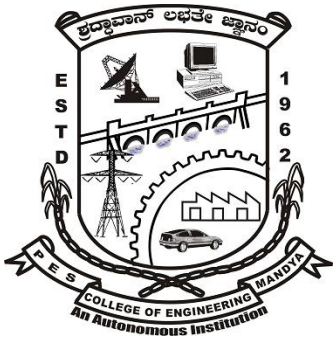
SYLLABUS

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

ಪಠ್ಯಕ್ರಮ

(ಶೈಕ್ಷಣಿಕವರ್ಷ 2013–14)
ಫಲಿತಾಂಶ ಆಧಾರಿತ ಶಿಕ್ಷಣ

V and VI Semester
Bachelor Degree
in
Automobile 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)

Ph : 08232- 220043, Fax : 08232 – 222075,Web : www.pescemandya.org

Preface

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

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

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

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

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

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

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

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

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

P.E.S.COLLEGE OF ENGINEERING, MANDYA-57140
(An Autonomous Institution under VTU, Belagavi)

Vision

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

Mission

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

DEPARTMENT OF AUTOMOBILE ENGINEERING

The discipline Automobile Engineering was established in the year 1980, and now it has gained expertise and contributing vitally to the Automobile Engineering community. The focus is to consistently pursue in providing innovative and quality training to the talented and dedicated students, to empower them in engineering the development of national economy, specialized in transport sector. We are the pioneers in Karnataka to introduce the Department of Automobile Engineering to impart sound automotive knowledge to the students with a passion towards Automobiles. We take honor in being recognized as a 'research centre' in Karnataka by VTU and Mysore University. In addition to these regular programmes, this department is also actively involved in conducting Faculty Development Programmes, Technical talks, Training programmes and technical visits to various industries & regular industrial traiinings for the benefits of students. The department has well qualified and well experienced faculty members to meet the present day curriculum requirements both in theory and practical.

Vision

Outstanding department, exploring new technologies through continuous learning, research and innovation towards developing competent automobile engineers.

Mission

Committed to**,**

- *Impart knowledge in basic and applied areas*
- *Provide Teaching and Learning ambience in emerging areas with state of art infrastructure*
- *Enhance institute – industry interaction for developing centres of excellence.*
- *Develop students with excellent analytical skills and technical expertise*
- *Create environment on research and innovation for faculty and students.*
- *Committed to deliver interpersonal communication ,team work and engineers with high ethics*

Programme Education Objctives (PEOs)

- **PEO1:** Excel in professional career by acquiring knowledge in Basic sciences and Automobile engineering.

- **PEO2**: Expertise in Thermal, Design and Dynamics, Production, Automotive Electronics, Alternative Fuels and Vehicle Pollution Control with a focus on research and innovation.

- **PEO3**: Ability of problem solving by adopting analytical, numerical and experimental skills with Social Responsibility and societal impact.

- **PEO 4**: Exhibit professionalism, ethical attitude, communication skills, team work in their profession and adapt Innovative Technologies by engaging in life- long learning principles.

Program Outcomes (PO's)

The graduates of Automobile Engineering of PESCE will be able to:

a. **AUPO1**:Demonstrate basic knowledge in mathematics, basic science, materials and environmental science and engineering to identify, formulate and solve Automobile engineering problems

b. **AUPO2** :Design and conduct experiments, as well as to analyze and interpret the results

c. **AUPO3**:Design and analyse Automotive Systems, thermal systems or processes, Dynamics, and Vehicle Pollution Control for desired Automobile specifications

d. **AUPO4** :Function on multidisciplinary teams with sound communication skills

e. **AUPO5** : Self-learn to acquire and apply allied knowledge and update the same by engaging in life-long learning, practice profession with ethics and promote entrepreneurship

f. **AUPO6**: Apply engineering solutions in global, economic, environmental, and societal context.

P.E.S COLLEGE OF ENGINEERING, MANDYA
(An Autonomous Institution under VTU)
V SEMESTER B.E. AUTOMOBILE ENGINEERING

SL. No	Subject Code	Title of the Subject	Teaching Dept.	Hours /week L : T : P:H	Total Credits	Examination Marks			Exam Duration in hours
						CIE	SEE	Total	
1	P13AU51	Industrial Management and Entrepreneurship	Auto	4:0:0:4	4	50	50	100	3
2	P13AU52	Design of Machines Elements-I	Auto	3:2:0:5	4	50	50	100	3
3	P13AU53	Heat Transfer	Auto	4:0:0:4	4	50	50	100	3
4	P13AU54	Theory of Machines-II	Auto	3:2:0:5	4	50	50	100	3
5	P13AU55	Auxiliary Systems of Automotive Engines	Auto	4:0:0:4	4	50	50	100	3
6	P13AU56	Automotive Fuels & Combustion	Auto	2:2:0:4	3	50	50	100	3
7	P13AUL57	Diagnosis and Reconditioning Lab	Auto	0:0:3:3	1.5	50	50	100	3
8	P13AUL58	Fuel Testing and Measurement Lab	Auto	0:0:3:3	1.5	50	50	100	3
9	P13HU59	Professional and Efficient Avocation-I (PEA-I)	HS&M	2:0:0:2	0	(50)	---	---	---
10	P13AULL510	Industry visit and interaction-II	Auto	0:0:1:1	--	(50)	--	--	--
Total					**26**	**400**	**400**	**800**	

VI SEMESTER B.E. AUTOMOBILE ENGINEERING

SL. No	Subject Code	Title of the Subject	Teaching Dept.	Hours /week L : T : P:H	Total Credits	Examination Marks			Exam Duration in hours
						CIE	SEE	Total	
1	P13AU61	Automotive Chassis and Suspension	Auto	4:0:0:4	4	50	50	100	3
2	P13AU62	Automotive Transmission	Auto	4:0:0:4	4	50	50	100	3
3	P13AU63	Design of Machines Elements-II	Auto	3:2:0:5	4	50	50	100	3
4	P13AU64	Automotive Electrical and Autotronics	Auto	2:2:0:4	3	50	50	100	3
5	P13AU65	Mechanical Vibrations	Auto	3:2:0:5	4	50	50	100	3
6	P13AU66X	Elective –A	Auto	4:0:0:4	4	50	50	100	3
7	P13AUL67	Automotive Chassis and Transmission Lab	Auto	0:0:3:3	1.5	50	50	100	3
8	P13AUL68	Automotive Electricals and Autotronics Lab	Auto	0:0:3:3	1.5	50	50	100	3
9	P13HU69	Professional and Efficient Avocation-I (PEA-II) *	HS&M	2:0:0:2	0	(50)	---	---	--
10	P13EEL610	Mini Project - II*	Auto	0:0:1:1	--	(50)	--	--	--
Total					**26**	**400**	**400**	**800**	

* PEA-I, , Industry visit and interaction-II, PEA-II, Mini Project: All students shall have to pass this mandatory learning courses before completion of VIII-Semester

Elective –A

SL. No.	Subject Code	Subject
1	P13AU661	Non Traditional Machining
2	P13AU662	Operation Research
3	P13AU663	CAD/CAM
4	P13AU664	Finite Element Methods

*** Elective shall be added as per knowledge, need of the course work**

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

Semester: V

Course Title: **INDUSTRIAL MANAGEMENT AND ENTREPRENEURSHIP**			
Total Contact Hours: 52	Course Code: **P13AU51**	L:T:P:H- 4:0:0:4	Credits:4
CIE marks: 50: SEE marks: 50		Duration of Exam: 3 Hrs.	

Prerequisites:

Subject requires student to know about

Basic Knowledge about management concepts and Entrepreneurial knowledge**.**

Course Learning Objectives (CLO) :

This Course Aims to:

1. Explain fundamental understanding of management, nature scope, and functions of a manager and development of management thought. Also explain planning and decision making processes.
2. Explain the organizational structure, departmentation, staffing and leading processes.
3. Describe the conceptual understanding of motivation and different control systems in management.
4. Understanding of Entrepreneurships and Entrepreneurship development process.
5. Illustrate Small Scale Industries, various types of supporting agencies and financing available for an entrepreneur.
6. Summarize the preparation of project report, need significance of report. Also to explain about industrial ownership.

Relevance of the Course:

INDUSTRIAL MANAGEMENT AND ENTREPRENEURSHIP is a management course in BE (Automobile engineering) program which Provide a fundamental understanding of management, Planning, organizing, staffing, directing and controlling to student. These are essential in Industries to get managerial skills. The course also aims to provide basic understanding of Entrepreneurships and to create awareness about various types of supporting agencies and financing available for an entrepreneur and to impart strategies to be followed in managing and growing new venture. It also helps in preparing project report and to know about Industrial ownership.

Course Content

UNIT-1: MANAGEMENT: Introduction - Meaning - nature and characteristics of Management, Scope and functional areas of management, - Management as an art or science, art or profession, Management & Administration - Roles 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. **11 Hours**

UNIT-2: ORGANISING AND STAFFING: Nature and purpose of organization -Principles of organization - Types of organization – Departmentation-Committees - Centralization Vs 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; Meaning and nature of directing -Leadership styles, Motivation Theories, Communication - Meaning and importance - Coordination, meaning and importance and Techniques of Co -ordination.

10 Hours

UNIT-3: CONTROLLING: Meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control (in brief)

ENTREPRENEUR: Meaning of Entrepreneur; Evolution of the Concept, Functions of an Entrepreneur, Types of Entrepreneur, Entrepreneur – an emerging class. Concept of Entrepreneurship – Evolution of Entrepreneurship, Development of Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Entrepreneurship in India; Barriers to entrepreneurship.

10 Hours

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 S.S.L; Government Support for S.S.L during 5 year plans, Impact of Liberalization, Privatization, Globalization on S.S.I., Effect of WTO/GATT Supporting Agencies of Government for S.S.L, 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; SlDBI; KSFC. ***10 Hours***

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.

INDUSTRIAL OWNERSHIP; Definition and meaning of Partnership, Characteristics of Partnership, Kinds of Partners, Partnership Agreement or Partnership Deed, Registration of Partnership Firm, Rights, Duties and Liabilities of Partners, Advantages and Disadvantages of Partnership, Sole proprietorship, Features, Scope Advantages and Disadvantages of Sole Proprietorship. **11 Hours**

TEXT BOOKS:

1. "Principles of Management" - P.c. Tripathi, P.N. Reddy; TataMcGraw Hill,
2. "Dynamics of Entrepreneurial Development & Management" -
Vansant Desai, Himalaya Publishing House Entrepreneurship Development -
3. "Small Business Enterprises" - Poornima M Charantimath – Pearson Education – 2006 (2 & 4)

REFERENCE BOOKS:

1. Management Fundamentals - Concepts, Application, Skill Development Robert Lusier - Thomson
2. Entrepreneurship Development - S S Khanka - S Chand & Co
3. Management - Stephen Robbins - Pearson Education /PHI -17thEdition, 2003
4. Management and Entrepreneurship-N.V.R.Naidu, T.KrishnaRao, I.K.International Publishing House Pvt.Ltd.

Course Outcomes (COs):

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

1. Explain fundamental understanding of management, nature scope, and functions of a manager and development of management thought. Also explain planning and decision making processes.
2. Explain the organizational structure, departmentation, staffing and leading processes.
3. Describe the conceptual understanding of motivation and different control systems in management.
4. Understanding of Entrepreneurships and Entrepreneurship development process.
5. Illustrate Small Scale Industries, various types of supporting agencies and financing available for an entrepreneur.
6. Summarize the preparation of project report, need significance of report. Also to explain about industrial ownership.

Unit wise plan

UNIT-1

Topic Learning Objectives (TLO): L1, L2, L3

At the end of this chapter student should be able to:

- Define management and planning (L1).
- Explain the functions of management (L2)
- Explain the scope of management (L2).
- List the nature and characteristics of management (L1).
- Differentiate between administration and management (L2).

- List and explain the roles and levels of management (L1).
- Describe management as an art or science, art or profession (L3).
- Discuss in brief the nature of management (L2).
- Explain early management approaches (L2).
- Explain the modern management approaches (L2).
- Explain the steps involved in planning (L2).
- Explain the importance and purpose of planning process (L2).
- List and explain the objectives of planning (L1).
- Explain briefly the types of planning (L2).
- Describe the process of decision making (L2).
- Explain the steps in decision making (L2).
- Explain briefly hierarchy of plans (L2).

Lesson Schedule

1. **MANAGEMENT**: Introduction - Meaning - nature and characteristics of Management,
2. Scope and functional areas of management,
3. Management as an art or science, art or profession, Management & Administration,
4. Roles of Management, Levels of Management,
5. Development of Management Thought-
6. Early management approaches - Modern management approaches
7. **PLANNING:** Nature, importance and purpose of planning process,
8. Objectives - Types of plans (Meaning only),
9. Decision making - Importance of planning,
10. Steps in planning & planning premises,
11. Hierarchy of plans, Revision.

UNIT-2

Topic Learning Objectives (TLO): L1, L2

At the end this chapter student should be able to:

- Explain the nature and purpose of organization (L2).
- Describe the principles of organization (L2).
- List the different types of organizations (L1).
- Explain the different types of organization charts (L2).
- List the advantages and disadvantages of line and staff organization (L1).
- Explain the principles of committees (L2).
- Enumerate the merits and demerits of centralization and decentralization (L2).
- Explain the process of delegation and difficulties in delegation (L2).
- Explain span of control (L2).
- List management by objectives (MBO) and management by exception (MBE) (L1).
- Differentiate between MBO and MBE (L2).
- Describe the nature and importance of staffing (L2).
- Explain the techniques of selection (L2).
- Explain meaning and nature of directing (L2).
- Describe principles of leadership (L2).
- Describe about Maslow's theory of motivation (L2).
- Define communication. Explain different systems of communication (L2).
- Explain the importance of coordination (L2).

Lesson Schedule

1. **ORGANISING AND STAFFING**: Nature and purpose of organization,
2. Principles of organization - Types of organization,
3. Departmentation-Committees,
4. Centralization Vs Decentralization of authority and responsibility,
5. Span of control- MBO and MBE (Meaning 'only),
6. Nature and importance of Staffing - Process of Selection &Recruitment (in brief).
7. **DIRECTING**; Meaning and nature of directing -Leadership styles,
8. Motivation Theories,
9. Communication - Meaning and importance,
10. Coordination, meaning and importance and Techniques of Co -ordination.

UNIT-3

Topic Learning Objectives (TLO): L1, L2, L3

At the end this chapter student should be able to:

- Define controlling (L1).
- Describe the steps in controlling (L2).
- List the essentials of sound controlling (L1).
- Define entrepreneurship and explain its model (L1).
- Explain the evolution of concept of entrepreneurship (L2).
- List the qualities and characteristics of entrepreneur (L1).
- Explain the functions of entrepreneur (L2).
- List out the types of entrepreneur (L1).
- Explain the meaning and role of intrapreneur (L2).
- Differentiate between entrepreneur, intrapreneur and manager (L3).
- Explain the concept of entrepreneurship (L2).
- Describe about evolution of entrepreneurship (L2).
- Explain the development of entrepreneurship (L2).
- List and explain the various stages of entrepreneurship processes (L2).
- Explain the role of entrepreneur in economic development (L2).

Lesson Schedule

1. **CONTROLLING**: Meaning and steps in controlling,
2. Essentials of a sound control system,
3. Methods of establishing control (in brief),
4. **ENTREPRENEUR**: Meaning of Entrepreneur; Evolution of the Concept,
5. Functions of an Entrepreneur, Types of Entrepreneur,
6. Entrepreneur – an emerging class. Concept of Entrepreneurship,
7. Evolution of Entrepreneurship, Development of Entrepreneurship,
8. Stages in entrepreneurial process,
9. Role of entrepreneurs in Economic Development; Entrepreneurship in India,
10. Barriers to entrepreneurship, Revision.

