboloid).
22. Sensible heat storage, latent heat storage.
23. Application of solar energy water heating, Solar heating and cooling of buildings.
24. Active and passive systems, Solar power generation, refrigeration.
25. Principle and working of Solar distillation, solar pond and Operational problems.
26. Introduction to Geothermal energy and geothermal plants in the world.
27. Principle of working of geothermal energy conversion.
28. Problems associated with geothermal conversion.

Unit IV

29. Introduction to wind energy and availability of wind energy in India.
30. Wind velocity and power from wind.
31. Major problems associated with wind power, wind machines.
32. Types of wind machines and their characteristics.
33. Horizontal and vertical axis wind mills.
34. Coefficient of performance of a wind mill rotor.
35. Introduction to Tides and waves as energy suppliers and their mechanics.
36. Harnessing tidal energy and problem associated with it.
37. Principle of working of ocean thermal energy conversion.
38. Problems associated with OTEC.

Unit V

39. Introduction to Photosynthesis and biomass.
40. Photosynthetic oxygen production, energy plantation.
41. Bio gas production from organic wastes by anaerobic fermentation.
42. Description of bio-gas plants, , application of bio-gas in engines.
43. Advantages, problems involved with bio-gas production.
44. Introduction to Hydrogen energy.
45. Properties of Hydrogen with respect to its utilization as a renewable energy source.
46. Production of hydrogen, electrolysis of water.
47. Thermal decomposition of water.
48. Thermo chemical production and bio-chemical production.

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Identify production and reserves of commercial energy sources in India and **Evaluate** the availability of solar radiation.		L	M		**M**		**H**					**H**
Analyse solar energy with the help of solar radiation measuring instruments and **Explain** the angles related to solar radiation geometry.	**H**	**H**	**M**									
Analyse and **design** solar collectors for harnessing solar energy. **Discuss characteristics** of geothermal energy.	**H**	L	H							**M**		
Explain different types of wind mills and their design principles. **Compute** coefficient of performance of wind mill. **Discuss characteristics** of tidal energy, ocean thermal energy.	H									**H**		
Discuss characteristics of biomass energy and **Describe** the methods of production of hydrogen for utilization as a renewable form of source of energy.										**H**		**H**

Course Title: Computational Fluid Dynamics			
Course Code: P13ME834	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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**
	P13ME31	Engg. Mathematics-III	P13ME834	Computational Fluid Dynamics	P08ME836	Computational Fluid Dynamics
1	P13ME45	Fluid Mechanics				
2	P13ME63	Heat and Mass Transfer				

Course objective: This course will prepare students in the fundamentals of the computational approach to study fluid flow and heat transfer problems, and will provide a deeper understanding of the physical models and governing equations of fluid dynamics. It will also impart the knowledge of numerical techniques to the solution of fluid dynamics and heat transfer problems.

Course Content

Unit – 1

GOVERNING EQUATIONS:

Basics of computational fluid dynamics, Comparison of experimental, theoretical and computational approaches, 3-D general mass conservation, momentum and energy equations in differential form, integral form and vector representation (no derivations) Cartesian and curvilinear co-ordinates. Forms of the governing equations particularly suited for CFD work: Generic form of equations. **12 Hrs**

Unit- 2

PARTIAL DIFFERENTIAL EQUATIONS (PDE):

Classification of PDE - physical & mathematical classification of PDE - equilibrium problems, marching problems, Cramer rule and Eigen value method, hyperbolic, parabolic and elliptic forms of equations and their physical behavior. Physical boundary conditions.

09 Hrs

Unit -3

FINITE DIFFERENCE METHOD:

Derivation of finite difference equations for first and second order accuracy,- different numerical schemes –Explicit and Implicit approach - upwind, downwind, FTCS, etc., truncation error, Round-off and discretization errors and analysis of stability, Error propagation, Stability properties of Explicit and Implicit methods, numerical dissipation and numerical dispersion. Application of numerical methods to selected model Equations : Wave equation, Heat equation, Laplace equation **11 Hrs**

Unit - 4

FINITE VOLUME METHOD FOR DIFFUSION :

Finite volume formulation of steady state One dimensional diffusion problems. simple problem solving, Finite volume methods for diffusion equation.

One dimensional unsteady heat conduction through Explicit, Crank – Nicolson and fully implicit **10 Hrs**

Unit -5

FINITE VOLUME METHOD FOR CONVECTION - DIFFUSION

Finite volume formulation of steady state One dimensional convection-diffusion problems – Central, upwind, Hybrid, Power-law, QUICK differencing schemes. properties of discretization schemes – Conservativeness, Boundedness, Trasnportiveness, **10 Hrs**

Text books

1. **J**ohn c. tannehill, Dule A Anderson, Richard H Pletcher, "**Computational fluid mechanics and Heat transfer",** CRC press, 3rd edition, April 15, 2011, ISBN-13: 9781591690375
2. Suhas.V Patankar " **Numerical Heat Transfer and Fluid Flow**", CRC Press 1980,ISBN-13:9780891165224
3. Versteeg, H.K., and Malalasekera, W. "**An Introduction to Computational Fluid Dynamics-The finite volume Method**", Pearson, 2ND edition, 2007. ISBN-13:9780131274983

References

1. T.J. Chung, "**Computational Fluid Dynamics"**, Cambridge University Press, 2nd edition, 2010, ISBN-13:9780521769693
2. John D.Anderson, Jr. **"Computational fluid Dynamics- The basics with applications"** McGraw-Hill, Inc.1995, ISBN-13:9780070016859
3. Muralidhar, K., and Sundararajan, T. "**Computationsl Fluid Flow and Heat Transfer"**, Narosa Publishing House, New Delhi, 2ndedition, 2009, , ISBN-13:9788173195228.