UNIT-4

Topic Learning Objectives (TLO): L1, L2, L3

At the end this chapter student should be able to:

- Define Small scale Industry, Ancillary Industry and Tiny Industries (L1).
- List and explain the characteristics of SSIs (L2).

- Explain need and rationale of SSIs (L2)
- Explain the Scope and objectives of SSIs (L2).
- Explain the role of SSI in economic development (L2).
- List the advantages of SSIs (L1).
- Explain the steps to start SSIs (L2).
- Explain various Government policies towards SSIs (L2).
- Describe briefly Government support to SSIs during 5 year plans (L2).
- Explain the Impact of Liberalization, Privatization and Globalization on SSIs (L2).
- Explain the functions of WTO and its impact on trade (L2).
- Describe about GATT and list their advantages (L3).
- List the various supporting agencies of government to SSIs (L1).
- Discuss the necessity if institutional support to the SSIs (L2).
- Explain the role of SSIDC in developing the small-scale industries (L2).
- Explain the roles of DICs, IDBI/SIDBI (L2).
- Explain the role of KSFC (L2).
- Explain the role and help extended by SISIs in developing SSIs (L2).

Lesson Schedule

1 ***SMALL SCALE INDUSTRY: Definition; Characteristics; Need and rationale,***
2 Objectives; Scope; role of SSI in Economic Development. Advantages of SSI,
3 Steps to start an SSI - Government policy towards SSI,
4 Different Policies of S.S.L; Government Support for S.S.I during 5 year plans,
5 Impact of Liberalization, Privatization, Globalization on S.S.I., Effect of WTO/GATT,
6 Supporting Agencies of Government for S.S.I, Meaning; Nature of Support, Objectives;
7 Functions; Types of Help; Ancillary Industry and Tiny Industry (Definition only).
8 **INSTITUTIONAL SUPPORT**: Different Schemes; TECKSOK,
9 KIADB; KSSIDC; KSIMC; DIC Single Window Agency,
10 SISI; NSIC; SlDBI; KSFC.

UNIT-5

Topic Learning Objectives (TLO): L1, L2, L3

At the end this chapter student should be able to:

- Classify and define the project (L1).
- Explain the Phase of project Identification with its sources (L2).
- Describe about selection of project (L2).
- Explain the need and significance of project report (L2).
- Describe project formulation process (L3).
- Explain the contents of project report (L2).
- List the guidelines of Planning Commission for project report (L2).
- Explain network analysis. What are various techniques used for network analysis (L2).
- Explain PERT. What are its advantages and disadvantages (L2).
- Explain CPM.What are its advantages and disadvantages (L2).
- List and explain common errors in project report (L1).
- Explain the process of project appraisal (L2).
- Describe about market feasibility, financial feasibility, technical feasibility and social feasibility studies (L3).
- Explain the characteristics of partnership (L2).
- List the advantages and disadvantages of partnership (L1).
- Name and explain the various kinds of partnership (L2).

- Explain the features of sole proprietorship (L2).
- Enumerate the advantages and disadvantages sole proprietorship (L2).

Lesson Schedule

1 **PREPARATION OF PROJECT**: Meaning of Project; Project Identification,
2 Project Selection; Project Report; Need and Significance of Report; Contents
3 formulation; Guidelines by Planning Commission for Project report; Network Analysis
4 Errors of Project Report; Project Appraisal. Identification of. Business Opportunities
5 Market Feasibility Study; Technical Feasibility Study
6 Financial Feasibility Study & Social Feasibility Study
7 **INDUSTRIAL OWNERSHIP**; Definition and meaning of Partnership
8 Characteristics of Partnership, Kinds of Partners, Partnership Agreement or Partnership Deed
9 Registration of Partnership Firm, Rights, Duties and Liabilities of Partners
10 Advantages and Disadvantages of Partnership, Sole proprietorship, Features
11 Scope Advantages and Disadvantages of Sole Proprietorship.

Review questions:

UNIT-1

1. Define management and planning (L1).
2. Explain the functions of management (L2)
3. Explain the scope of management (L2).
4. List the nature and characteristics of management (L1).
5. Differentiate between administration and management (L2).
6. List and explain the roles and levels of management (L1).
7. Describe management as an art or science, art or profession (L3).
8. Discuss in brief the nature of management (L2).
9. Explain early management approaches (L2).
10. Explain the modern management approaches (L2).
11. Explain the steps involved in planning (L2).
12. Explain the importance and purpose of planning process (L2).
13. List and explain the objectives of planning (L1).
14. Explain briefly the types of planning (L2).
15. Describe the process of decision making (L2).
16. Explain the steps in decision making (L2).
17. Explain briefly hierarchy of plans (L2).

UNIT-2

1. Explain the nature and purpose of organization (L2).
2. Describe the principles of organization (L2).
3. List the different types of organizations (L1).
4. Explain the different types of organization charts (L2).
5. List the advantages and disadvantages of line and staff organization (L1).
6. Explain the principles of committees (L2).
7. Enumerate the merits and demerits of centralization and decentralization (L2).
8. Explain the process of delegation and difficulties in delegation (L2).
9. Explain span of control (L2).
10. List management by objectives (MBO) and management by exception (MBE) (L1).
11. Differentiate between MBO and MBE (L2).
12. Describe the nature and importance of staffing (L2).
13. Explain the techniques of selection (L2).

14. Explain meaning and nature of directing (L2).
15. Describe principles of leadership (L2).
16. Describe about Maslow's theory of motivation (L2).
17. Define communication. Explain different systems of communication (L2).
18. Explain the importance of coordination (L2).

UNIT-3

1. Define controlling (L1).
2. Describe the steps in controlling (L2).
3. List the essentials of sound controlling (L1).
4. Define entrepreneurship and explain its model (L1).
5. Explain the evolution of concept of entrepreneurship (L2).
6. List the qualities and characteristics of entrepreneur (L1).
7. Explain the functions of entrepreneur (L2).
8. List out the types of entrepreneur (L1).
9. Explain the meaning and role of intrapreneur (L2).
10. Differentiate between entrepreneur, intrapreneur and manager (L3).
11. Explain the concept of entrepreneurship (L2).
12. Describe about evolution of entrepreneurship (L2).
13. Explain the development of entrepreneurship (L2).
14. List and explain the various stages of entrepreneurship processes (L2).
15. Explain the role of entrepreneur in economic development (L2).

UNIT-4

1. Define Small scale Industry, Ancillary Industry and Tiny Industries (L1).
2. List and explain the characteristics of SSIs (L2).
3. Explain need and rationale of SSIs (L2)
4. Explain the Scope and objectives of SSIs (L2).
5. Explain the role of SSI in economic development (L2).
6. List the advantages of SSIs (L1).
7. Explain the steps to start SSIs (L2).
8. Explain various Government policies towards SSIs (L2).
6. Describe briefly Government support to SSIs during 5 year plans (L2).
7. Explain the Impact of Liberalization, Privatization and Globalization on SSIs (L2).
8. Explain the functions of WTO and its impact on trade (L2).
9. Describe about GATT and list their advantages (L3).
10. List the various supporting agencies of government to SSIs (L1).
11. Discuss the necessity if institutional support to the SSIs (L2).
12. Explain the role of SSIDC in developing the small-scale industries (L2).
13. Explain the roles of DICs, IDBI/SIDBI (L2).
14. Explain the role of KSFC (L2).
15. Explain the role and help extended by SISIs in developing SSIs (L2).

UNIT-5

1. Classify and define the project (L1).
2. Explain the Phase of project Identification with its sources (L2).
3. Describe about selection of project (L2).
4. Explain the need and significance of project report (L2).
5. Describe project formulation process (L3).
6. Explain the contents of project report (L2).
7. List the guidelines of Planning Commission for project report (L2).
8. Explain network analysis. What are various techniques used for network analysis (L2).

9. Explain PERT. What are its advantages and disadvantages (L2).
10. Explain CPM.What is its advantages and disadvantages (L2).
11. List and explain common errors in project report (L1).
12. Explain the process of project appraisal (L2).
13. Describe about market feasibility, financial feasibility, technical feasibility and social feasibility studies (L3).
14. Explain the characteristics of partnership (L2).
15. List the advantages and disadvantages of partnership (L1).
16. Name and explain the various kinds of partnership (L2).
17. Explain the features of sole proprietorship (L2).
18. Enumerate the advantages and disadvantages sole proprietorship (L2).

Course Articulation Matrix

Course Outcome (CO)	**Program Outcome (ABET/NBA-(3a-k))**											
		a	b	c	d	e	f	g	h	i	j	k
Explain fundamental understanding of management, nature scope, and functions of a manager and development of management thought. Also explain planning and decision making processes.	L1, L2	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Explain the organizational structure, departmentation, staffing and leading processes.	L1, L2	**-**	**-**	**-**	**M**	**-**	**L**	**M**	**-**	**L**	**-**	**-**
Describe the conceptual understanding of motivation and different control systems in management	L1, L2	**-**			**M**	**-**	**L**	**M**	**-**	**L**	**-**	**-**
Understanding of Entrepreneurships and Entrepreneurship development process.	L1 ,L2	**-**	-	-	**M**	**-**	**L**	**M**	**-**	**L**	**-**	-
Illustrate Small Scale Industries, various types of supporting agencies and financing available for an entrepreneur.	L1, L2	**-**	**-**	**-**	**M**	**-**	**L**	**M**	**-**	**L**	**-**	**-**
Summarize the preparation of project report, need significance of report. Also to explain about industrial ownership.	L1, L2	**-**	**-**	**-**	**L**	**-**	**L**	**M**	**-**	**L**	**-**	**-**
L – Low, M – Moderate, H - High												

Course Assessment Matrix (CAM)

Course Outcome (CO)	**Program Outcome (ABET/NBA-(3a-k))**											
		a	b	c	d	e	f	g	h	i	j	k
Explain fundamental understanding of management, nature scope, and functions of a manager and development of management thought. Also explain planning and decision making processes.	L1, L2				**2**		**1**	**2**		**1**		
Explain the organizational structure, departmentation, staffing and leading processes.	L1, L2				**2**		**1**	**2**		**1**		
Describe the conceptual understanding of motivation and different control systems in management	L1, L2				**2**		**1**	**2**		**1**		
Understanding of Entrepreneurships and Entrepreneurship development process.	L1, L2				**2**		**1**	**2**		**1**		
Illustrate Small Scale Industries, various types of supporting agencies and financing available for an entrepreneur.	L1, L2				**1**		**1**	**2**		**1**		
Summarize the preparation of project report, need significance of report. Also to explain about industrial ownership.	L1, L2				**1**		**1**	**2**		**1**		
1 – Low, 2 – Moderate, 3 - High												

Course Title: DESIGN OF MACHINE ELEMENTS-I			
Course Code: P13AU52	Semester: 5	L:T:P:H- 3:2:0:5	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

Subject requires student to know about

Student should have the knowledge of the fundamentals of Engineering Mathematics, Engg physics, Mechanics of Materials, Engineering Drawing, Workshop Processes, Theory of Machines, Material Science and Fundamentals of Mechanical Engineering Design

Course Learning Objectives (CLOs)

This Course aims to:

a) Define and explain various terms connected to the design of machine elements-I like static strength, fatigue strength, Impact stresses, theories of failures, rigidity based design, factor of safety, and stress concentration etc.
b) Demonstrate how engineering design make use of the principles learnt in science courses and identify their practical applications.
c) Develop problem-solving skill in design of machine elements using appropriate assumptions and correct methodology.
d) Consider environmental impact of the design and take measures to avoid environmental deterioration.
e) Work on the given assignment and to get first hand information and also be able to present and submit a brief report.

Relevance of the course:

1. Get expertise in the selection of material for designing a particular machine element
2. Design machine element based on static and dynamic strengths.
3. Identify the type of joints required for a particular application and to design as per ASM standards

Course Content

Unit – 1

INTRODUCTION:

Basic design procedure, types of machine design, design consideration, codes and standards, stress – strain diagrams. Design against static loading, modes of failure, factor of safety, design of simple machine members subjected to static loading including eccentric load, limited to biaxial stresses (normal, shear, bending, torsional, crushing/bearing), principal stresses.

THEORIES OF FAILURE - Maximum normal stress theory, Maximum shear stress theory, Distortion energy theory.

IMPACT STRENGTH: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia. **10 Hrs**

Unit – 2

Design for fatigue strength: Stress concentration, Stress concentration factors, Reduction of Stress concentration, fluctuating stresses, fatigue and endurance limit, S-N Diagram, Low cycle & High cycle fatigue, notch sensitivity, endurance limit ,modifying factors; load, size and surface factors, Stress concentration effects; design for infinite life, combined steady and variable stress, Soderberg and Goodman relationship, stresses due to combined loading, cumulative fatigue damage.

Case studies:

a) Bicycle Brake Lever Loading and failure Analysis
b) Hand-Operated Crimping-Tool Loading and failure Analysis
c) Automobile Scissors-Jack Loading and failure Analysis
d) Bicycle Brake Arm Loading and Analysis. **10 Hrs**

Unit –3

Design of Cotter joint, Knuckle joint and Couplings: Design of Cotter and Knuckle joints , Design of keys, , flange coupling, Bush - Pin type coupling.

DESIGN OF SHAFTS: Transmission shaft, shaft design on strength and rigidity basis, ASME code for shaft design, Design of Hollow shaft. **12 Hrs**

Unit – 4

RIVETED JOINTS: Types of riveted joints, failures of riveted joints, efficiency, and boiler Joints, structural joints, eccentrically loaded riveted joints.

WELDED JOINTS: Types, Strength of butt and fillet joints, welds, eccentrically loaded welded joints. **10 Hrs**

Unit – 5

THREADED JOINTS: Introduction, basic terminology of screw threads, types of screw threads, types of screw fastenings, designations of screw threads, Stresses in threaded fasteners due to static loading, Effect of initial tension, threaded joints for cylinder covers, design of eccentrically loaded bolted joints

POWER SCREWS: Introduction, Types of screw threads used for power screws, Design of Power Screws, efficiency, self-locking and over hauling **10 Hrs**

Text Books:

1. T Krishna Rao, Design of Machine Elements –II, I K International Publishing house Pvt.Ltd., New Delhi, 2013
2. V.B.Bhandari – **Design of Machine Elements-I** – third edition, Tata McGraw Hill Education Private Limited, New Delhi, 2007

Reference books:

1. Machine Design: Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 2008
2. Joseph E Shigley and Charles R. Mischke., Mechanical Engineering Design McGraw Hill International edition, 2003.
3. Robert.L.Norton, Machine Design , An integrated Approach, Pearson Education Asia, 2001

Design Data Hand Book:

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

Note: All the Case studies are only for CIE Assessment purpose only

Course Outcomes (COs)

At the end of the course student will be able to:

i. **Explain** the importance of Standards in Design, Selection of materials as per CODES & STANDARDS Selection of preferred sizes and Concurrent Engineering.
ii. **Analyze** the various modes of failure of machine components under different static load conditions and use appropriate theories of failures to design machine components.
iii. **Compute** the dimensions of simple machine components by properly considering stress concentrations and fatigue / impact loads for both finite and infinite life.
iv. **Design** power transmission shafts carrying various combinations of gears and pulleys to ensure safe operation using ASME codes.
v. Design of permanent and temporary joints
vi. **Reinforce** the fundamentals of machine elements through case study.
vii. Selection of materials as per CODES & STANDARDS

Unit wise plan
UNIT-1

Topic Learning Objectives (TLO):

At the end of the Unit-I student should be able to:

- Define Machine Design. [L1]
- Distinguish between different engineering materials & their properties
- Materials Codes & Standards.
- Identify the elements of the design process. [L1]
- Use material properties data for strength, stiffness, and ductility in the analysis and design of achine elements to insure safe operation. [L2]
- Describe the basic procedure of Machine Design. [L1]
- Define and explain factory of safety [L1]]
- Design for static strength and evaluate design parameters such as deflection, stress & strains. .[L2]
- Stress Analysis of bi-axial, tri-axial loading[L2]
- Simple numerical problems involving the above.[L2]
- Evaluate loading and stress results using principal shear stress criterion. [L2]
- Identify the stresses acting on a surface and find principal stresses.[L1
- State and explain Maximum Principal Stress Theory, Maximum Shear Stress Theory and
- Distortion-Energy Theory. [L2]
- Compare the theories of failure and suggest their usage [L2, L3]
- Define Impact stresses. [L1]
- Design machine elements for impact strength &compare with static strength. .[L3]
- Solve the problems for impact type of loading of a machine component for a given data. [L3]

Lesson Schedule

1. **Introduction to machine design,** Basic design procedure, types of machine design, design consideration,
2. codes and standards, stress – strain diagrams.
3. Design against static loading, modes of failure, factor of safety,
4. design of simple machine members subjected to static loading including eccentric load,
5. limited to biaxial stresses (normal, shear, bending, torsional, crushing/bearing), principal stresses.
6. Theories of failures
7. Numerical on theories of failures
8. Numerical on theories of failures
9. Impact stresses due to axial, bending and torsional loads, effect of inertia10.Problems on Impact loading

UNIT – 2

Topic Learning Objectives(TLO)

At the end of the Unit 2, student will be able to:

- Know how to account for stress concentration in design of the machine parts [L2]
- Evaluate stress concentration factor and hence calculate the maximum stresses induced in the machine elements when subjected to various loading conditions[L3]
- Use different methods of reducing stress concentration in machine components. [L3
- Distinguish between fatigue strength and static strength.[L1]
- Define fluctuating, repeated and reversed stresses.[L1]

- S-N Diagrams, endurance limit, endurance strength and modifying factors
- Analyze and design a mechanical component for both steady and time-varying loads (cyclic fatigue), and account for the presence of stress raisers, surface finish, component size, type of load, environment and other factors [L4]
- Calculate stresses and loads involved with fatigue effect [L3]
- Create a Soderberg endurance failure line [L2]
- Calculate the endurance limit of a material with appropriate corrections. [L2]
- Differentiate Low and High cycle fatigue. [L2]
- Define fatigue stress concentration factor, notch sensitivity, and notch sensitivity factor. [L1]
- Calculate the endurance limit of a material with appropriate corrections. [L2]
- Fluctuating stresses, Goodman and Soderberg's equations. [L3]
- Stresses due to combined fatigue loading, cumulative fatigue damage. [L3]

Lesson Schedule

1. Stress concentration, Stress concentration factors, Reduction of Stress concentration
2. fluctuating stresses, fatigue and endurance limit, S-N Diagram
3. Low cycle & High cycle fatigue, notch sensitivity, endurance limit ,modifying factors; load, size and surface factors
4. Stress concentration effects; design for infinite life,
5. combined steady and variable stress, Soderberg and Goodman relationship,
6. stresses due to combined loading, cumulative fatigue damage
7. Numerical problems
8. Numerical problems
9. Numerical problems
10. Numerical problems

UNIT – 3:

Topic Learning Objectives(TLO)

At the end of Unit-III student should be able to:

- Define cotter and knuckle joints and their purpose in machine assembly. [L1]
- Demonstrate the procedure for cotter and knuckle joint. [L3]
- List different types of keys used in transmission of shaft. [L1]
- Determine hub and shaft key dimensions. [L3]
- Summarize the advantages and disadvantages of different types of keys. [L2]
- Illustrate the requirements of coupling in a machine element. [L2]
- Discuss different types of couplings and their applications[L2]
- Design and Sketch rigid type and Bushed-Pin flexible Coupling for a given data. [L4]
- List the advantages and disadvantages of bushed –pin flexible coupling. [L1]
- List different types of the shafts with their applications [L1]
- Design and Analyze transmission shafts subjected to torque, bending and axial loading. [L4]
- Use ASME code for shaft design [L1]
- Differentiate hollow shaft and solid shaft with respect to strength and stiffness [L3]

Lesson Schedule

1. Transmission Shafts, Shaft Design on Strength Basis, Shaft Design on Torsional rigidity Basis
2. ASME Code for shaft design and numerical problems
3. Numerical problems
4. Numerical problems
5. Design of Hollow Shaft on Strength and Torsional rigidity basis
6. Numerical problems

7. Keys, Sunk Key, Design of Square and flat keys.
8. Numerical Examples
9. Design of cotter joint
10. Design of Knuckle joint
11. Design of flange coupling and Bush-pin type coupling
12. Numerical Problems

UNIT – 4

Topic Learning Objectives (TLO)

At the end of Unit-IV student should be able to:

- Demonstrate different types of riveted joints. [L1]
- Discuss with aid of neat sketches, different failure modes of riveted joints. [L2]
- Evaluate the efficiency of riveted joints[L3]
- Design riveted joints for boilers as per IBR Act[L3]
- Describe the concept of eccentrically loaded riveted joints. [L2]
- Differentiate between parallel and transverse weld [L1]
- Design lap and butt welded joints [L3]
- Design the eccentrically loaded welded joints [L3]
- List different types of Butt joint. [L1]
- Write the expression for strength of transverse fillet weld in terms of permissible tensile stress, leg of weld and length of welded joint. [L2]
- Design, Welded Joint Subjected to Torsional moment, Welded Joint Subjected to Bending moment and Welded Joints Subjected to fluctuating Forces. [L3]

Lesson Schedule

1. Types of riveted joints, failures of riveted joints, efficiency
2. Numerical problems
3. Boiler Joints and Numerical problems
4. structural Joints and Numerical problems
5. Eccentrically loaded riveted joints.
6. Numerical problems
7. Types of welded joints, Strength of butt and fillet joints welds
8. Numerical problems
9. eccentrically loaded welded joints
10. Numerical problems

UNIT – 5

Topic Learning Objectives(TLO)

At the end of Unit-V student should be able to:

- Describe the applications of threaded fasteners. [L1]
- Explain the advantages & disadvantages of threaded screws. [L2]
- Evaluate different standard screw joints available in literature. [L3]
- Demonstrate the dimensions & designation of threaded screws. [L2]
- Describe the function of power screws[L1]
- Evaluate the design procedure of screw jack[L4]
- Explain application, advantages and disadvantages of power screws. [L1]
- Describe why square threads are preferred to V threads in power screws. [L2]
- Explain what the condition for self locking in power screws. [L3]
- Discuss application, advantages and disadvantages of recalculating ball screws. [L2]
- Design the Screw jack for a given lift and load. [L4]

Lesson Schedule

1. Introduction to threaded joints, basic terminology of screw threads, types of screw threads and screw fastenings, designations of screw threads
2. Stresses in threaded fasteners due to static loading, , Effect of initial tension, Numerical problems
3. Numerical problems
4. Threaded joints for cylinder covers, design of eccentrically loaded bolted joints
5. Numerical problems
6. Introduction to power screws, Types of screw threads used for power screws
7. Design of Power Screws, efficiency, self-locking and over hauling
8. Numerical problems
9. Numerical problems
10. Numerical problems

Review Questions

UNIT – 1

1. What are the steps in machine design process? [L2]
2. Distinguish between design synthesis and design analysis [L3]
3. What is standardization? [L2]
4. Draw the stress strain curve for mild steel and cast iron. Name the salient points. [L3]
5. Define Standardization. State the standards used in machine design. [L2]
6. Draw the stress strain diagrams for a ductile material and brittle material and show the salient points on them. [L3]
7. What are the important mechanical properties of metals? Explain each of them briefly.[L2, L3]
8. Design machine members subjected to axial tensile and compressive forces, bending moments, and torsion. [L4]
9. Evaluate loading and stress results using maximum distortion energy criterion. [L3]
10. Evaluate loading and stress results using principal shear stress criterion. [L3]
11. Identify the stresses acting on a surface and find principal stresses.[L3]
12. Apply three basic modes of failure of mechanical components to solve the engineering problems.[L3]
13. Define factor of safety. [L1]
14. Describe the necessary of using factor of safety. [L2]
15. State and explain Maximum Principal Stress Theory, Maximum Shear Stress Theory and Distortion-Energy Theory. [L2]
16. A rod of circular section is to sustain a torsional moment of 300 kN-m and bending moment of 200 kN-m. Selecting C45 steel (σ_y = 353 MPa) and assuming factor of safety = 3, determine the diameter of rod as per the following theories of failure. (i) Maximum shear stress theory ii) Distortion energy theory
17. Derive an expression for stress induced in a rod due to the axial impact of a weight W dropped from a height h on to a collar attached at the free end of the rod. What is the stress due to suddenly applied load? [L3]
18. A 500N weight drops through a height of 25mm and impacts the center of 300mm long simply supported square steel beam. If the maximum allowable bending stress is 90MPa, find the dimensions of the beam and the maximum deflection. Neglect the inertia effects and take E = 200GPa. [L3]

UNIT – 2

1. Compare the theories of failure and suggest their usage [L2, L3]
2. A plate of C45 steel is subjected to the following stresses, σ_x=150 MPa, σ_y=150 Mpa and τ_{xy}=50 Mpa. Find the factor of safety by Maximum Principal Stress Theory, Maximum Shear Stress Theory, and Distortion-Energy Theory. [L4]
3. Write the following theories of failure. When they are used? A) Maximum normal stress theory, b) Maximum shear stress theory, c) Distortion energy theory. [L4]

4. What is stress concentration? Give two examples. Show how the stress concentration can be minimized in these cases.[L2, L3]
5. A bolt is subjected to a direct tensile load of 20kN and a shear load of 15kN. Suggest a suitable size of the bolt according to: a) Maximum normal stress theory, b) Maximum shear stress theory, c) Distortion energy theory, if the yield stress in simple tension is 360MPa. A factor of safety of 3 should be used. [L4]
6. A cold drawn steel rod of circular cross-section is subjected to a variable bending moment of 565Nm to 1130Nm as the axial load varies from 4500N to 13500N The maximum bending moment occurs at the same instant that the axial load is maximum. Determine the required diameter of the rod for a factor of safety 2. Neglect any stress concentration and column effect. Take σu= 550MPa, σy = 470MPa, endurance limit as 50% of the ultimate strength and size, load and surface correction coefficients as 0.85, 1 and 0.85 respectively. [L5]
7. Explain briefly: i. Low cycle fatigue, ii. High cycle fatigue, iii. Endurance limit. [L3]
8. The work cycle of a mechanical component subjected to completely reversed bending stresses consists of the following three elements: i. ± 300N/mm^2 for 85 % of time, ii. ± 400N/mm^2 for 12 % of time and iii. ± 500N/mm^2 for 3 % of time. The material for the component is 50C4 (σ_{ut}=660N/mm^2) and the corrected endurance strength of the component is 250N/mm^2. Determine the life of the component. [L3]
9. Derive the Soderberg relation. [L3]
10. Define fluctuating, repeated and reversed stresses [L1]
11. Define fatigue stress concentration factor, notch sensitivity, and notch sensitivity factor. [L2]
12. A shaft of circular cross section of diameter 1.5d is stepped down to diameter 'd' with a fillet produces an stress concentration factor [K_f] of 1.22. The shaft is subjected to torsion. The material has a yield point stress as 336 MPa and endurance strength as 375 MPa. Determine the size of the shaft required for a torque, which varies from 0 to 2.26 kN-m. Use FOS = 2.0. Take B = C = 0.85, q = 0.9
13. A shaft is stepped from 1.5d to d with a fillet which produces a theoretical stress concentration factor of 1.22 for the shaft in torsion. The material has an yield point in shear as 336 MPa and endurance limit as 375 MPa. Determine the size of the shaft required for a torque which varies from 0 to 2.26 kN-m. Use FOS = 2.0, Size Factor = 0.85, Surface finish factor = 0.85 and q = 0.9

UNIT – 3

1. Enumerate the applications of cotter and knuckle joints[L2]
2. Design a cotter joint to connect two mild steel rods for a pull of 30kN. The maximum permissible stresses are 55MPa in tension, 40MPain shear, and 70MPa in crushing. Draw a neat sketch of the joint designed.[L4]
3. Design a Knuckle Joint for a rod of circular section to sustain a maximum pull of 70 kN. The ultimate strength of the material of the rod against tearing is 420 MPa. The ultimate strength and shearing strength of the pin material are 510 MPa and 396 MPa respectively. Take FOS = 6[L4]
4. Discuss the design procedure for spigot and socket cotter joint[L2]
5. Describe the function of a coupling. Give at least 5 practical applications,[L2]
6. What are flexible couplings? List their applications.[L2,L3]
7. Design a cast iron rigid flange coupling for a steel shaft transmitting 15 kW of power at 200 rpm and having an allowable shear stress of 40 N/mm^2. The working stress in the bolts should not exceed 30 N/mm^2. Assume that the crushing stress is twice the value of shear stress. The maximum torque is 25% greater than the mean torque. [L4]
8. Design a rigid flange coupling to transmit a power of 40kW at a rated speed of 1000rpm.[L4]
9. Summarize the advantages and disadvantages of different types of keys. [L3]
10. A bush pin type flexible coupling has four pins of size M16 made of steel having allowable shear stress of 60MPa. The outside diameter and length of rubber bush on the pin are 38mm and 45mm respectively. The pins are located on a pitch circle of diameter 200mm. The allowable

bearing pressure in the rubber bush is 1.0MPa. If the coupling rotates 900rpm, calculate the power that can be transmitted. Check whether the size of pin is acceptable for the power transmitted. [L4]

11. Design a flexible flanged coupling to transmit a power of 50kW at a rated speed of 500rpm. [L4]
12. List different types of the shafts with their applications [L1]
13. Derive an expression for power transmitted by a solid shaft[L3]
14. Compare the power transmitted by a solid shaft and a hollow shaft[L3]
15. Explain torsional rigidity & write the expression for the same.[L2,L3}
16. Explain the basis of ASME & BIS Code for shafting.[L2}
17. A shaft is supported on bearings A and B, 800mm between centers. A 20^0 straight tooth spur gear having 600mm pitch diameter is located 20mm to the right of the left hand bearing A and a 700mm diameter pulley is mounted 250mm towards the left of bearing B. The gear is driven by a pinion with a downward tangential force while the pulley drives a horizontal belt having 180^0 angle of wrap. The pulley also serves as a flywheel and weighs 2000N. The belt is 150mm wide and 8mm thick and has a tension ratio of 3:1.The allowable tensile stress in the belt material is $1.75N/mm^2$. Determine the necessary shaft diameter if the allowable shear stress of the material is $42N/mm^2$. Assume C_m=2.0 and C_t=1.5 [L4]
18. A steel shaft with σ_y = 309.9 MPa, 1.5 m long between bearings carries a 1kN pulley at its midpoint. The pulley is keyed to the shaft and receives 20kW power at 200 rpm. The belt drive is horizontal and ratio of belt tensions is 3:1. The diameter of pulley is 600mm. Calculate the necessary shaft diameter. Take C_m = 1.75; C_t = 1.25 and FOS = 2.0 Draw Bending Moment diagrams.[L3]
19. A section of commercial shaft 2m long between bearings carries a 900 N pulley at its midpoint. The shaft transmits 21kW at 300 rpm. The belt drive is horizontal. The sum of tensions is 6kN. Find suitable diameter of shaft and angle of twist between the bearings. Assume the allowable tensile stress for the material of the shaft to be 80 MPa and take G = 80GPa.[L3]
20. Design a shaft to transmit power from an electric motor to a lathe head stock through a pulley by means of a belt drive. The pulley weighs 200N and is located at 300 mm from the center of the bearing. The diameter of the pulley is 200 mm and the maximum power transmitted is 1kW at 120 rpm. The angle of lap of the belt is 180° and coefficient of friction between the belt and the pulley is 0.3. The shock and fatigue factors may be taken as 1.5 and 2.0 respectively. The allowable shear stress in the shaft may be taken as $35 N/mm^2$[L4]
21. Compare the weight, strength and stiffness of a hollow shaft of the same external diameter as that of a solid shaft. The inside diameter of the hollow shaft being half the external diameter. Both shafts have the same material and length. [L4]