Course Outcomes

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

1. **Apply** the differential equations governing fluid flow and heat transfer .
2. **Classify** and **understand** behaviour of partial differential equations
3. **Understand and develop** finite difference discretizations schemes and implement them to solve engineering problems
4. **Understand** the importance and implications of analytical issues: consistency, stability, convergence, error analysis.
5. **Understand and develop** finite volume discretization schemes and implement them to solve engineering problems

Topic Learning Objectives (Unitwise)

Unit I

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

1. Compare traditional and computational approaches for understanding fluid motion
2. Identify the main elements involved in a complete CFD analysis
3. Exemplify the need that arose to the development of computational fluid dynamics
4. Differentiate between conservation and non conservation form of equations
5. Write down the continuity, Navier Stokes and energy equations in different forms

Unit II

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

6. Give the classification of main categories of PDE
7. Classify the PDE as an Elliptic , Parabolic and Hyperbolic equations
8. Define domain of dependence and Range of influence for PDE
9. Discuss the physical significance of characteristic path on solution to hyperbolic, parabolic and elliptic partial differential equations

Unit III

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

10. Explain how a truncated Taylor's series expansion can be used to express continuous derivative into their corresponding discrete form.
11. Understand what the finite difference method is and how to use it to solve problems
12. Define Truncation error, Discretization error and Round off error
13. Distinguish between Explicit and Implicit schemes with examples
14. Use a Von Neumann stability analysis for stability analysis
15. Understand the concept of numerical dissipation and numerical dispersion

Unit IV

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

16. Compare FDM and FVM
17. Discretize the equation for a steady one dimensional diffusion equation
18. Analyze the problems on source free and including source, one dimensional steady state diffusion equation
19. Discretize the equation for a unsteady one dimensional diffusion equation

Unit V

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

20. Discretize the governing equation for a one dimensional steady state convection diffusion equation
21. Understand different differencing schemes
22. Understand different Properties of discretization scheme

Review Questions

1. Computational fluid dynamics is a synergy of pure experimental fluid dynamics and theoretical fluid dynamics, discuss this statement
2. Discuss with a typical case study or example the need that arose to the development of computational fluid dynamics
3. Computational fluid dynamics is a 'research tool' to carry out numerical experiment, discuss this statement with suitable example.
4. Derive the momentum equation in three dimension for viscous flow, in Cartesian coordinate system
5. Write down the Navier Stokes equation (Continuity, Momentum and Energy equations) for unsteady flow of viscous compressible fluid
6. What are the different types of PDE? Describe how do you find their types
7. Classify the following PDE as an Elliptic , Parabolic and Hyperbolic equations
   Laplace's equation $\partial^2\varphi/\partial x^2 + \partial^2\varphi/\partial y^2 = 0$
   One-dimensional unsteady state heat conduction equation $\partial T/\partial t = \alpha\, \partial^2 T/\partial x^2$
8. What is characteristic lines or characteristic paths and explain the physical significance of this on the solution of Hyperbolic, parabolic and elliptic Partial differential equations
9. Give the classification of main categories of fluid flow problem
10. Derive the following expression, which is a third-order-accurate one-sided difference.
    $$\left(\frac{\partial u}{\partial y}\right)_{i,j} = \frac{1}{6\,\Delta y}\left[-11u_{i,j} + 18u_{i,j+1} - 9u_{i,j+2} + 2u_{i,j+3}\right]$$
11. Explain the effects of numerical dissipation and numerical dispersion on the computation of discontinuity
12. Explain the three basic properties of numerical scheme such as consistency, stability and convergence

13. Write the finite difference algorithms for the simple explicit and simple implicit scheme that can be used to solve heat equations
14. Prove that the CFL condition is the stability requirement when the Lax Wendroff method is applied to solve the simple 1-D wave equation
15. Derive modified equation for upwind (FTBS) method applied to wave equation retain the term up to and including $U_{xxx.}$
16. Write the finite difference algorithms for the simple explicit and simple implicit scheme that can be used to solve heat equations
17. Give the comparison between FDM and FVM
18. Derive the discretization equation for a steady one dimensional diffusion equation by control volume formulation $\frac{d}{dx}\left(\Gamma\frac{d\varphi}{dx}\right)+S=0$

where Γ is diffusion coefficient and S is the source term.

19. Write the governing equation for source - free one dimensional convection and diffusion of a scalarφ. Discretize this equation on a control volume enclosing node P using central differencing and obtain a relation between φ_p ,$\varphi_{w,}$ andφ_e where 'w' and 'e' are neighboring nodes
20. The one dimensional convection and diffusion of a scalar φ is described by central differencing $\varphi_{w,}$ and $\varphi_e$being 100 and 200, respectively, with usual notation. Let F = ρu and D = □/Δx, where □ is the diffusion coefficient and Δx is the mesh spacing. Obtain the value of φ_p for $F_e= F_w = 4$ and $D_e = D_w = 1$, and comment on the result.

Lesson Plan

Unit I

1. Introduction to CFD
2. Comparison of experimental, theoretical and computational approaches,
3. 3-D general mass conservation integral from
4. 3-D general mass conservation differential representation
5. Conservation and non conservation form of continuity equations
6. Conversion from one form to another form of equation
7. Momentum equation - N-S equation
8. Euler equation
9. energy equations in differential form,
10. Energy equation in different form
11. curvilinear co-ordinates.
12. Generic form of CFD equations

Unit II

1. Introduction to PDE
2. Classification of PDE (physical and mathematical)
3. Equilibrium problems, marching problems
4. Mathematical classifications- Cramer's rule method
5. Eigen value method
6. Characteristic lines or path and domain of dependence and Range of influence
7. Mathematical behavior of hyperbolic PDE equations
8. Mathematical behavior of parabolic PDE equations
9. Mathematical behavior of elliptic PDE equations

Unit III

1. Introduction to Finite differences (FD), Taylor's series of expansion
2. FD representation of PDE,
3. Truncation error, Round-off and discretization errors,

4. Consistency, stability, convergence criteria.
5. FTCS, and other finite differencing schemes for solving PDE
6. FTCS, and other finite differencing schemes for solving PDE
7. Use of Von Neumann stability analysis for different schemes
8. Numerical dissipation and numerical dispersion.
9. Discretization of Wave equation, Heat equation
10. Discretization of Laplace equation

Unit IV

1. *Introduction to FVM*
2. Finite volume methods for 1D steady state diffusion equation
3. Discretize the equation for diffusion equation
4. Problems on source free, 1D steady state diffusion equation
5. Problems on including source ,1D steady state diffusion equation
6. Problems on fin
7. Finite volume methods for 1D unsteady heat conduction
8. Explicit method
9. Crank – Nicolson scheme
10. Fully implicit method