UNIT – 4

1. Define riveted joint. Explain its necessity?[L1,L2]
2. Explain with aid of neat sketches the different failure modes of riveted joints.[L2]
3. Explain the procedure for design boiler joints.[L2]
4. What are eccentrically loaded riveted joints? .[L2]
5. Design a double riveted single cover butt joint with zigzag riveting to connect two plates of 16mm thick. The allowable stresses for plates and rivets are 100 MPa in tension, 72 MPa in shear and 160 MPa in crushing[L4]
6. Design a double riveted double cover butt joint with unequal cover plates and zigzag riveting to connect two plates of 25mm thick. Assume the following, [L4]

   σ_t = 115 MPa

   τ = 70 MPa

σ_c = 140 MPa

7. Design a double riveted double strap butt joint for the longitudinal seam of a boiler of diameter 1.3m with a stream pressure of 2.4MPa. The working stresses to be used are 77 MPa in tension, 54 MPa in shear and 120 MPa in crushing. Assume the joint efficiency to be 81%.[L4}
8. What do you understand by the term welded joints? Bring out the differences between riveted and welded joints.[L2,L3]
9. List out the advantages of welded joints over riveted joints[L2]
10. A plate of 80mm wide and 15mm thick is joined with another plate by a single transverse weld and a double parallel weld. Determine the length of parallel fillet weld if the joint is subjected to both static and fatigue loading. Take σ_t=90 MPa; τ = 55 MPa as the allowable stresses and stress concentration factor as 1.5 for transverse and 2.7 for parallel weld. [L3]

11. Determine the weld size for a welded joint as shown in Fig 1. [L3]

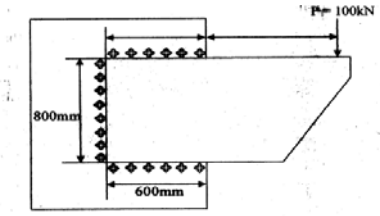


Fig 1

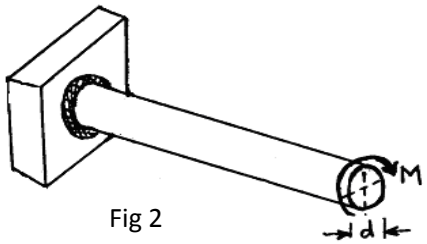


Fig 2

12. List different types of Butt joint. [L2]
13. A Circular shaft, 50mm in diameter, is welded to the support by means of circumferential fillet weld, as shown in Fig. 2. It is subjected to torsional moment of 2500 N-m. Determine the size of the weld, if the permissible shear stress in the weld is limited to 140 MPa [L3}

UNIT – 5

1. What are the stresses in threaded fasteners?[L2]
2. Derive an expression for the maximum shear stress induced in threaded fasteners.[L3]
3. Explain the separation of a joint when it is subjected to tensile force.[L2]
4. Explain the effect of compressive load in bolt joints.[L2]
5. What are the different application of eccentric loading on bolted connection with respect to the axis of the bolts and the direction of load?[L3}
6. Two members are connected by a bolt whose stiffness is equal to the bolted members. If the initial tension in the bolt is 60kN [L3]
    a) What is the external load that has to be applied to the bolt to cause separation of the bolted members?
    b) What is the resultant load for an external load of 70kN?
    c) What is the resultant load for an external load of 150 kN?

7. A bolted assembly is subjected to an external force that varies from 0 to 10kN. The combined stiffness of the parts, held together by the bolt, is three times the stiffness of the bolt. The bolt is initially so tight that at 50% overload condition, the parts held together by the bolt are just about to separate. The bolt is made of plain carbon steel 50C4 (σ_{ut}=660 MPa and (σ_{yt}=460 MPa). The fatigue stress concentration factor is 2.2 and the expected reliability is 90%. The factor of safety is 2. Determine the size of the bolt with fine threads. [L3]
8. Explain the method of determining the size of the bolt when the bracket carries an eccentric load perpendicular to the axis of the bolt. [L2]
9. Brackets are fixed on a steel column as shown in Fig 3 for supporting a traveling crane in a workshop. The maximum load that comes on the bracket is 12kN acting vertically at a distance of 400mm from

the face of the column. The vertical face of the bracket is secured to the column by four bolts in two rows (two in each row) at a distance of 50mm from the lower edge of the bracket. Determine the size of the bolts if the permissible value of the tensile stress for the bolt material is 84N/mm^2. Also, find the cross section of the arm of the bracket, which is rectangular. Assume depth of the arm of the bracket b = 250mm. [L3]

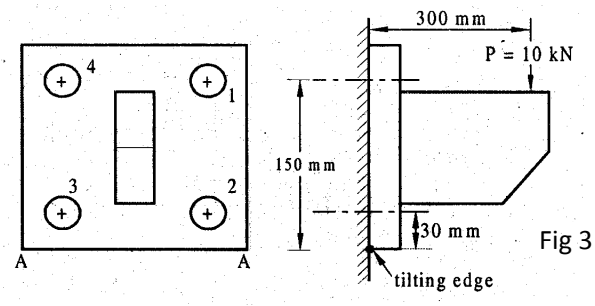


Fig 3

10. Explain application, advantages and disadvantages of power screws [L1]
11. Why square threads are preferred to V threads in power screws. [L2]
12. Show that the efficiency of self-locking screw is less than 50%. [L3]
13. What are the advantages and disadvantages of threaded joints over other fasteners? [L2]
14. A triple – threaded power screw is used in a screw jack, has a nominal diameter of 50 mm and a pitch of 8 mm. The threads are square shape and the length of the nut is 48 mm. The screw jack is used to lift a load of 7.5kN. The coefficient of friction at the threads is 0.12 and the collar friction is negligible. Calculate: i) the principal shear stresses in the screw rod ii) the transverse shear stresses in the screw and nuts iii) the unit bearing pressure for threads and iv) state whether the screw is self locking [L5]

Course Articulation Matrix (CAM)

Course Outcomes (CO's)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
Explain the importance of Standards in Design, Selection of materials as per CODES & STANDARDS Selection of preferred sizes and Concurrent Engineering	L3	M				M						
Analyze the various modes of failure of machine components under different static load conditions and use appropriate theories of failures to design machine components.	L3	M				M						
Compute the dimensions of simple machine components by properly considering stress concentrations and fatigue / impact loads for both finite and infinite life.	L3, L4	M				M						
Design power transmission shafts carrying various combinations of gears and pulleys to ensure safe operation using ASME codes.	L3	M				M						
Design of permanent and temporary joints	L3, L4	M				M						
Reinforce the fundamentals of machine elements through case study.	L4	H						M				
L – Low, M – Moderate, H - High												

Course Assessment Matrix (CAM)

Course Outcomes (CO's)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
Explain the importance of Standards in Design, Selection of materials as per CODES & STANDARDS Selection of preferred sizes and Concurrent Engineering	L3, L4	2				2						
Analyze the various modes of failure of machine components under different static load conditions and use appropriate theories of failures to design machine components.	L3, L4	2				2						
Compute the dimensions of simple machine components by properly considering stress concentrations and fatigue / impact loads for both finite and infinite life.	L3, L4	2				2						
Design power transmission shafts carrying various combinations of gears and pulleys to ensure safe operation using ASME codes.	L3, L4	2				2						
Design of permanent and temporary joints.	L3, L4	2				2						
Reinforce the fundamentals of machine elements through case study.	L3	3										
1 – Low, 2 – Moderate, 3 – High												

Course Title: HEAT TRANSFER			
Course Code: **P13AU53**	Semester: 5	L:T:P:H- 4:0:0:4	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

This subject requires the student to know about the basics of engineering mathematics, basic laws of physics, thermodynamics and fluid mechanic

Course Learning Objectives (CLOs)

This Course aims to

At the end of the course student will be able to

- Demonstrate and understanding of fundamental principles and laws of conduction, convection, and radiation modes of heat transfer.
- Formulate, solve and analyze one dimensional steady state heat transfer,
- Formulate, solve and analyze one dimensional un steady state heat transfer
- Formulate, solve and analyze one dimensional extended surfaces
- Formulate, solve and analyze one dimensional critical thickness of insulation
- Formulate, solve and analyze one dimensional forced convection heat transfer problems
- Formulate, solve and analyze one dimensional free convection heat transfer problems
- Formulate, solve and analyze one dimensional application like flow over flat plate etc.
- Understanding of basic principle of heat exchanger analysis and thermal design
- Apply laws of radiation heat transfer to solve engineering problems
- Demonstrate application of knowledge to related problems in an automobile.

Course Content

Unit-1

1.Introductory concepts and definitions: - Modes of heat transfer; Basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity; convective heat transfer coefficient; Radiation heat transfer coefficient; combined heat transfer mechanism. Conduction - Basic Equations: - General form of one dimensional heat conduction equation in rectangular, cylindrical and spherical coordinates. Discussion (no derivation) on three dimensional conduction in rectangular, cylindrical and spherical coordinate systems. Boundary conditions of first, second and third kinds; Illustrative problems on mathematical formulation of conduction problems. **9 Hrs**

Unit-2

One-dimensional Steady state conduction:- Steady state conduction in a slab, in a cylinder and in a sphere without and with heat generation; overall heat transfer coefficient for a composite medium; thermal contact resistance; critical thickness of insulation; Steady state conduction in fins of uniform cross section long fin, fin with insulated tip and fin with convection at the tip; fin efficiency; conduction in solids with variable thermal conductivity**.** **11 Hrs**

Unit-3

One-dimensional Transient conduction :- Conduction in solids with negligible internal temperature tradients (Lumped system analysis); Use of Transient Temperature charts (Jeisler ‘s Charts) for transient conduction in slab, long cylinder and sphere; Use of transient temperature charts for transient conduction in semi infinite solids. Forced Convection :- Application of dimensional analysis for forced convection problems. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydrodynamically and thermally developed flows; use of correlations for flow over a flat plate, over a cylinder and across a tube bundle. **11 Hrs**

Unit-4

Free or Natural convection :- Application of dimensional analysis for free convection-physical significance of Grashoff number; Use of correlations for free convection from or to vertical, horizontal and inclined flat plates, vertical and horizontal cylinders. Heat Exchangers: - Classification of heat exchangers; overall heat transfer coefficient, Fouling and fouling factor; LMTD and NTU methods of analysis of heat exchangers. **10 Hrs**

Unit-5

Radiation Heat Transfer :- Thermal radiation; Definitions of various terms used in radiation heat transfer; Stefan-Boltzman law, Kirchoff's law, Planck's Law and Wein's displacement law' Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces; Effect of radiation shield; Intensity of radiation and solid angle; Lambert's Law; Radiation heat exchange between two finite surfaces **.** **10hrs**

TEXT BOOKS:

1) P.K. Nag, Heat Transfer by Tata Mc Graw Hill 2002
2) M Necats Osisik , Heat Transfer- A Basic approach by Mc Graw Hill International ed 1988

REFERENCE BOOKS:

1) Yunus A Cengel, Heat transfer a practical approaches by Tata Mc Graw Hill 2002.
2) Kreith Thomas, Principles of Heat Transfer by learning 2001.
3) Frank. P. Incropera and David. P, Fundamentals of Heat and Mass Transfer by Dewitt Jhon wiley and Sons 4th ed 1995.
4) Sucec, Heat Transfer by Jaico Book house 2002.
5) Jojo, Heat transfer Jaico Book house 2003**.**

Course Outcomes (Cos)

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

1. **Understand** and **formulate** to solve problems in fundamentals of three heat transfer modes using basic material properties: thermal conductivity, heat capacity and thermal diffusivity
2. **Understand** and **apply** basics of heat conduction: steady and unsteady, one-dimensional conduction, with special applications to extended surfaces with fin design in mind.
3. **Understand** and **apply** concepts of convection heat transfer with both analytical and empirical approaches.
4. **Understand** and **demonstrate** about the application of heat exchangers
5. **Understand** and **demonstrate** fundamentals of radiation heat transfer: explaining concepts and application to radiations in daily life.

Unit wise Plan

Unit -1:

Topic Learning objectives: At the end of the unit-1 student will be able to

- Identify the different modes of heat transfer
- Define thermal conductivity, thermal resistance, convective heat transfer coefficient.
- Describe the basic laws governing the modes of heat transfer.
- Formulate the general one dimensional heat conduction equation in Cartesian coordinate, cylindrical coordinate, and spherical coordinate
- Understand boundary condition and application in various problems.
- formulate the general three dimensional heat conduction equation in Cartesian coordinate, cylindrical coordinate, and spherical coordinate
- numerical problems

Lesson Schedule

1. Modes of heat transfer ; Basic laws governing conduction, convection, and radiation heat transfer;
2. Thermal conductivity; convective heat transfer coefficient; Radiation heat transfer coefficient; combined heat transfer mechanism.
3. Conduction - Basic Equations :- General form of one dimensional heat conduction equation in rectangular,
4. cylindrical coordinates and spherical coordinates.
5. Discussion (no derivation) on three dimensional conduction in rectangular, cylindrical and spherical coordinate systems.
6. Boundary conditions of first, second and third kinds;
7. Illustrative problems on mathematical formulation of conduction problems.
8. numerical.

Unit -2:

Topic Learning objectives: At the end of the unit-2 student will be able to

- Study and formulation of equations for steady state heat conduction in slab, cylinder and sphere.
- Study and formulation of equations for steady state heat conduction in composite slab, composite cylinder and composite sphere
- Analyze and solve problems with contact resistance
- Calculate the rate of heat transfer through slab, cylinder and sphere
- Calculate the rate of heat transfer through composite slab, composite cylinder and composite sphere.
- Explain the fin performance by considering fin efficiency and effectiveness
- Describe the critical thickness of insulation for the tube.
- Calculate the critical thickness of insulation for the tube
- Explain the effect of extended surface on heat transfer
- Calculate the effect of extended surface on heat transfer for different boundary conditions
- Numerical problems

Lesson Schedule

1. Steady state conduction in a slab,
2. in a cylinder
3. and in a sphere without and with heat generation;
4. overall heat transfer coefficient for a composite medium;
5. thermal contact resistance;
6. critical thickness of insulation;
7. Steady state conduction in fins of uniform cross section long fin,
8. fin with insulated tip and fin with convection at the tip;
9. Fin efficiency; conduction in solids with variable thermal conductivity**.**
10. Numerical.
11. Numerical

Unit -3:

Topic Learning objectives: At the end of the unit-3 student will be able to

- Study and formulation of equations for unsteady state heat conduction (lumped system analysis)
- Study of Transient Temperature charts
- Use of Transient Temperature charts for solving problems
- Application of dimensional analysis for forced convection problems
- Understanding Physical significance of non dimensional numbers
- Understand ,Formulate, solve and analyze various correlations for hydro dynamically and thermally developed flows

- Applications like Flow over flat plate, cylinder etc
- Numerical problems

Lesson Schedule

1. Conduction in solids with negligible internal temperature tradients (Lumped system analysis);
2. Use of Transient Temperature charts (Jeisler ‘s Charts) for transient conduction in slab,
3. long cylinder
4. sphere;
5. Use of transient temperature charts for transient conduction in semi infinite solids.
6. Application of dimensional analysis for forced convection problems.
7. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers.
8. Use of various correlations for hydro dynamically and thermally developed flows;
9. use of correlations for flow over a flat plate,
10. over a cylinder
11. across a tube bundle.
12. numerical

Unit-4:

Topic Learning objectives: At the end of the unit-4 student will be able to

- Application of dimensional analysis for free convection problems(LI)
- Explain the mechanism of heat transfer by natural convection(LI)
- Understanding Physical significance of non dimensional numbers (LI)
- Understand ,Formulate, solve and analyze various correlations for hydro dynamically and thermally developed flows(L3)
- Applications like Flow over flat plate, cylinder etc(L3)
- Classify the heat exchanger on the basis of nature of heat exchange process, direction of fluid motion, design and constructional features.(L3)
- Develop an expression for LMTD in case of parallel flow heat exchanger and counter flow heat exchanger(L3)
- Calculate overall heat transfer coefficient(L3)
- Calculate heat transfer area of a heat exchanger(L3)
- Calculate effectiveness of a heat exchanger(L3)
- Numerical problems,(L3)

Lesson Schedule

1. Application of dimensional analysis for free convection-
2. physical significance of Grashoff number;
3. Use of correlations for free convection from or to vertical,
4. horizontal and inclined flat plates, vertical and horizontal cylinders.
5. Heat Exchangers :- Classification of heat exchangers; ,
6. Fouling and fouling factor;
7. LMTD
8. NTU methods of analysis of heat exchangers.
9. numerical

Unit 5 :

Topic Learning objectives: At the end of the unit-5 student will be able to

- Meaning of absorptivity, reflectivity, and transmissivity (L1)
- Define total emissive power and monochromatic emissive power of a body(L1)
- Distinguish between grey body and black body(L2)
- Interpret Stefan-Boltzmann law(L2)
- Explain Kirchoff’slaw and planck’s law(L2)

- Calculate total emissive power of the SUN(L3)

Lesson Schedule

1. introduction, Thermal radiation;
2. Definitions of various terms used in radiation heat transfer;
3. Stefan-Boltzman law, Kirchoff's law,
4. Planck's Law and Wein's displacement law'
5. Radiation heat exchange between two parallel infinite black surfaces,
6. between two parallel,
7. infinite gray surfaces;
8. intensity of radiation and solid angle,
9. Lambert's cosine law,
10. numerical problems,

Review Questions:

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

Course Articulation Matrix (CAM)

Course Outcome (CO)	Program Outcome (ABET/NBA-(3a-k))											
	a	b	c	d	e	f	g	h	i	j	k
understand and **formulate** to solve problems in fundamentals of three heat transfer modes using basic material properties: thermal conductivity, heat capacity and thermal diffusivity	**M**	**L**		**L**							
Understand and **apply** basics of heat conduction: steady and unsteady, one-dimensional conduction, with special applications to extended surfaces with fin design in mind.	**H**	**M**		**L**							
Understand and **apply** concepts of convection heat transfer with both analytical and empirical approaches.	**H**	**M**		**L**							
understand and **demonstrate** about the application of heat exchangers	**H**	**M**		**L**							
Understand and **demonstrate** fundamentals of radiation heat transfer: explaining concepts and application to radiations in daily life.	**H**	**M**		**L**							
L – Low, M – Moderate, H - High											

Course Assessment Matrix (CAM)

Course Outcome (CO)	Program Outcome (ABET/NBA-(3a-k))										
	a	b	c	d	e	f	g	h	i	j	k
understand and **formulate** to solve problems in fundamentals of three heat transfer modes using basic material properties: thermal conductivity, heat capacity and thermal diffusivity	**2**	**1**		**1**							
understand and **apply** basics of heat conduction: steady and unsteady, one-dimensional conduction, with special applications to extended surfaces with fin design in mind.	**3**	**2**		**1**							
understand and **apply** concepts of convection heat transfer with both analytical and empirical approaches.	**3**	**2**		**1**							
understand and **demonstrate** about the application of heat exchangers	**3**	**2**		**1**							
understand and **demonstrate** fundamentals of radiation heat transfer: explaining concepts and application to radiations in daily life.	**3**	**2**		**1**							
1 – Low, 2 – Moderate, 3 – High											

Course Title: **THEORY OF MACHINES-II**			
Course Code: **P13AU54**	Semester: 5	L:T:P:H- 3:2:0:5	Credits:4
50 Total Contact Hours: 52		Contact period : Lecture: 52 Hrs., Exam 3 Hrs.	

Prerequisites:

Subject requires students to know about

- Basics of Engineering Mathematics
- Engineering Mechanics
- Theory of Machine-I

Course Learning Objectives (CLOs)

This Course aims to

1. Explain equilibrium of forces and calculate static forces at various points in different types of mechanism(L3,L2)
2. Identify, describe inertia force in a link and calculate fluctuation of energy in flywheel(L1, L2,L3)
3. Explain method of balancing of rotating masses and to solve analytically and graphically to balance the systems(L2,L3)
4. Explain method of balancing of reciprocating masses in internal combustion engine, V engine, radial engine and to solve analytically and graphically to balance the systems(L2,L3)
5. Describe the various types of governors and to understand method of finding controlling force
    - Describe gyroscopic couple and to understand effect of gyroscopic couple(L1,L2)

Relevance of the Course

Theory of Machine is a fundamental course in B.E(Mechanical and Automobile Engineering) programme that helps in understanding various mechanisms and various forces transmitted from one link to other.

Course Content

UNIT – 1:

Static force Analysis: Equilibrium of two force, three force and four force members, Members with two forces and couple, Free body diagrams, Static force analysis of single slider-crank mechanism, Quick return motion mechanism, four link mechanism, rivets mechanism, effect of sliding friction, friction in pin joints. **10 Hrs**

UNIT – 2:

Dynamic/Inertia force Analysis: Introduction, D'Alembert's principle, Inertia force, inertia torque, dynamically equivalent systems, correction couple, line of action of inertia force in a link, inertia force analysis (graphical) of a four bar mechanism, inertia force analysis (analytical) of slider crank mechanism [(i) neglecting the mass of the connecting rod; (ii) considering the mass of the connecting rod].

Flywheels: Introduction, Turning moment diagrams, Fluctuation of Energy and speed, energy stored in a flywheel, determination of size of flywheels. **10 Hrs**

UNIT – 3:

Balancing of rotating masses: Introduction, Static and dynamic balancing, balancing of single revolving mass by balancing masses in same plane and in different planes, Balancing of several masses revolving in the same plane, balancing of several masses revolving in different planes. **10 Hrs**

UNIT – 4:

Balancing of reciprocating masses: Introduction, acceleration of the reciprocating mass of a slider crank mechanism, primary balancing, secondary balancing, Inertia effect of crank and connecting rod, balancing of single cylinder engine, balancing of multi cylinder-inline engine, balancing of radial engines, balancing of V – engines. **10 Hrs**

UNIT – 5:

Governors: Introduction, Types of governors; force analysis of Porter and Hartnell governors. Controlling force, stability, condition for stability, sensitiveness, isochronisms, hunting, effort and power of governor.

Gyroscopes: Introduction, Vectorial representation of angular motion, gyroscopic couple, effect of gyroscopic couple on bearings, aircraft, ship, two wheelers and four wheelers. **12 Hrs**

TEXT BOOKS:

1. Theory of Machines: V.P. Singh, Dhanpat Rai & Co., 2012
2. Theory of Machines: Rattan S.S. Tata McGraw Hill Publishing Company Ltd., 2012

REFERENCE BOOKS:

1. Theory Of Machines And Mechanisms by Joseph E. Shigley, Jr. Uicker John, McGraw- hill publications., 2011
2. Kinematics & Dynamics of Machinery by R L. Norton, Tata - McGraw Hill., 2010
3. Theory of Machines by R.S.Khurmi and J.K.Gupta, S.Chand and Co., 2011
4. Theory of Machines by P.L. Ballaney, Khanna Publishers.2011

Course Outcomes (Cos):

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

1. Explain equilibrium of forces and calculate static forces at various points in different types of mechanism(L3,L2)
2. Identify, describe inertia force in a link and calculate fluctuation of energy in flywheel(L1, L2,L3)
3. Explain method of balancing of rotating masses and to solve analytically and graphically to balance the systems(L2,L3)
4. Explain method of balancing of reciprocating masses in internal combustion engine, V engine, radial engine and to solve analytically and graphically to balance the systems(L2,L3)
5. Describe the various types of governors and to understand method of finding controlling force
    - Describe gyroscopic couple and to understand effect of gyroscopic couple(L1,L2)

Unitwise Plan

UNIT-I:

Topic Learning objectives -

After learning the contents of Unit-1, the student is able to identify, explain and calculate

- Various forces comes on mechanism
- Condition for equilibrium of two force member, three force member, Four force member and two force and a couple member
- Free body diagram
- Law of super position
- Static force analysis in a mechanism
- Effect of frictional force
- Solve different mechanism for static force

Lesson Schedule

1. Introduction to various forces comes on to mechanism
2. Conditions for equilibrium, free body diagram, law of super position
3. Method of static force analysis
4. Static force analysis of four bar chain (with one and two forces)
5. Static force analysis of four bar chain (with forces and movements)
6. Static force analysis of single slider crank chain(with one and two forces)
7. Static force analysis of single slider crank chain (with forces and movements)

8. Static force analysis of quick return motion mechanism
9. Static force analysis by considering frictional force
10. Static force analysis by considering frictional force

UNIT-II:

Topic Learning objectives -

After learning the contents of Unit-II, the student is able to identify, explain and calculate

- Dynamic forces comes on mechanism
- D'Alembert's principle
- Inertia force
- inertia torque
- dynamically equivalent systems
- correction couple
- line of action of inertia force in a link
- inertia force analysis (graphical) of a four bar mechanism
- inertia force analysis (analytical) of slider crank mechanism
- function of a fly wheel
- turning movement diagram
- Fluctuation of Energy and speed, energy stored in a flywheel
- determination of size of flywheels

Lesson Schedule

1. Introduction, D'Alembert's principle, inertia force, inertia torque
2. dynamically equivalent systems, line of fraction of inertia force
3. inertia force analysis (analytical) of slider crank mechanism
4. (i) neglecting the mass of the connecting rod; (ii) considering the mass of the connecting rod.
5. Numerical problems
6. Function of a flywheel, turning movement diagram
7. Fluctuation of Energy and speed, energy stored in a flywheel
8. determination of size of flywheels
9. solving the numerical problems
10. solving the numerical problems

UNIT-III:

Topic Learning objectives -

After learning the contents of Unit-III, the student is able to identify, explain and calculate

- Centrifugal force
- Reasons for unbalanced forces in rotating members
- Static balancing and dynamic balancing
- Balancing of masses rotating in a same plane(analytical and graphical method)
- Balancing of masses rotating in different planes (analytical and graphical method)

Lesson Schedule

1. Introduction, Centrifugal force, reasons for unbalanced forces in rotating members
2. Static balancing and dynamic balancing
3. Method of Balancing of masses rotating in a same plane(analytical method)
4. Method of Balancing of masses rotating in a same plane(graphical method)
5. Method of Balancing of masses rotating in different planes (analytical method)
6. Method of Balancing of masses rotating in different planes (graphical method)
7. Solving numerical problems analytically
8. Practice of graphical method in drawing hall
9. Practice of graphical method in drawing hall
10. Practice of graphical method in drawing hall

UNIT-IV

Topic Learning objectives -

After learning the contents of Unit-IV, the student is able to identify, explain and calculate

- Unbalanced forces in reciprocating masses
- primary balancing and secondary balancing
- partial balancing of Unbalanced forces in reciprocating masses
- Unbalanced forces in single cylinder engine
- Unbalanced forces in multi cylinder-inline engine
- Method of balancing multi cylinder-inline engine
- balancing of radial engines (reverse crank method)
- balancing of V – engines

Lesson Schedule

1. Introduction, acceleration of the reciprocating mass of a slider crank mechanism,
2. Partial balancing of reciprocating masses
3. Unbalanced forces in single cylinder engine
4. Unbalanced forces and movements in multi cylinder-inline engine
5. Method of balancing multi cylinder-inline engine
6. Practice of graphical Method of balancing multi cylinder-inline engine in drawing hall
7. Practice of graphical Method of balancing multi cylinder-inline engine in drawing hall
8. Practice of graphical Method of balancing multi cylinder-inline engine in drawing hall
9. balancing of radial engines (reverse crank method)
10. balancing of V – engines

UNIT-V:

Topic Learning objectives -

After learning the contents of Unit-V, the student is able to identify, explain and calculate

- Function of a governor
- Types of governor
- Construction of Porter governor
- Force analysis of Porter governor
- Construction of Hartnell governors
- Force analysis of Hartnell governor
- Controlling force
- Stability of governors
- Sensitiveness, isochronisms, hunting, effort and power of governor.
- Gyroscopic couple effect
- Vectorial representation of angular motion
- gyroscopic couple on bearings
- Gyroscopic couple effect on aircraft, ship, two wheelers and four wheelers

Lesson Schedule

1. Function of a governor, Types of governor
2. Construction of Porter governor, Force analysis of Porter governor
3. Construction of Hartnell governors, Force analysis of Hartnell governor
4. Controlling force and Stability of governors
5. Sensitiveness, isochronisms, hunting, effort and power of governor
6. Solving numerical problems
7. Solving numerical problems
8. Vectorial representation of angular motion
9. Gyroscopic couple effect
10. gyroscopic couple on bearings

11. Gyroscopic couple effect on aircraft, ship
12. Gyroscopic couple effect on two wheelers and four wheelers

Review Questions:

UNIT-I:

1. What do you mean by applied and constraint forces? Explain.
2. What are conditions for a body to be in equilibrium under the action of two forces, three forces and two forces and a torque?
3. What are free body diagrams of a mechanism? How are they helpful in finding the various forces acting on the various members of the mechanism?
4. Define and explain the superposition theorem as applicable to a system of forces acting on a mechanism.
5. What is the principle of virtual work? Explain.
6. How is the friction at the bearings and at sliding pairs of a mechanism is taken into account?
7. The dimensions of a four-link mechanism are: AB == 400 mm, BC == 600 rnm. CD == 500 mm, AD == 900 mm, and LDAB == 60°. AD is the fixed link. E is a point on link BC such that BE == 400 mm and CE == 300 mm (BEC clockwise).
   A force of 150 L4SO N acts on DC at a distance of 250 mm from D.
   Another force of magnitude 100 L 180° N acts at point E. Find the required input torque on link AB for static equilibrium of the mechanism. (4.6 N.m clockwise)
8. Determine the required input torque on the crank of a slider-crankmechanism for the static equilibrium When the applied piston load is 1500 N. The lengths of the crank and the connecting rod are 40 rnm and 100 mrn respectively and the crank has turned through 45° from the inner-dead centre.
9. For the mechanism shown in Fig. 1, find the required input torque for the static equilibrium. The lengths OA and AB are 250 rnm and 650 rnrn respectively. F == 500 N. (68 N.m clockwise)