Unit V

1. Introduction to convection diffusion equation
2. Finite volume methods for 1D steady state convection diffusion equation
3. Central differencing scheme
4. Problems on 1D steady state convection diffusion equation
5. Properties of discretization scheme
6. Conservativeness, boundedness, Transprotiveness
7. Effect of peclet number on the solution,
8. Upwind differencing schemes
9. Hybrid differencing schemes
10. QUICK differencing schemes

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
apply the differential equations governing fluid flow and heat transfer .	**M**	**M**		**M**	**H**		**L**	**M**	**M**	**M**		**L**
classify and **understand** behaviour of partial differential equations	**M**	**M**								**M**		
understand and develop finite difference discretizations schemes and implement them to solve engineering problems	**M**	**M**	**L**	**M**	**H**			**M**	**M**	**M**	**M**	**L**
understand the importance and implications of analytical issues: consistency, stability, convergence, error analysis.	**M**	**M**								**M**		
understand and develop finite volume discretization schemes and implement them to solve engineering problems	**M**	**M**	**L**	**M**	**H**			**M**	**M**	**M**	**M**	**L**

Course Title: Project Management			
Course Code: P13ME841	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**Weightage: CIE 50%, SEE: 50%**	

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

Course Content

Unit – 1 CONCEPTS OF PROJECT MANAGEMENT: Concepts of a Project, Characteristics of a project, Categories of projects, Phases of project life cycle, Roles and responsibilities of project leader, tools and techniques for project management. PROJECT PLANNING AND ESTIMATING: Feasibility report phased Planning, Project planning steps, Objectives and goals of the project, preparation of cost estimation, and evaluation of the project profitability. **10 hrs**

Unit- 2 ORGANIZING AND STAFFING: The Project Team: Skills / abilities required for project manager, Authorities and responsibilities of project manager, Project organization and types accountability in project execution, controls, tendering and selection of contractors **11 hrs**

Unit -3 PROJECT SCHEDULING: Project implementation scheduling, different scheduling techniques bar (GANTT) charts, Bar charts for combined activities. Project evaluation and Review Techniques, PERT, planning. Simple Numerical Problems. **10 hrs**

Unit - 4 CO-ORDINATION AND CONTROL: Project direction, Communication in a project, Project coordination, Role of MIS in project control, performance control, schedule control, cost Control Examples. **11 hrs**

Unit -5 PERFORMANCE MEASURES IN PROJECT MANAGEMENT: Performance indicators, Performance improvement-Do-It-Yourself, Performance improvement for the CM & DM companies for better project management. CLOSING OF PROJECT: Types of project termination, strategic implications, project in trouble, termination strategies, evaluation of termination possibilities **10 hrs**

Text books

1. Harold Kerzner, "**Project Management: A Systems Approach To Planning, Scheduling And Controllin**g", Wiley India Pvt. Ltd. New Delhi, Feb18, 2013- ISBN: 9781118022276
2. Lawrence P Leach, "**Project Management**", Mc-Graw Hill (1970), Artech house 2014 3rd edition , ISBN:9781608077342

References

1. James P. Lewis, "Project planning, Scheduling & control", Mc-Graw Hill education, 5th edition, 2010, ISBN: 9780071746526
2. S Choudhury, "Project Management", TATA Mc-Graw Hill, 1989, ISBN: 9780074600689.

Course Outcomes

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

1. **Define** and **Recognise** project management stages
2. **Write** Feasibility report,
3. **Illustrate** Project implementation scheduling.
4. **Demonstrate** Performance improvement.
5. **Identify** project in trouble.

Topic Learning Objectives (Unit wise)

Unit I

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

1. List categories of projects.
2. Define Phases of project life cycle.
3. Write Feasibility report.
4. Judge the project profitability.
5. Explain Project planning steps.

Unit II

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

6. Recognise Skills / abilities required for project manager.
7. List the Authorities and responsibilities of project manager.
8. Apply types accountability in project execution.
9. Choose contractors.

Unit III

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

10. Analyse Project implementation scheduling.
11. Compare different scheduling techniques.
12. Illustrate bar charts for combined activities.
13. Use Project evaluation and Review Techniques.

Unit IV

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

14. Design Project direction communication in a project.
15. Plan Project coordination.
16. Use MIS in project control.
17. Demonstrate performance control, schedule control, cost Control Examples.
18. Evaluate cost control.

Unit V

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

19. Evaluate Performance indicators.
20. Analyse Performance improvement-Do-It-Yourself.
21. Devise Performance improvement for the CM companies.
22. Devise Performance improvement for the DM companies.
23. Justify project termination.
24. Analyse strategic implications, project in trouble, termination strategies.

Evaluate termination possibilities

Review Questions

1. List the characteristics of a project.
2. Explain different categories of projects.
3. Explain Phases of a project life cycle.
4. Describe Skills / abilities required for a project manager.
5. Summarise Authorities and responsibilities of a project manager,

6. Compare different scheduling techniques bar (GANTT) charts.
7. Explain Communication in a project.
8. Explain Role of MIS in project control.
9. Describe Performance indicators.
10. Discuss Performance improvement for CM and DM companies.

Lesson Plan

Unit I

1. Concepts of a Project.
2. Characteristics of a project.
3. Categories of projects.
4. Phases of project life cycle.
5. Roles and responsibilities of project leader.
6. Tools and techniques for project management.
7. Feasibility report.
8. Phased Planning.
9. Project planning steps.
10. Objectives and goals of the project.

Unit II

11. Introduction to organizing and staffing
12. The Project Team.
13. The Project Team.
14. Skills / abilities required for project manager.
15. Authorities and responsibilities of project managers.
16. Project organization
17. Types of accountability in project execution.
18. Types of accountability in project execution.
19. Project controls.
20. Tendering.
21. Selection of contractor.

Unit III

22. Introduction to project scheduling.
23. Project implementation scheduling.
24. Different scheduling techniques.
25. GANTT charts.
26. Bar charts for combined activities.
27. Project evaluation and Review Techniques.
28. Project evaluation and Review Techniques.
29. Planning.
30. Simple Numerical Problems.
31. Simple Numerical Problems.

Unit IV

32. CO-ORDINATION AND CONTROL:
33. Project direction,
34. Communication in a project,
35. Project coordination.
36. Project coordination.
37. Role of MIS in project control.
38. Role of MIS in project control.
39. Performance control.