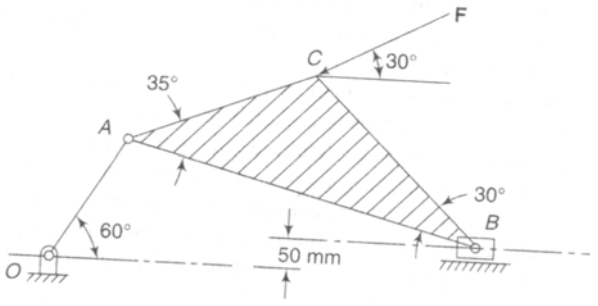


Figure 1

10. For the static equilibrium of the mechanism of Fig. 2, find the required input torque. The dimensions are:

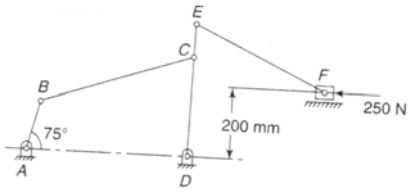


Fig.2

Figure 2

AB = 150 rnm, BC = CE = 100 mm and EF = 450 rnm. (45.5 N.m clockWise)

11. A two-cylinder engine shown in Fig. 3, is in static equilibrium. The dimensions are OA = OB = 50 mm, AC = BD = 250 mm, L.AOB = 90°. Determine the torque on the crank OAB. (106 N.m clockwise)

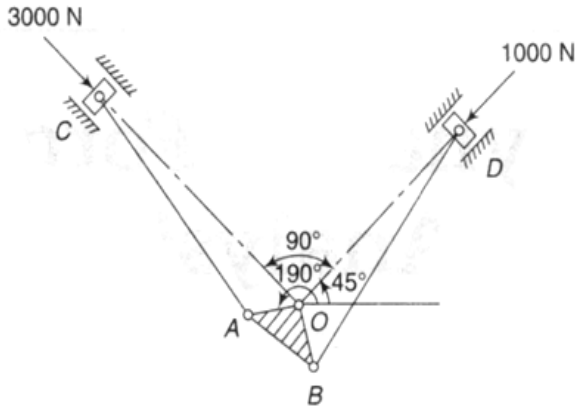


Figure 3

UNIT-II

1. Define ‘inertia force’ and ‘inertia torque’.
2. Draw and explain Klien’s construction for determining the velocity and acceleration of the piston in a slider crank mechanism.
3. Explain Ritterhaus’s and Bennett’s constructions for determining the acceleration of the piston of a reciprocating engine.
4. How are velocity and acceleration of the slider of a single slider crank chain determined analytically?
5. Derive an expression for the inertia force due to reciprocating mass in reciprocating engine, neglecting the mass of the connecting rod.
6. What is the difference between piston effort, crank effort and crank-pin effort?
7. Discuss the method of finding the crank effort in a reciprocating single acting, single cylinder petrol engine.
8. The inertia of the connecting rod can be replaced by two masses concentrated at two points and connected rigidly together. How to determine the two masses so that it is dynamically equivalent to the connecting rod ? Show this.
9. Given acceleration image of a link. Explain how dynamical equivalent system can be used to determine the direction of inertia force on it.
10. Describe the graphical and analytical method of finding the inertia torque on the crankshaft of a horizontal reciprocating engine.
11. Derive an expression for the correction torque to be applied to a crankshaft if the connecting rod of a reciprocating engine is replaced by two lumped masses at the piston pin and the crank pin respectively.
12. The crank and connecting rod of a reciprocating engine are 150 mm and 600 mm respectively. The crank makes an angle of 60° with the inner dead centre and revolves at a uniform speed of 300 r.p.m. Find, by Klein’s or Ritterhaus’s construction, 1. Velocity and acceleration of the piston, 2. Velocity and acceleration of the mid-point D of the connecting rod, and 3. Angular velocity and angular acceleration of the connecting rod.
13. In a slider crank mechanism, the length of the crank and connecting rod are 100 mm and 400 mm respectively. The crank rotates uniformly at 600 r.p.m. clockwise. When the crank has turned through 45° from the inner dead centre, find, by analytical method : 1. Velocity and acceleration of the slider, 2. Angular velocity and angular acceleration of the connecting rod. Check your result by Klein’s or Bennett’s construction.
14. A petrol engine has a stroke of 120 mm and connecting rod is 3 times the crank length. The crank rotates at 1500 r.p.m. in clockwise direction. Determine: 1. Velocity and acceleration of the piston, and 2. Angular velocity and angular acceleration of the connecting rod, when the piston had travelled one-fourth of its stroke from I.D.C.
15. The stroke of a steam engine is 600 mm and the length of connecting rod is 1.5 m. The crank rotates at 180 r.p.m. Determine: 1. velocity and acceleration of the piston when crank has travelled through an angle of 40° from inner dead centre, and 2. the position of the crank for zero acceleration of the piston.
16. The following data refer to a steam engine : Diameter of piston = 240 mm; stroke = 600 mm; length of connecting rod = 1.5 m; mass of reciprocating parts = 300 kg; speed = 125 r.p.m.. Determine the magnitude and direction of the inertia force on the crankshaft when the crank has turned through 30° from inner dead centre.
17. A vertical petrol engine 150 mm diameter and 200 mm stroke has a connecting rod 350 mm long. The mass of the piston is 1.6 kg and the engine speed is 1800 r.p.m. On the expansion stroke with crank angle 30° from top dead centre, the gas pressure is 750 kN/m2. Determine the net thrust on the piston.
18. A horizontal steam engine running at 240 r.p.m. has a bore of 300 mm and stroke 600 mm. The connecting rod is 1.05 m long and the mass of reciprocating parts is 60 kg. When the crank is 60° past its inner dead centre, the steam pressure on the cover side of the piston is 1.125 N/mm2 while that on the

crank side is 0.125 N/mm2. Neglecting the area of the piston rod, determine : 1. the force in the piston rod ; and 2. the turning moment on the crankshaft.

19. A steam engine 200 mm bore and 300 mm stroke has a connecting rod 625 mm long. The mass of the reciprocating parts is 15 kg and the speed is 250 r.p.m.When the crank is at 30° to the inner dead centre and moving outwards, the difference in steam pressures is 840 kN/m2. If the crank pin radius is 30 mm, determine: 1. the force on the crankshaft bearing; and 2. the torque acting on the frame.
20. A vertical single cylinder engine has a cylinder diameter of 250 mm and a stroke of 450 mm. The reciprocating parts have a mass of 180 kg. The connecting rod is 4 times the crank radius and thespeed is 360 r.p.m. When the crank has turned through an angle of 45° from top dead centre, the net pressure on the piston is 1.05 MN/m2. Calculate the effective turning moment on the crankshaft for this position.
21. A horizontal, double acting steam engine has a stroke of 300 mm and runs at 240 r.p.m. The cylinder diameter is 200 mm, connecting rod is 750 mm long and the mass of the reciprocating parts is 70 kg. The steam is admitted at 600 kN/m2 for one-third of the stroke, after which expansion takes place according to the hyperbolic law p.V = constant. The exhaust pressure is 20 kN/m2. Neglecting the effect of clearance and the diameter of the piston rod, find : 1. Thrust in the connecting rod, and 2.Effective turning moment on the crankshaft when the crank has turned through 120° from inner dead centre.
22. A horizontal steam engine running at 150 r.p.m. has a bore of 200 mm and a stroke of 400 mm. The connecting rod is 1 m long and the reciprocating parts has a mass of 60 kg. When the crank has turned through an angle of 30° from inner dead centre, steam pressure on the cover side is 0.6 N/mm2 while on the crankside is 0.1 N/mm2. Neglecting the area of the piston rod, determine: 1. turning moment on the crankshaft, 2. acceleration of the flywheel, if the mean resistance torque is 600 N-m and the moment of inertia is 2.8 kg-m2. The ratio of the connecting rod length to crank length for a vertical petrol engine is 4:1. The bore / stroke is 80/100 mm and mass of the reciprocating parts is 1 kg. The gas pressure on the piston is 0.7N/mm2 when it has moved 10 mm from T.D.C. on its power stroke. Determine the net load on the gudgeon pin. The engine runs at 1800 r.p.m. At what engine speed will this load be zero?
23. A petrol engine 90 mm in diameter and 120 mm stroke has a connecting rod of 240 mm length. The piston has a mass of 1 kg and the speed is 1800 r.p.m. On the explosion stroke with the crank at 30° from top dead centre, the gas pressure is 0.5 N/mm2. Find :1. the resultant load on the gudgeon pin, 2. the thrust on the cylinder walls, and 3. the speed, above which other things remaining same, the gudgeon pin load would be reserved in direction. Also calculate the crank effort at the given position of the crank.
24. A single cylinder vertical engine has a bore of 300 mm, storke 360 mm and a connecting rod of length 720 mm. The mass of the reciprocating parts is 130 kg. When the piston is at quarter stroke from top dead centre and is moving downwards, the net pressure on it is 0.6 MPa. If the speed of the engine is 250 r.p.m., calculate the turning moment on the crankshaft at the instant corresponding to the position stated above.
25. A horizontal, single cylinder, single acting, otto cycle gas engine has a bore of 300 mm and a stroke of 500 mm. The engine runs at 180 r.p.m. The ratio of compression is 5.5. The maximum explosion pressure is 3.2 N/mm2 gauge and expansion follows the law p.V1.3 = constant. If the mass of the piston is 150 kg and the connecting rod is 1.25 m long. Calculate the turning moment on the crankshaft when the crank has turned through 60° from the inner dead centre. The atmospheric pressure is 0.1 N/mm2.
26. A vertical single cylinder, diesel engine running at 300 r.p.m. has a cylinder diameter 250 mm and stroke 400 mm. The mass of the reciprocating parts is 200 kg. The length of the connecting rod is 0.8 m. The ratio of compression is 14 and the pressure remains constant during injection of oil for 1/10th of stroke. If the index of the law of expansion and compression is 1.35, find the torque on the crankshaft when it makes an angle of 60° with the top dead centre during the expansion stroke. The suction pressure may be taken as 0.1 N/mm2.
27. A gas engine is coupled to a compressor, the two cylinders being horizontally opposed with the pistons connected to a common crank pin. The stroke of each piston is 500 mm and the ratio of the length of the connecting rod to the length of crank is 5. The cylinder diameters are 200 mm and 250 mm and the

masses of reciprocating parts are 130 kg and 150 kg respectively. When the crank has moved through 60° from inner dead centre on the firing stroke, the pressure of gas on the engine cylinder is 1 N/mm2 gauge and the pressure in the compressor cylinder is 0.1 N/mm2 gauge. If the crank moves with 200 r.p.m. and the flywheel of radius of gyration 1 m has a mass of 1350 kg, determine the angular acceleration of the flywheel.

28. The length of a connecting rod of an engine is 500 mm measured between the centres and its mass is 18 kg. The centre of gravity is 125 mm from the crank pin centre and the crank radius is 100 mm. Determine the dynamically equivalent system keeping one mass at the small end. The frequency of oscillation of the rod, when suspended from the centre of the small end is 43 vibrations per minute.
29. A small connecting rod 220 mm long between centres has a mass of 2 kg and a moment of inertia of 0.02 kg-m2 about its centre of gravity. The centre of gravity is located at a distance of 150 mm from the small end centre. Determine the dynamically equivalent two mass system when one mass is located at the small end centre. If the connecting rod is replaced by two masses located at the two centres, find the correction couple that must be applied for complete dynamical equivalence of the system when the angular acceleration of the connecting rod is 20 000 rad/s2 anticlockwise.
30. The connecting rod of a horizontal reciprocating engine is 400 mm and length of the stroke is 200 mm. The mass of the reciprocating parts is 125 kg and that the connecting rod is 100 kg. The radius of gyration of the connecting rod about an axis through the centre of gravity is 120 mm and the distance of centre of gravity of the connecting rod from big end centre is 160 mm. The engine runs at 750 r.p.m. Determine the torque exerted on the crankshaft when the crank has turned 30° from the inner dead centre.
31. If the crank has turned through 135° from the inner dead centre in the above question, find the torque on the crankshaft.
32. Draw the turning moment diagram of a single cylinder double acting steam engine.
33. Explain precisely the uses of turning moment diagram of reciprocating engines.
34. Explain the turning moment diagram of a four stroke cycle internal combustion engine.
35. Discuss the turning moment diagram of a multicylinder engine.
36. Explain the terms ‘fluctuation of energy’ and ‘fluctuation of speed’ as applied to flywheels.
37. Define the terms ‘coefficient of fluctuation of energy’ and ‘coefficient of fluctuation of speed’, in the case of flywheels.
38. An engine flywheel has a mass of 6.5 tonnes and the radius of gyration is 2 m. If the maximum andminimum speeds are 120 r. p. m. and 118 r. p. m. respectively, find maximum fluctuation of energy.
39. A vertical double acting steam engine develops 75 kW at 250 r.p.m. The maximum fluctuation of energy is 30 per cent of the work done per stroke. The maximum and minimum speeds are not to vary more than 1 per cent on either side of the mean speed. Find the mass of the flywheel required, if the radius of gyration is 0.6 m.
40. In a turning moment diagram, the areas above and below the mean torque line taken in order are 4400, 1150, 1300 and 4550 mm2 respectively. The scales of the turning moment diagram are: Turning moment, 1 mm = 100 N-m ; Crank angle, 1 mm = 1° Find the mass of the flywheel required to keep the speed between 297 and 303 r.p.m., if the radius of gyration is 0.525 m.
41. The turning moment diagram for a multicylinder engine has been drawn to a scale of 1 mm = 4500 N-m vertically and 1 mm = 2.4° horizontally. The intercepted areas between output torque curve and mean resistance line taken in order from one end are 342, 23, 245, 303, 115, 232, 227, 164 mm2, when the engine is running at 150 r.p.m. If the mass of the flywheel is 1000 kg and the total fluctuation of speed does not exceed 3% of the mean speed, find the minimum value of the radius of gyration.
42. An engine has three single-acting cylinders whose cranks are spaced at 120° to each other. The turning moment diagram for each cylinder consists of a triangle having the following values:

Angle	0°	60°	180°	180° – 360°
Torque (N-m)	0	200	0	0

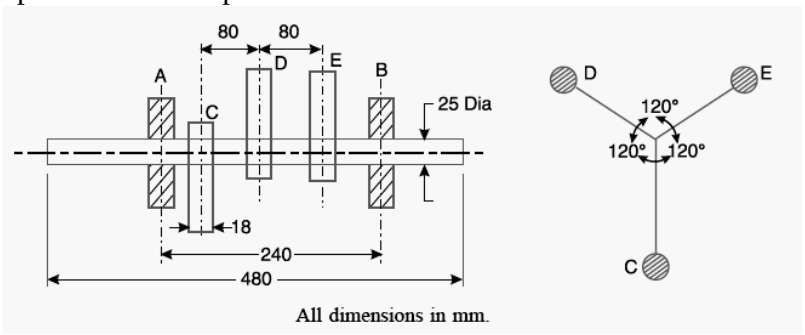
43. Find the mean torque and the moment of inertia of the flywheel to keep the speed within 180 ± 3 r.p.m.

44. The turning moment diagram for a four stroke gas engine may be assumed for simplicity to be represented by four triangles, the areas of which from the line of zero pressure are as follows: Expansion stroke = 3550 mm2; exhaust stroke = 500 mm2; suction stroke = 350 mm2; and compression stroke = 1400 mm2. Each mm2 represents 3 N-m. Assuming the resisting moment to be uniform, find the mass of the rim of a flywheel required to keep the mean speed 200 r.p.m. within ± 2%. The mean radius of the rim may be taken as 0.75 m. Also determine the crank positions for the maximum and minimum speeds.
45. A single cylinder, single acting, four stroke cycle gas engine develops 20 kW at 250 r.p.m. The work done by the gases during the expansion stroke is 3 times the work done on the gases during the compression stroke. The work done on the suction and exhaust strokes may be neglected. If the flywheel has a mass of 1.5 tonnes and has a radius of gyration of 0.6m, find the cyclic fluctuation of energy and the coefficient of fluctuation of speed.
46. A single cylinder double acting steam engine delivers 185 kW at 100 r.p.m. The maximum fluctuation of energy per revolution is 15 per cent of the energy developed per revolution. The speed variation is limited to 1 per cent either way from the mean. The mean diameter of the rim is 2.4 m. Find the mass and cross-sectional dimensions of the flywheel rim when width of rim is twice the thickness. The density of flywheel material is 7200 kg/m3.
47. The turning moment diagram for the engine is drawn to the following scales: Turning moment, 1 mm = 1000 N-m and crank angle, 1 mm = 6°. The areas above and below the mean turning moment line taken in order are : 530, 330, 380, 470, 180, 360, 350 and 280 mm2. The mean speed of the engine is 150 r.p.m. and the total fluctuation of speed must not exceed 3.5% of mean speed. Determine the diameter and mass of the flywheel rim, assuming that the total energy of the flywheel to be 15/14 that of rim. The peripheral velocity of the flywheel is 15 m/s. Find also the suitable cross-scetional area of the rim of the flywheel. Take density of the material of the rim as 7200 kg/m3.
48. A single cylinder internal combustion engine working on the four stroke cycle develops 75 kW at 360 r.p.m. The fluctuation of energy can be assumed to be 0.9 times the energy developed per cycle. If the fluctuation of speed is not to exceed 1 per cent and the maximum centrifugal stress in the flywheel is to be 5.5 MPa, estimate the mean diameter and the cross-sectional area of the rim. The material of the rim has a density of 7.2 Mg/m3.
49. A cast iron flywheel used for a four stroke I.C. engine is developing 187.5 kW at 250 r.p.m. The hoop stress developed in the flywheel is 5.2 MPa. The total fluctuation of speed is to be limited to 3% of the mean speed. If the work done during the power stroke is 1/3 times more than the average workdone during the whole cycle, find: 1. mean diameter of the flywheel, 2. mass of the flywheel and 3. cross-sectional dimensions of the rim when the width is twice the thickness. The density of cast iron may be taken as 7220 kg/m3.
50. A certain machine tool does work intermittently. The machine is fitted with a flywheel of mass 200 kg and radius of gyration of 0.4 m. It runs at a speed of 400 r.p.m. between the operations. The machine is driven continuously by a motor and each operation takes 8 seconds. When the machine is doing its work, the speed drops from 400 to 250 r.p.m. Find 1. minimum power of the motor, when there are 5 operations performed per minute, and 2. energy expanded in performing each operation.
51. A constant torque 4 kW motor drives a riveting machine. A flywheel of mass 130 kg and radius of gyration 0.5 m is fitted to the riveting machine. Each riveting operation takes 1 second and requires 9000 N-m of energy. If the speed of the flywheel is 420 r.p.m. before riveting, find: 1. the fall in speed of the flywheel after riveting; and 2. the number of rivets fitted per hour.
52. A machine has to carry out punching operation at the rate of 10 holes per minute. It does 6 kN-m of work per mm2 of the sheared area in cutting 25 mm diameter holes in 20 mm thick plates. A flywheel is fitted to the machine shaft which is driven by a constant torque. The fluctuation of speed is between 180 and 200 r.p.m. The actual punching takes 1.5 seconds. The frictional losses are equivalent to 1/6 of the work done during punching. Find: 1. Power required to drive the punching machine, and 2. Mass of the flywheel, if the radius of gyration of the wheel is 0.5 m.

UNIT-III

1. Why is balancing of rotating parts necessary for high speed engines ?
2. Explain clearly the terms ‘static balancing’ and ‘dynamic balancing’. State the necessary conditions to achieve them.
3. Discuss how a single revolving mass is balanced by two masses revolving in different planes
4. Explain the method of balancing of different masses revolving in the same plane.
5. How the different masses rotating in different planes are balanced ?
6. Four masses A, B, C and D are attached to a shaft and revolve in the same plane. The masses are 12 kg, 10 kg, 18 kg and 15 kg respectively and their radii of rotations are 40 mm, 50 mm, 60 mm and 30 mm. The angular position of the masses B, C and D are 60°, 135° and 270° from the mass A. Find the magnitude and position of the balancing mass at a radius of 100 mm.
7. Four masses A, B, C and D revolve at equal radii and are equally spaced along a shaft. The mass B is 7 kg and the radii of C and D make angles of 90° and 240° respectively with the radius of B. Find the magnitude of the masses A, C and D and the angular position of A so that the system may be completely balanced.
8. A rotating shaft carries four masses A, B, C and D which are radially attached to it. The mass centres are 30 mm, 38 mm, 40 mm and 35 mm respectively from the axis of rotation. The masses A, C and D are 7.5 kg, 5 kg and 4 kg respectively. The axial distances between the planes of rotation of A and B is 400 mm and between B and C is 500 mm. The masses A and C are at right angles to each other. Find for a complete balance, 1. the angles between the masses B and D from mass A, 2. the axial distance between the planes of rotation of C and D, 3. the magnitude of mass B.
9. A rotating shaft carries four unbalanced masses 18 kg, 14 kg, 16 kg and 12 kg at radii 50 mm, 60 mm, 70 mm and 60 mm respectively. The 2nd, 3rd and 4th masses revolve in planes 80 mm, 160 mm and 280 mm respectively measured from the plane of the first mass and are angularly located at 60°, 135° and 270° respectively measured clockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by two masses, both located at 50 mm radii and revolving in planes mid-way between those of 1st and 2nd masses and midway between those of 3rd and 4th masses. Determine, graphically or otherwise, the magnitudes of the masses and their respective angular positions.
10. A shaft carries five masses A, B, C, D and E which revolve at the same radius in planes which are equidistant from one another. The magnitude of the masses in planes A, C and D are 50 kg, 40 kg and 80 kg respectively. The angle between A and C is 90° and that between C and D is 135°. Determine the magnitude of the masses in planes B and E and their positions to put the shaft in complete rotating balance.
11. A shaft with 3 metres span between two bearings carries two masses of 10 kg and 20 kg acting at the extremities of the arms 0.45 m and 0.6 m long respectively. The planes in which these masses rotate are 1.2 m and 2.4 m respectively from the left end bearing supporting the shaft. The angle between the arms is 60°. The speed of rotation of the shaft is 200 r.p.m. If the masses are balanced by two counter-masses rotating with the shaft acting at radii of 0.3 m and placed at 0.3 m from each bearing centres, estimate the magnitude of the two balance masses and their orientation with respect to the X-axis, i.e. mass of 10 kg.
12. A, B, C and D are four masses carried by a rotating shaft at radii 100 mm, 150 mm, 150 mm and 200 mm respectively. The planes in which the masses rotate are spaced at 500 mm apart and the magnitude of the masses B, C and D are 9 kg, 5 kg and 4 kg respectively. Find the required mass A and the relative angular settings of the four masses so that the shaft shall be in complete balance.
13. A 3.6 m long shaft carries three pulleys, two at its two ends and third at the mid-point. The two end pulleys has mass of 79 kg and 40 kg and their centre of gravity are 3 mm and 5 mm respectively from the axis of the shaft. The middle pulley mass is 50 kg and its centre of gravity is 8 mm from the shaft axis. The pulleys are so keyed to the shaft that the assembly is in static balance. The shaft rotates at 300 r.p.m. in two bearings 2.4m apart with equal overhang on either side. Determine : 1. the relative angular positions of the pulleys, and 2. dynamic reactions at the two bearings.

14. The camshaft of high speed pump consists of a parallel shaft 25 mm diameter and 480 mm long. It carries three eccentrics, each of diameter 60 mm and a uniform thickness of 18 mm. The assembly is symmetrical as shown in Fig. and the bearings are at A and B. The angle between the eccentrics is 120° and the eccentricity of each is 12.5 mm. The material density is 7000 kg/m3, and the speed of rotation is 1430 r.p.m. Find : **1.** dynamic load on each bearing due to the out-of-balance couple ; and **2.** kinetic energy of the complete assembly



UNIT-IV

1. Write a short note on primary and secondary balancing.
2. Explain why only a part of the unbalanced force due to reciprocating masses is balanced by revolving mass.
3. Derive the following expressions, for an uncoupled two cylinder locomotive engine : (a) Variation is tractive force ; (b) Swaying couple ; and (c) Hammer blow.
4. What are in-line engines ? How are they balanced ? It is possible to balance them completely ?
5. Explain the 'direct and reverse crank' method for determining unbalanced forces in radial engines.
6. Discuss the balancing of V-engines
7. A single cylinder horizontal engine runs at 120 r.p.m. The length of stroke is 400 mm. The mass of the revolving parts assumed concentrated at the crank pin is 100 kg and mass of the reciprocating parts is 150 kg. Determine the magnitude of the balancing mass required to be placed opposite to the crank at a radius of 150mm which is equivalent to all the revolving and 2/3rd of the reciprocating masses. If the crank turns 30° from the inner dead centre, find the magnitude of the unbalanced force due to the balancing mass.
8. A single cylinder engine runs at 250 r.p.m. and has a stroke of 180 mm. The reciprocating parts has a mass of 120 kg and the revolving parts are equivalent to a mass of 70 kg at a radius of 90 mm. A mass is placed opposite to the crank at a radius of 150 mm to balance the whole of the revolving mass and two-thirds of the reciprocating mass. Determine the magnitude of the balancing mass and the resultant residual unbalance force when the crank has turned 30° from the inner dead centre, neglect the obliquity of the connecting rod.
9. A two cylinder uncoupled locomotive has inside cylinders 0.6 m apart. The radius of each crank is 300 mm and are at right angles. The revolving mass per cylinder is 250 kg and the reciprocating mass per cylinder is 300 kg. The whole of the revolving and two-third of the reciprocating masses are to be balanced and the balanced masses are placed, in the planes of rotation of the driving wheels, at a radius of 0.8 m. The driving wheels are 2 m in diameter and 1.5 m apart. If the speed of the engine is 80 km. p.h. ; find hammer blow, maximum variation in tractive effort and maximum swaying couple.
10. A two cylinder uncoupled locomotive with cranks at 90° has a crank radius of 325 mm. The distance between the centres of driving wheels is 1.5 m. The pitch of cylinders is 0.6 m. The diameter of treads of driving wheels is 1.8 m. The radius of centres of gravity of balance masses is 0.65 m. The pressure due to dead load on each wheel is 40 kN. The masses of reciprocating and rotating parts per cylinder are 330 kg and 300 kg respectively. The speed of the locomotive is 60 km. p.h. find : 1. The balancing masses both in magnitude and position required to be placed is the planes of driving wheels to balance whole of the revolving and two-third of the reciprocating masses ; 2. The swaying couple ; 3.The variation is tractive force ; 4. The maximum and minimum pressure on rails ; and 5. The maximum speed at which it is possible to run the locomotive, in order that the wheels are not lifted from the rails.

11. Two locomotives are built with similar sets of reciprocating parts. One is an inside cylinder engine with two cylinders with centre lines at 0.6 m apart. The other is an outside cylinder with centre lines at 1.98 m apart. The distance between the driving wheel centres is 1.5 m in both the cases. The inside cylinder locomotive runs at 0.8 times the speed of the outside cylinder locomotive and the hammer blow of the inside cylinder locomotive is 1.2 times the hammer blow of the outside cylinder locomotive. If the diameter of the driving wheel of the outside cylinder locomotive is 1.98 m, calculate the diameter of the driving wheel of the inside cylinder locomotive. Compare also the variation in the swaying couples of the two engines. Assume that the same fraction of the reciprocating masses are balanced in both the cases.
12. An air compressor has four vertical cylinders 1,2,3 and 4 in line and the driving cranks at 90° intervals reach their upper most positions in this order. The cranks are of 150 mm radius, the connecting rods 500 mm long and the cylinder centre line 400 mm apart. The mass of the reciprocating parts for each cylinder is 22.5 kg and the speed of rotation is 400 r.p.m. Show that there are no out-of-balance primary or secondary forces and determine the corresponding couples, indicating the positions of No. 1 crank for maximum values. The central plane of the machine may be taken as reference plane.
13. A four cylinder engine has the two outer cranks at 120° to each other and their reciprocating masses are each 400 kg. The distance between the planes of rotation of adjacent cranks are 400 mm, 700 mm, 700 mm and 500 mm. Find the reciprocating mass and the relative angular position for each of the inner cranks, if the engine is to be in complete primary balance. Also find the maximumunbalanced secondary force, if the length of each crank is 350 mm, the length of each connecting rod 1.7 m and the engine speed 500 r.p.m.
14. The reciprocating masses of the first three cylinders of a four cylinder engine are 4.1, 6.2 and 7.4 tonnes respectively. The centre lines of the three cylinders are 5.2 m, 3.2 m and 1.2 m from the fourth cylinder. If the cranks for all the cylinders are equal, determine the reciprocating mass of the fourth cylinder and the angular position of the cranks such that the system is completely balanced for the primary force and couple. If the cranks are 0.8 m long, the connecting rods 3.8 m, and the speed of the engine 75 r.p.m. ; find the maximum unbalanced secondary force and the crank angle at which it occurs.
15. In a four cylinder petrol engine equally spaced, the cranks, numbered from the front end are 1,2,3, and 4. The cranks 1 and 4 are in phase and 180° ahead of cranks 2 and 3. The reciprocating mass of each cylinder is 1 kg. The cranks are 50 mm radius and the connecting rod 200 mm long. What are the resultant unbalanced forces and couples, primary and secondary, when cranks 1 and 4 are on top dead centre position ? The engine is rotating at 1500 r.p.m. in a clockwise direction when viewed from the front. Take the reference plane midway between cylinder 2 and 3.
16. A four cylinder inline marine oil engine has cranks at angular displacement of 90°. The outer cranks are 3 m apart and inner cranks are 1.2 m apart. The inner cranks are placed symmetrically between the outer cranks. The length of each crank is 450 mm. If the engine runs at 90 r.p.m. and the mass of reciprocating parts for each cylinder is 900 kg, find the firing order of the cylinders for the best primary balancing force of reciprocating masses. Determine the maximum unbalanced primary couple for the best arrangement.
17. In a four crank symmetrical engine, the reciprocating masses of the two outside cylinders A and D are each 600 kg and those of the two inside cylinders B and C are each 900 kg. The distance between the cylinder axes of A and D is 5.4 metres. Taking the reference line to bisect the angle between the cranks A and D, and the reference plane to bisect the distance between the cylinder axes of A and D, find the angles between the cranks and the distance between the cylinder axes of B and C for complete balance except for secondary couples. Determine the maximum value of the unbalanced secondary couple if the length of the crank is 425 mm, length of connecting rod 1.8 m and speed is 150 r.p.m.
18. In a four cylinder inline engine, the cylinders are placed symmetrically along the longitudinal axis, with a centre distance of 2.4 m between the outside cylinders and 0.6 m between the inside cylinders. The cranks between the two inside cylinders are at 90° to each other and the mass of reciprocating parts of each of these is 225 kg. All the four cranks are of 0.3 m radius. If the system is to be completely balanced

for the primary effects, determine 1. The mass of the reciprocating parts of each of the outside cranks, and 2. The angular position of the outside cranks with reference to the nearest inside cranks, measured in clockwise direction and draw an end view of the four primary cranks marking these angles therein. With the above arrangement, evaluate the secondary unbalanced effects completely, with reference to a plane through the centre line of cylinder no. 1 and show by means of an end view the angular position of these with reference to secondary crank no. 1. The engine is running at 180 r.p.m. and the length of each connecting rod is 1.2 m.