40. Performance control.
41. Schedule control.
42. Cost Control.

Unit V

43. Introduction to performance measures in project management
44. Performance indicators.
45. Performance improvement-Do-It-Yourself.
46. Performance improvement-Do-It-Yourself.
47. Performance improvement for the CM companies for better project management.
48. Performance improvement for the DM companies for better project management.
49. Types of project termination.
50. Strategic implications.
51. Project in trouble, and termination strategies,
52. Evaluation of termination possibilities

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
Define and **Recognise** project management stages	M											
Write Feasibility report,			M	**M**								
Illustrate Project implementation scheduling.	M										**M**	
Demonstrate Performance improvement.								**L**			**M**	
Identify project in trouble.	M				**M**							

Course Title: Additive Manufacturing			
Course Code: P13ME842	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME65	CAD/CAM	P13ME842	Additive Manufacturing	P08ME842	Rapid prototyping
2	P13MEL67	CAMA Lab				

Course objective: This course exposes students to latest additive manufacturing processes used to produce prototypes, parts and tools.

Course Content

Unit -1 INTRODUCTION: Need for the compression in product development, history of AM systems and classification of AM systems, basic steps in AM, advantages and disadvantages of AM process.
LIQUID BASED AM PROCESS: Stereolithography Systems**:** Principle, Process parameter, process details, , merits and demerits, Applications. Solid Ground Curing**:** Principle of operation, process parameters, Machine details, merits and demerits, Applications. **10hrs**

Unit - 2: POWDER BASED AM PROCESSES**:** Selective Laser Sintering**:** Type of machine, Principle of operation, process parameters, merits and demerits, Applications. Laser Engineering Net Shaping: Principle of operation, process details, merits and demerits, applications.
SOLID BASED AM PROCESSES**:** Laminated Object Manufacturing: Principle of operation, LOM materials, process parameters, process details, merits and demerits, application. Fusion Deposition Modelling: Principle, Process parameter, Path generation, merits and demerits, Applications **11hrs**

Unit- 3. APPLICATIONS OF ADDITIVE MANUFACTURING: Functional Models, Pattern for Investment and Vacuum Casting, Medical Models, Art Models, Engineering Analysis Models.
CONCEPTS MODELERS: Principle, types, difference between AM machine and Concept modeler, Thermal jet printer, Sander's model maker, 3- D printer. Genisys Xs printer, JP system 5, Object Quadra systems. **10hrs**

Unit - 4 RAPID TOOLING: Classification of Rapid tools, Soft Tooling vs. Hard Tooling. Indirect Rapid tooling: - Silicone rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling, Cast kirksite, 3D keltool. Direct Rapid Tooling: - Direct AIM, Quick cast process, RapidSteel1.0, RapidSteel 2.0, Copper polyamide, DMLS, Prometal, Sand casting tooling, Laminate tooling. DTM RapidToo1. **11hrs**

Unit -5 RAPID MANUFACTURING AND PROCESS OPTIMIZATION**:** Factors influencing accuracy. Data preparation errors, errors due to Tessellation and slicing Part building errors in SL process and SLS process, Error in finishing, influence of part build orientation in SL process and SLS process. **10hrs**

Text books

1. Paul F.Jacobs, "**Stereo lithography and other RP & M Technologies"** -SME, NY 1995.ISBN-13:9780872634671
2. Pham D.T & Dimov, S.S Verlog, "**Rapid Manufacturing"** springer, London 9 November 2011, ISBN-13:9781447111825

References

1. Wohlers, Terry T, "**Rapid Prototyping"** Wohler's Report 2000, Wohler's Association 2000. **Wohlers Report 2015**, 314-page publication, Wohlers Associates, Inc., April 2015
2. Gurumurthi, **Rapid prototyping materials,** IISc Bangalore
3. LamOnt wood, "**Rapid automated"** Industrial press, New York, August 1, 1993, ISBN-13: 9780831130473

Course Outcomes

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

1. **Identify** Classification of AM systems.
2. **Describe** working principle and applications of major AM systems
3. **Distinguish** AM Machine and Concept Modelers
4. **Explain** different types of rapid tooling
5. **Identify** factors influencing part accuracy in AM

Topic Learning Objectives (Unitwise)

Unit I

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

1. **Identify** Need for the compression in product development
2. **Describe** classification of AM systems
3. **Distinguish** Process parameters of Stereolithography Systems
4. **Explain** Solid ground curing process
5. **Distinguish** Process parameters of Solid ground curing process

Unit II

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

6. **Identify** the difference between powder based and solid based AM processes
7. **Describe** Selective Laser Sintering process
8. **Distinguish** Process parameters of Laser Engineering Net Shaping
9. **Explain** Laminated Object Manufacturing and Fusion Deposition Modelling

Unit III

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

10. **Identify** the applications of AM products in various field.
11. **Describe** Medical Models
12. **Distinguish** AM machine and Concept modeler
13. **Explain** various Concept modelers

Unit IV

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

14. **Distinguish** between various types of rapid tools
15. **Describe** production process of Indirect rapid tools
16. **Identify** the production process of direct rapid tools
17. **Explain** direct rapid tools

Unit V

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

18. **Describ**e Factors influencing accuracy of AM products
19. **Identify** errors due to Tessellation and slicing

20. **Distinguish** Part building errors in SL process and SLS process,
21. **Explain** the influence of part build orientation in SL process and SLS process.

Review Questions

1. Write complete classification of AM system
2. Explain basic five step process of AM
3. Enumerate benefits and limitations of AM
4. Sketch and explain working principle of Stereolithography System
5. Explain the following (i) Deep dip (ii) Z- wait (iii) Slice resolution with respect to SLA
6. Describe working of SGC process with neat sketches
7. Sketch and explain working principle of SLS process and list the materials used
8. Describe working of LENS process and list its applications
9. Sketch and explain working principle of LOM process
10. Describe working of FDM process and list its merits.
11. What are advantages of medical model produced by AM
12. Differentiate between AM machine and concept modeler.
13. Explain 3D Keltool process
14. Compare Rapid steel 1.0, Rapid steel 2.0 and Copper polyamide
15. Discuss part building errors in SLA

Lesson Plan

Unit I

1. Need for the compression in product development, history of AM systems
2. Classification of AM systems, basic steps in AM,
3. Advantages and disadvantages of AM process.
4. Types of Liquid based AM processes
5. Stereolithography Systems**:** Principle of operation
6. Process parameter, process details.
7. Merits and demerits, Applications of SLA
8. Solid Ground Curing**:** Principle of operation
9. Process parameters, Machine details
10. Merits and demerits, Applications of SGC

Unit II

11. Types of Powder based AM processes
12. Selective Laser Sintering Principle of operation process parameters
13. Merits and demerits, Applications of SGC
14. Laser Engineering Net Shaping: Principle of operation
15. Process details, merits and demerits, applications of LENS
16. Types of Solid based AM processes
17. Laminated Object Manufacturing: Principle of operation, LOM materials
18. Process parameters, process details
19. Merits and demerits, application of LOM
20. Fusion Deposition Modelling: Principle, Process parameter
21. Merits and demerits, Applications of FDM

Unit III

22. Applications of AM, Functional Models
23. Pattern for Investment and Vacuum Casting
24. Medical Models
25. Art Models, Engineering
26. Analysis Models

27. Concepts Modelers, Principle, types
28. Difference between AM machine and Concept modeler
29. Thermal jet printer, Sander's model maker
30. 3- D printer. Genisys Xs printer
31. JP system 5, Object Quadra systems

Unit IV

32. Classification of Rapid tools
33. Soft Tooling and. Hard Tooling, Direct and Indirect tools
34. Types of Indirect Rapid tooling, Silicone rubber tooling
35. Aluminium filled epoxy tooling, Spray metal tooling
36. Cast kirksite, 3D keltool
37. Types of Direct Rapid Tooling
38. Direct AIM, Quick Cast process
39. RapidSteel1.0, RapidSteel 2.0, ,
40. Copper polyamide, DMLS
41. Prometal, Sand casting tooling
42. Laminate tooling. DTM Rapid too1

Unit V

43. Accuracy of AM parts
44. Factors influencing accuracy
45. Data preparation errors,
46. Errors due to Tessellation
47. Errors due to slicing
48. Part building errors in SL process
49. Part building errors in SLS process
50. Error in finishing,
51. Influence of part build orientation in SL process
52. Influence of part build orientation in SLS process

Course Articulation Matrix

Course Outcomes	**Program Outcomes**											
	1	2	3	4	5	6	7	8	9	10	11	12
Identify AM systems based on raw materials used.	**M**	**L**	**L**									
Compare various AM process	**M**	**L**	**L**									
Distinguish between AM machines and concept modelers.	**M**	**L**	**L**									
Explain Direct and Indirect rapid tool	**M**	**L**	**L**									
Distinguish between part building errors in SL and SLS process	**H**	**M**	**L**									

Course Title: Power Plant Engineering			
Course Code: P13ME843	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13ME843	Power Plant Engineering	P08ME844	Power Plant Engineering
2	P13ME42	Applied Thermodynamics				

Course objective: the course is helps the student to understand about power plants and its working and the student must able understand the importance of renewable sources.

Course Content

Unit - 1

A BRIEF ACCOUNT OF HARNESSING ENERGY: From sources such as fuels, flowing water, wind, ocean, tides and waves, geothermal and nuclear energy. A brief description of thermionic, thermoelectric and fuel cell energy conversion devices. Choice of site for power station: load estimation; use factor diversity factor and demand factors effect of variable load on power plant: selection of the number and size of units. **10 Hr**

Unit- 2

HYDROELECTRIC AND THERMAL POWER PLANT: Hydrometric survey, rainfall, catchment area, runoff, storage and pondage; flow duration and mass curves, hydrographs. Classification of hydroelectric plants. General arrangement of a hydroelectric plant and its operation. Developing trends in thermal coal in lump form stokers; different types of stokers, equipment for preparation and burning of pulverized coal, unit system and bin system, pulverized fuel furnaces, cyclone furnace. **11 Hr**

Unit -3

GENERATION OF STEAM:A brief account of Lamont, Benson, Loeffler and Ramsin steam generators. Chimneys: Natural, forced, induced and balanced draft.

STEAM GENERATOR ACCESSORIES: Super-heaters and re-heaters. Different types of cooling towers, Coal and ash handling - different types of coal storage and coal conveyors, pneumatic and hydraulic methods of ash handling systems. **11 Hr**

Unit - 4

DIESEL ENGINE PLANT-Engines for power generation, Method of starting diesel engines, Cooling and lubrication system for the diesel engine. Filters, centrifuges, Oil heaters, intake and exhaust system, Layout of a diesel power plant. Gas turbine power plant: Advantages and disadvantages of the gas turbine plant, Open and closed cycle turbine plants with the accessories. **10 Hr**

Unit -5

NUCLEAR ENERGY: Fusion and fission reaction; elements of a nuclear reactor-moderator, control rod, fuel rods coolant. Nuclear fuels. Layout of a typical nuclear power plant.

REACTORS: Pressurized water reactor, Boiling water reactor, Sodium-Graphite reactor, Fast Breeder reactor, and Gas cooled reactor. Radiation hazards; shielding, and radioactive waste disposal. **10 Hr**

Text books

1. Arora& S Domkundwar, AV Domkundwar, "A course in Power Plant Engineering", Dhanpatrai& co. Pvt.ltd.2014, ISBN:9788177001075
2. P. K. Nag, "Power Plant Engineering" Tata McGraw Hill, INDIA 4TH edition. 2014, ISBN:9789339204044
3. F.T. Morse, "Power Plant Engineering", G. Van Nostrand. 3rd edition 1953, ISBN:9780442055561

References

1. Barrows,Water power Engineering, TMH, New Delhi, 3rd edition, 1998
2. Stanierr,Plant Engineering, Hand Book, McGraw Hill. 1998
3. JagadishLal, "Hydraulic Machines" Metropollitan Book Co. Pvt Ltd., 1994.ISBN: 978-8120000261

Course Outcomes

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

1. **Discuss** energy sources such as fuels, flowing water, wind, ocean, tides, waves, geochemical, nuclear energy and **Calculate** load estimation, use factor and demand factor.
2. **Characterize** the working principle of Hydroelectric power plant and **Describe** different types of stokers and oil burners in thermal power plant.
3. **Discuss** generation of steam by using high pressure boilers and **Calculate** height and efficiency of Chimney.
4. **Discuss** Steam Generator Accessories, Method of starting Diesel Engine to generate power, Cooling and Lubrication System and Layout of diesel Power plant.
5. **Recognize** the Principles of Nuclear Energy and **Describe** different types of nuclear Reactors.

Topic Learning Objectives (Unitwise)

Unit I

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

1. Know the importance of renewable& non renewable energy sources
2. Understand the principals of thermoelectric and fuel cell energy conversion devices
3. Know the knowledge about Choice of site for power station

Unit II

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

4. Know the General arrangement of a hydroelectric plant and its operation.
5. Understand the significance of flow duration and mass curves, hydrographs
6. Know about unit system and bin system
7. Explained the working of furnaces.

Unit III

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

8. Explained the working principals of steam generators
9. Explained the importance of Chimneys
10. Understand the Super-heaters and re-heaters. Different types of cooling towers
11. Explained the Coal and ash handling methods

Unit IV

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

12. Explained the Method of starting diesel engines, Cooling and lubrication system for the diesel engine
13. Explained the Filters, centrifuges, Oil heaters, intake and exhaust system

14. Know the knowledge about Gas turbine power plant
15. Explained the Open and closed cycle gas turbine plants with the accessories

Unit V

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

16. Explained the Fusion and fission reaction;
17. Understand the elements of a nuclear reactor.
18. Explained the different types reactors
19. Understand the Radiation hazards and their disposal.

Review Questions

1. Write a note on wind energy
2. Explain thermionic, thermoelectric and fuel cell energy conversion devices.
3. Explain Loefflerand Ramsin steam generators
4. Explain unit system and bin system
5. Describes the steps involved in pulverized fuel furnaces
6. Explain General arrangement of a hydroelectric plant and its operation.
7. Describes the Open and closed cycle gas turbine plants with the accessories.
8. Explain Cooling and lubrication system for the diesel engine
9. Define Fusion and fission reaction
10. With neat diagram explain Pressurized water reactor, Boiling water reactor

Lesson Plan

Unit I

1. Energy sources such as renewable and non renewable sources.
2. Wind and waves energy.
3. Ocean, energy.
4. Tidal energy.
5. Geothermal energy.
6. Nuclear energy.
7. A brief description of thermionic, & thermoelectric energy conversion
8. A brief description of fuel cell energy conversion devices.
9. Choice of site for power station; load estimation
10. Diversity factor and demand factors effect of variable load on power plant
11. selection of the number and size of units. Numericals
12. Numericals..

Unit II

1. Hydrometric survey, rainfall, catchment area
2. runoff, storage and pondage; Hydrographs; flow duration and mass curves,
3. Hydrographs problems
4. flow duration and mass curves, problems
5. Classification of hydroelectric plants
6. General arrangement of a hydroelectric plant and its operation
7. Developing trends in thermal coal in lump form stokers
8. different types of stokers,
9. Equipment for preparation and burning of pulverized coal
10. unit system and bin system, pulverized fuel furnaces, cyclone furnace

Unit III

1. A brief account of Lamont & Bensonsteam generators.
2. Loefflersteam generator.
3. Ramsinsteam generator.

4. Chimneys: Natural, forced, induced and balanced draft
5. Calculation involving height of chimney to produce given draft
6. Efficiencies of chimneys, max. discharge of flue gases though the chimney,
7. Numericals.
8. Super-heaters and re-heaters. Different types of cooling towers
9. Coal and ash handling - different types of coal storage and coal conveyors
10. Pneumatic and hydraulic methods of ash handling systems.

Unit IV

1. Engines for power generation, Method of starting diesel engine
2. Cooling and lubrication system for the diesel engine.
3. Filters; centrifuges, Oil heaters
4. Intake and exhaust system.
5. Layout of a diesel power plant
6. Introduction to Gas turbine power plant
7. Gas turbine power plant: Advantages and disadvantages of the gas turbine plant,
8. Open cycle turbine plants with the accessories.
9. Closed cycle turbine plants with the accessories.
10. Revision

Unit V

1. Fusion and fission reaction; -.
2. Elements of a nuclear reactor moderator, control rod, fuel rods, coolant
3. Elements of a nuclear reactor moderator, control rod, fuel rods ,coolant
4. Layout of a typical nuclear power plant.
5. Pressurized water reactor, Boiling water reactor,
6. Sodium-Graphite reactor, Fast Breeder reactor,
7. Gas cooled reactor
8. Radiation hazards; shielding
9. Radioactive waste disposal.
10. Revision

Course Articulation Matrix

Course Outcomes	**Program Outcomes**											
	1	2	3	4	5	6	7	8	9	10	11	12
Explain energy sources such as fuels, flowing water, wind, ocean, tides, waves, geochemical, nuclear energy and **Analyze** the load estimation, use factor and demand factor.	**H**	**H**										
Summarize the working principle of Hydroelectric power plant and different types of stokers and oil burners in thermal power plant.			**M**									
Explain generation of steam by using high pressure boilers and **solve height** and efficiency of Chimney.	**H**	**H**										**L**
Explain Steam Generator Accessories, Method of starting Diesel Engine to generate power, Cooling and Lubrication System and Layout of diesel Power plant.	**H**		**L**									
Define the Principles of Release in Nuclear Energy and **Explain** different types of nuclear Reactors.		**L**				**L**						

Course Title: Tribology			
Course Code: P13ME844	**Sem: 08**	**L –T-P-H: 4:0:0:4**	**Credit: 03**
Contact Period: Lecture: 52 Hrs, Exam: 3Hrs		**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	P13MA31	Engineering Mathematics II	P13ME844	Tribology	P08ME742	Tribology
2	P13ME45	Fluid Mechanics				

Course objective: The course aims at strengthening the capability of students to integrate friction, wear and lubrication theories in design, manufacturing and operation of sustainable machine elements and their maintenance.

Course Content

Unit - 1

Introduction to Tribilogy: Introduction to tribology, friction, laws of friction, friction theories, surface contaminants and frictional heating. Wear- classification of wear, mechanisms of wear, basic wear testing methods- pin on disc wear tester and dry sand rubber wheel abrasion tester, wear resistant materials.

Surface roughness: introduction, standardization of surface roughness, M & E system, centre line average, root mean square roughness, probability distribution function, autocorrelation function. Abott bearing area curve. Surface roughness measurement techniques- stylus method, interferometric method, optical profilometer and pneumatic method. **10 hrs**

Unit- 2

Lubricants and Lubrication: Types of bearing, lubricants, types of lubricants. Lubrication, types of sliding lubrication-fluid-film lubrication, boundary lubrication and extreme boundary lubrication. Properties of oils and equation of flow- viscosity, Newton's law of viscous flow, effect of temperature on viscosity, viscosity index, effect of pressure on viscosity, viscosity measuring apparatus- U-tube viscometer, Saybolt universal viscometer and Redwood viscometer. Hagen- Poiseuille Law, flow through capillary tube, flow between parallel stationary plates. **10 hrs**

Unit -3

Hydrodynamic Lubrication: Friction forces and power loss in lightly loaded bearing, coefficient of friction for a lightly loaded bearing (Petroff's equation), numerical examples of lightly loaded full-journal bearing, Tower's experiments, Reynolds investigations, mechanism of pressure development in an oil film, application of converging oil film in thrust bearing, formation of a converging oil film in a partial and full journal bearings. Reynold s equation in two dimensions. **10 hrs**

Unit - 4

Idealized Hydrodynamic Bearings: Definition of idealized bearings, idealized plane-slider bearing with a fixed shoe- Pressure distribution, load carrying capacity, coefficient of friction. Idealized slider bearing with a pivoted shoe- load carrying capacity, frictional

resistance, coefficient of friction, location of the pivot point of a slider bearing with a pivot shoe. Numerical problems. **10 hrs**

Unit -5

Hydrodynamic Journal Bearing: Idealized journal bearings- infinitely long-full journal bearing- oil film thickness, Sommerfeld substitution, pressure distribution (no derivation), load carrying capacity, Sommerfeld number, viscous friction, modified Sommerfeld solution. Infinitely short-full journal bearing- pressure distribution (no derivation), load capacity and friction force. Numerical problems on idealized hydrodynamic journal bearing.

Hydrostatic Lubrication: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing. Numerical on hydrostatic lubrication. **12 hrs**

Text books

1. Basu S K., Sengupta S N., Ahuja B. B., Fundamentals of Tribiology, PHI, 1st edition, 2009, ISBN: 978-8120327238
2. B. C. Mujumdar, Introduction to Tribiology of bearings, S.Chand (G/L) & Company Ltd, 2nd edition, 2010, ISBN: 978-8121929875.
3. E. I. Redzimovskay, Lubrication of bearings theoretical principles and design, The Ronald Press Company, 1st edition, 1959, ASIN: B0000EGL66.

References

1. Dudley D. Fuller, Theory and Practice of Lubrication for Engineers, John Wiley & Sons; 2nd Edition, 12 September 1984, ISBN: 978-0471047032.
2. Desmond F. Moore, Principles and Applications of Tribiology, Pergamaon Press, 1st edition, 1975, ISBN: 9780080179025.
3. Sushil Kumar Srivastava, Tribiology in Industries, S Chand and Company limited, India, 2004, ISBN: 9788121920452.
4. Prasanta Sahoo, Engineering tribology, PHI, 2005, ISBN: 978-8120327245

Course Outcomes

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

1. **Explain** friction, laws of friction and different types of wear in materials undergoing relative motion. **Characterize** surface texture and **determine** roughness characteristics using its measuring techniques.
2. **Explain** the properties of lubricants and classify them. **Derive** Hagen-Poiseuille law.
3. **Explain** the concept of lightly loaded bearings and **derive** Petroff's equation.
4. **Derive** expressions for pressure distribution, load carrying capacity, coefficient of friction, frictional resistance in a idealized slider bearing.
5. **Derive** expressions for pressure distribution, load carrying capacity and oil flow through the hydrodynamic journal bearing and hydrostatic step bearing.

Topic Learning Objectives (Unit wise)

Unit I

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

1. **Apply** laws and theories of friction in the design of machine elements.
2. **Determine** frictional heating.
3. **Describe** wear and its mechanism.
4. **Identify** wear resistant materials in the design process of machine elements.
5. **Describe** surface roughness and its characteristics.
6. **Explain** some important roughness measuring techniques.

Unit II

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

1. **List** the type of bearings and lubricants.
2. **Describe** types of sliding lubrication process.
3. **Define** viscosity of oil and Newton's law of viscous flow.
4. **Discuss** the effects of temperature and pressure on viscosity of oil.
5. **Describe** viscosity measuring instruments.
6. **Use** Hagen-Poiseuille law to **derive** expression for flow through capillary tube and between parallel plates.

Unit III

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

1. **Derive** expressions for friction force, power loss and coefficient of friction in a lightly loaded bearing.
2. **Explain** Tower's experiments and **discuss** the mechanism of pressure development in oil film.
3. **Explain** the application of converging oil film in pressure development in thrust bearing and partial and full journal bearings.
4. **Derive** Reynolds equation in two dimensions.

Unit IV

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

1. **Define** idealized bearings.
2. **Derive** expressions for pressure distribution, load carrying capacity, coefficient of friction and frictional resistance in an idealized slider bearing with a fixed shoe.
3. **Derive** expressions for pressure distribution, load carrying capacity, coefficient of friction and frictional resistance in an idealized slider bearing with a pivoted shoe.

Unit V

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

1. **Derive** expressions for oil film thickness, pressure distribution, load carrying capacity of idealized journal bearing.
2. **Obtain** Sommerfeld number and Sommerfeld solution of a journal bearing.
3. **Describe** systems of hydrostatic lubrication systems.
4. **Derive** expressions for pressure distribution, load carrying capacity and flow of lubricant of hydrostatic circular step bearing.
5.

Review Questions	
1	State clearly laws of friction.
2	Name friction theories and explain any three friction theories.
3	Briefly explain mechanical interlocking and molecular attraction theories of friction.
4	Write the classification of wear and explain adhesive wear mechanism.
5	Sketch and explain the Pin on disc wear test and dry sand rubber wheel abrasion test.
6	Explain the following related to surface roughness characterization: i) Centre line average ii) root mean square roughness, iii) probability distribution function, and iv) autocorrelation function.
7	With neat sketch, explain the optical profilometer technique used for the measurement of roughness of a surface.
8	What are the main types of lubricant? Briefly explain them.
9	Briefly explain the fluid-film and boundary lubrications.
10	Derive an expression for the flow of lubricant through capillary tube using Hagen-Poiseulle law.

11	An oil supply line 1.2 m long having internal diameter 6.25 mm and delivering $6x10^{-5}$ m^3/sec of oil having viscosity of 0.0555 Pa-sec. Calculate the pressure drop in the supply line and the energy required in forcing the oil through the supply line against viscous friction.
12	Derive expressions for friction force and power loss in a lightly loaded journal bearing.
13	Derive Petroff's equation for a lightly loaded journal bearing,
14	A bearing used for a light duty compressor has the following specifications: i) Load : 1kN ii) Diameter of journal : 50 mm iii) Length to diameter ratio, L/d : 1.2 iv) Diametral clearance : 0.001 v) Speed of the journal : 15000 rpm vi) Oil used is SAE 60 at the effective temperature of 50^o C. Determine the frictional torque, coefficient of friction and power loss
15	Write a note on: i) Tower's experiments ii) mechanism of pressure development in an oil film. iii) Formation of a converging oil film in a partial journal bearing.
16	Derive Reynolds equation in two dimensions.
17	Derive an expression for the load carrying capacity of an idealized slider bearing with fixed shoe.
18	Obtain the load carrying capacity of a long journal bearing.
19	An idealized full journal bearing has the following specifications: i) Diameter of the journal = 50 mm ii) Length of bearing = 60 mm iii) Speed of journal = 1200 rpm\ iv) Radial clearance = 0.025 mm v) Attitude = 0.8 vi) Average viscosity of oil under operating conditions = 0.01125 Pa-sec Determine: a) Coefficient of friction b) Load carrying capacity of bearing c) Power loss in the bearing d) Minimum film thickness under the given operating condition
20	Explain the two main systems of hydrostatic lubrication.
21	The following data refer to a hydrostatic thrust bearing: i) shaft speed = 720 rpm ii) shaft diameter = 500 mm iii) recess diameter = 350 mm iv) film thickness = 0.15 mm v) viscosity of lubricant = 30 cp vi) specific gravity = 0.86 vii) specific heat = 1.75 kJ/kg^o C viii)supply pressure = 5 MPa. Determine, a) Load carrying capacity b) Flow requirement c) Pumping power loss d) Frictional power loss e) Temperature rise

Lesson Plan

Unit I

1. Introduction to tribology, friction, laws of friction
2. Friction theories, surface contaminants
3. Frictional heating, wear- classification of wear
4. Mechanisms of wear
5. Mechanisms of wear and wear resistant materials
6. Surface roughness- introduction, standardization of surface roughness
7. M&E system, centre line average
8. Root mean square roughness, probability distribution function, Autocorrelation function, Abott bearing area curve
9. Surface roughness measurement techniques- stylus method, interferometric method
10. Surface roughness measurement techniques-Optical profilometer and pneumatic method.

Unit II

1. Types of bearing, lubricants, types of lubricants
2. Lubrication, types of sliding lubrication – fluid-film lubrication, boundary lubrication and extreme boundary lubrication
3. Properties of oils and equation of flow- viscosity, Newton's law of viscous flow
4. Effect of temperature on viscosity, viscosity index, effect of pressure on viscosity
5. Viscosity measuring apparatus- U-tube viscometer, Saybolt universal viscometer
6. Redwood viscometer, Hagen- Poiseuille Law, flow through capillary tube
7. Hagen- Poiseuille law for flow between parallel stationary plates.
8. Numerical examples on Hagen- Poiseuille law
9. Numerical examples on Hagen- Poiseuille law
10. Numerical examples on Hagen- Poiseuille law

Unit III

1. Friction forces in lightly loaded bearing
2. Power loss in lightly loaded bearing
3. Coefficient of friction for a lightly loaded bearing (Petroff's equation)
4. Numerical examples on lightly loaded full-journal bearing
5. Numerical examples on lightly loaded full-journal bearing
6. Tower's experiments, Reynolds investigation
7. Mechanism of pressure development in an oil film
8. Application of converging oil film in thrust bearing
9. Formation of a converging oil film in a partial journal bearing
10. Reynold s equation in two dimensions

Unit IV

1. Definition of idealized bearings and idealized plane-slider bearing with a fixed shoe
2. Pressure distribution and load carrying capacity of idealized plane-slider bearing with a fixed shoe.
3. Coefficient of friction of Idealized plane-slider bearing with a fixed shoe.
4. Numerical examples on plane-slider bearing with a fixed shoe
5. Numerical examples on plane-slider bearing with a fixed shoe
6. Idealized slider bearing with a pivoted shoe- load carrying capacity
7. Frictional resistance and coefficient of friction of idealized slider bearing with a pivoted shoe
8. Numerical examples on plane-slider bearing with pivoted shoe.
9. location of the pivot point of a slider bearing with a pivot shoe
10. Numerical problems

Unit V

1. Introduction to idealized journal bearings, infinitely long-full journal bearing- oil film thickness
2. Sommerfeld substitution and pressure distribution of infinitely long- full journal bearing.
3. Load carrying capacity of infinitely long- full journal bearing.
4. Sommerfeld number, viscous friction and Modified Sommerfeld solution
5. Infinitely short-full journal bearing- pressure distribution
6. Load capacity and friction force of infinitely short-full journal bearing
7. Numerical problems on idealized hydrodynamic journal bearing
8. Numerical problems on idealized hydrodynamic journal bearing
9. Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity
10. Oil flow through the hydrostatic step bearing.
11. Numerical on hydrostatic lubrication
12. Numerical on hydrostatic lubrication

Course Articulation Matrix

Course Outcomes	Program Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
1. **Explain** friction, laws of friction and different types of wear in materials undergoing relative motion. **Characterize** surface texture and **determine** roughness characteristics using its measuring techniques.	H	H	M	H	M	L	L					
2. **Explain** the properties of lubricants and classify them. **Derive** Hagen-Poiseuille law.	H	H	M			L						
3. **Explain** the concept of lightly loaded bearings and **derive** Petroff's equation.	H	H	H									
4. **Derive** expressions for pressure distribution, load carrying capacity, coefficient of friction, frictional resistance in a idealized slider bearing.	H	H	L									
5. **Derive** expressions for pressure distribution, load carrying capacity and oil flow through the hydrodynamic journal bearing and hydrostatic step bearing.	H	H	L									