19. A six-cylinder, single acting, two stroke Diesel engine is arranged with cranks at 60° for the firing sequence 1-4-5-2-3-6. The cylinders, numbered 1 to 6 in succession are pitched 1.5 m apart, except cylinders 3 and 4 which are 1.8 m apart. The reciprocating and revolving masses per line are 2.2 tonnes and 1.6 tonnes respectively. The crank length is 375 mm, the connecting rod length is 1.6 m, and the speed is 120 r.p.m. Determine the maximum and minimum values of the primary couple due to the reciprocating and revolving parts. Also find the maximum secondary couple and angular position relative to crank No. 1. Take the plane between the cylinders 3 and 4 as the reference plane.
20. A three cylinder radial engine driven by a common crank has the cylinders spaced at 120°. The stroke is 125 mm, length of the connecting rod 225 mm and the mass of the reciprocating parts per cylinder 2 kg. Calculate the primary and secondary forces at crank shaft speed of 1200 r.p.m.
21. The pistons of a 60° twin V-engine has strokes of 120 mm. The connecting rods driving a common crank has a length of 200 mm. The mass of the reciprocating parts per cylinder is 1 kg and the speed of the crank shaft is 2500 r.p.m. Determine the magnitude of the primary and secondary forces.
22. A twin cylinder V-engine has the cylinders set at an angle of 45°, with both pistons connected to the single crank. The crank radius is 62.5 mm and the connecting rods are 275 mm long. The reciprocating mass per line is 1.5 kg and the total rotating mass is equivalent to 2 kg at the crank radius. A balance mass fitted opposite to the crank, is equivalent to 2.25 kg at a radius of 87.5 mm. Determine for an engine speed of 1800 r.p.m. ; the maximum and minimum values of the primary and secondary forces due to the inertia of reciprocating and rotating masses.

Unit-V:

1. What is the function of a governor ? How does it differ from that of a flywheel ?
2. State the different types of governors. What is the difference between centrifugal and inertia type governors ? Why is the former preferred to the latter ?
3. Explain the term height of the governor. Derive an expression for the height in the case of a Watt governor. What are the limitations of a Watt governor ?
4. What are the effects of friction and of adding a central weight to the sleeve of a Watt governor ?
5. Discuss the controlling force and stability of a governor and show that the stability of a governor depends on the slope of the curve connecting the controlling force (FC) and radius of rotation (r) and the value (FC /r).
6. What is stability of a governor ? Sketch the controlling force versus radius diagrams for a stable, unstable and isochronous governor. Derive the conditions for stability.
7. Explain clearly how would you determine from the controlling force curve whether a governor is stable, unstable or isochronous. Show also how the effect of friction may be indicated on the curve.
8. Define and explain the following terms relating to governors :1. Stability, 2. Sensitiveness, 3. Isochronism, and 4. Hunting.
9. Explain the terms and derive expressions for ‘effort’ and ‘power’ of a Porter governor.
10. Prove that the sensitiveness of a Proell governor is greater than that of a Porter governor.
11. Write short note on ‘coefficient of insensitiveness’ of governors.
12. The length of the upper arm of a Watt governor is 400 mm and its inclination to the vertical is 30°. Find the percentage increase in speed, if the balls rise by 20 mm.
13. A Porter governor has two balls each of mass 3 kg and a central load of mass 15 kg. The arms are all 200 mm long, pivoted on the axis. If the maximum and minimum radii of rotation of the balls are 160 mm

and 120 mm respectively, find the range of speed.

14. In a Porter governor, the mass of the central load is 18 kg and the mass of each ball is 2 kg. The top arms are 250 mm while the bottom arms are each 300 mm long. The friction of the sleeve is 14 N. If the top arms make 45° with the axis of rotation in the equilibrium position, find the range of speed of the governor in that position.
15. A loaded governor of the Porter type has equal arms and links each 250 mm long. The mass of eachball is 2 kg and the central mass is 12 kg. When the ball radius is 150 mm, the valve is fully open and when the radius is 185 mm, the valve is closed. Find the maximum speed and the range of speed. If the maximum speed is to be increased 20% by an addition of mass to the central load, find what additional mass is required.
16. The arms of a Porter governor are 300 mm long. The upper arms are pivoted on the axis of rotation and the lower arms are attached to the sleeve at a distance of 35 mm from the axis of rotation. The load on the sleeve is 54 kg and the mass of each ball is 7 kg. Determine the equilibrium speed when theradius of the balls is 225 mm. What will be the range of speed for this position, if the frictional resistances to the motion of the sleeve are equivalent to a force of 30 N?
17. In a Porter governor, the upper and lower arms are each 250 mm long and are pivoted on the axis of rotation. The mass of each rotating ball is 3 kg and the mass of the sleeve is 20 kg. The sleeve is in its lowest position when the arms are inclined at 30° to the governor axis. The lift of the sleeve is 36 mm. Find the force of friction at the sleeve, if the speed at the moment it rises from the lowest position is equal to the speed at the moment it falls from the highest position. Also, find the range of speed of the governor.
18. A Porter governor has links 150 mm long and are attached to pivots at a radial distance of 30 mm from the vertical axis of the governor. The mass of each ball is 1.75 kg and the mass of the sleeve is 25 kg. The governor sleeve begins to rise at 300 r.p.m. when the links are at 30° to the vertical. Assuming the friction force to be constant, find the minimum and maximum speed of rotation when the inclination of the links is 45° to the vertical.
19. A Proell governor has all the four arms of length 250 mm. The upper and lower ends of the arms are pivoted on the axis of rotation of the governor. The extension arms of the lower links are each 100 mm long and parallel to the axis when the radius of the ball path is 150 mm. The mass of each ball is 4.5 kg and the mass of the central load is 36 kg. Determine the equilibrium speed of the governor.
20. A Proell governor has arms of 300 mm length. The upper arms are hinged on the axis of rotation, whereas the lower arms are pivoted at a distance of 35 mm from the axis of rotation. The extension of lower arms to which the balls are attached are 100 mm long. The mass of each ball is 8 kg and the mass on the sleeve is 60 kg. At the minimum radius of rotation of 200 mm, the extensions are parallel to the governor axis. Determine the equilibrium speed of the governor for the given configuration. What will be the equilibrium speed for the maximum radius of 250 mm?
21. A spring controlled governor of the Hartnell type with a central spring under compression has balls each of mass 2 kg. The ball and sleeve arms of the bell crank levers are respectively 100 mm and 60 mm long and are at right angles. In the lowest position of the governor sleeve, the radius of rotation of the balls is 80 mm and the ball arms are parallel to the governor axis. Find the initial load on the spring in order that the sleeve may begin to lift at 300 r.p.m. If the stiffness of the spring is 30 kN/m, what is the equilibrium speed corresponding to a sleeve lift of 10 mm?
22. In a governor of the Hartnell type, the mass of each ball is 1.5 kg and the lengths of the vertical and horizontal arms of the bell crank lever are 100 mm and 50 mm respectively. The fulcrum of the bell crank lever is at a distance of 90 mm from the axis of rotation. The maximum and minimum radii of rotation of balls are 120 mm and 80 mm and the corresponding equilibrium speeds are 325 and 300 r.p.m. Find the stiffness of the spring and the equilibrium speed when the radius of rotation is 100 mm.
23. A governor of the Hartnell type has equal balls of mass 3 kg, set initially at a radius of 200 mm. The arms of the bell crank lever are 110 mm vertically and 150 mm horizontally. Find : 1. the initial

compressive force on the spring, if the speed for an initial ball radius of 200 mm is 240 r.p.m. ; and 2. the stiffness of the spring required to permit a sleeve movement of 4 mm on a fluctuation of 7.5 per cent in the engine speed.

24. A spring controlled governor of the Hartnell type has the following data : Mass of the ball = 1.8 kg ; Mass of the sleeve = 6 kg ; Ball and sleeve arms of the bell crank lever = 150 mm and 120 mm respectively. The equilibrium speed and radius of rotation for the lowest position of the sleeve are 400 r.p.m. and 150 mm respectively. The sleeve lift is 10 mm and the change in speed for full sleeve lift is 5%. During an overhaul, the spring was compressed 2 mm more than the correct compression for the initial setting. Determine the stiffness of the spring and the new equilibrium speed for the lowest position of the sleeve.
25. A spring controlled governor of the Hartnell type has two rotating balls of mass 1.35 kg each. The ball arm is 75 mm and the sleeve arm is 62.5 mm. In the mid position of the sleeve, the sleeve arm is horizontal and the balls rotate in a circle of 100 mm radius. The total sleeve movement is 30 mm. Due to maladjustment of the spring, it is found that the equilibrium speed at the topmost position of the sleeve is 420 r.p.m. and that corresponding to the lowest position is 435 r.p.m. Determine : 1. stiffness and initial compression of the spring, and 2. the required initial compression of the spring to give an equilibrium speed at the topmost position which is 12 r.p.m. more than at the lowest position. Neglect the moment due to mass of the balls.
26. A Hartnell governor has two rotating balls, of mass 2.7 kg each. The ball radius is 125 mm in the mean position when the ball arms are vertical and the speed is 150 r.p.m. with the sleeve rising. The length of the ball arms is 140 mm and the length of the sleeve arms 90 mm. The stiffness of the spring is 7 kN/m and the total sleeve movement is 12 mm from the mean position. Allowing for a constant friction force of 14 N acting at the sleeve, determine the speed range of the governor in the lowest and highest sleeve positions. Neglect the obliquity of the ball arms.
27. The spring controlled governor of the Hartung type has two rotating masses each of 2.5 kg and the limits of their radius of rotation are 100 mm and 125 mm. The each mass is directly controlled by a spring attached to it and to the inner casing of the governor as shown in Fig 18.26 (a). The stiffness of the spring is 8 kN/m and the force on each spring, when the masses are in their mid-position, is 320 N. In addition, there is an equivalent constant inward radial force of 80 N acting on each revolving mass in order to allow for the dead weight of the mechanism. Neglecting friction, find the range of speed of the governor.
28. In a spring controlled governor of the Hartung type, the lengths of the horizontal and vertical arms of the bell crank levers are 100 mm and 80 mm respectively. The fulcrum of the bell crank lever is at a distance of 120 mm from the axis of the governor. The each revolving mass is 9 kg. The stiffness of the spring is 25 kN/m. If the length of each spring is 120 mm when the radius of rotation is 70 mm and the equilibrium speed is 360 r.p.m., find the free length of the spring. If the radius of rotation increases to 120 mm, what will be the corresponding percentage increase in speed ? [**Hint.** Free length of the spring = Length of the spring + compression of the spring]
29. The following particulars refer to a Wilson-Hartnell governor : Mass of each ball = 4 kg ; minimum radius = 80 mm ; maximum radius = 90 mm ; minimum speed = 240 r.p.m.; maximum speed = 252 r.p.m.; length of the ball arm of each bell crank lever = 80 mm ; length of sleeve arm of each bell crank lever = 60 mm ; combined stiffness of the two ball springs = 750 N/m. Find the required stiffness of the auxiliary spring, if the lever is pivoted at the mid-point.

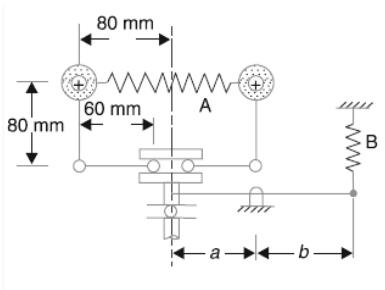


Fig. 18.50

30. A spring loaded governor of the Wilson-Hartnell type is shown in Fig. Two balls each of mass 4 kg are connected across by two springs A. The stiffness of each spring is 750 N/m and a free length of 100 mm. The length of ball arm of each bell crank lever is 80 mm and that of sleeve arm is 60 mm. The lever is pivoted at its mid-point. The speed of the governor is 240 r.p.m.

in its mean position and the radius of rotation of the ball is 80 mm. If the lift of the sleeve is 7.5 mm for an increase of speed of 5%, find the required stiffness of the auxiliary spring B.

31. A Porter governor has all four arms 200 mm long. The upper arms are pivoted on the axis of rotation and the lower arms are attached to a sleeve at a distance of 25 mm from the axis. Each ball has a mass of 2 kg and the mass of the load on the sleeve is 20 kg. If the radius of rotation of the balls at a speed of 250 r.p.m. is 100 mm, find the speed of the governor after the sleeve has lifted 50 mm. Also determine the effort and power of the governor.
32. A Porter governor has arms 250 mm each and four rotating flyballs of mass 0.8 kg each. The sleeve movement is restricted to ± 20 mm from the height when the mean speed is 100 r.p.m. Calculate the central dead load and sensitivity of the governor neglecting friction when the flyball exerts a centrifugal force of 9.81 N. Determine also the effort and power of the governor for 1 percent speed change.
33. The upper arms of a Porter governor are pivoted on the axis of rotation and the lower arms are pivoted to the sleeve at a distance of 30 mm from the axis of rotation. The length of each arm is 300 mm and the mass of each ball is 6 kg. If the equilibrium speed is 200 r.p.m. when the radius of rotation is 200 mm, find the required mass on the sleeve. If the friction is equivalent to a force of 40 N at the sleeve, find the coefficient of insensitiveness at 200 mm radius.
34. In a spring controlled governor, the radial force acting on the balls was 4500 N when the centre of balls was 200 mm from the axis and 7500 N when at 300 mm. Assuming that the force varies directly as the radius, find the radius of the ball path when the governor runs at 270 r.p.m. Also find what alteration in spring load is required in order to make the governor isochronous and the speed at which it would then run. The mass of each ball is 30 kg.
35. Write a short note on gyroscope.
36. What do you understand by gyroscopic couple ? Derive a formula for its magnitude.
37. Explain the application of gyroscopic principles to aircrafts.
38. Describe the gyroscopic effect on sea going vessels.
39. Explain the effect of the gyroscopic couple on the reaction of the four wheels of a vehicle negotiating a curve.
40. Discuss the effect of the gyroscopic couple on a two wheeled vehicle when taking a turn.
41. What will be the effect of the gyroscopic couple on a disc fixed at a certain angle to a rotating shaft ?
42. A flywheel of mass 10 kg and radius of gyration 200 mm is spinning about its axis, which is horizontal and is suspended at a point distant 150 mm from the plane of rotation of the flywheel. Determine the angular velocity of precession of the flywheel. The spin speed of flywheel is 900 r.p.m.
43. A horizontal axle AB, 1 m long, is pivoted at the mid point C. It carries a weight of 20 N at A and a wheel weighing 50 N at B. The wheel is made to spin at a speed of 600 r.p.m in a clockwise direction looking from its front. Assuming that the weight of the flywheel is uniformly distributed around the rim whose mean diameter is 0.6 m, calculate the angular velocity of precession of the system around the vertical axis through C.
44. An aeroplane runs at 600 km / h. The rotor of the engine weighs 4000 N with radius of gyration of 1 metre. The speed of rotor is 3000 r.p.m. in anticlockwise direction when seen from rear side of the aeroplane. If the plane takes a loop upwards in a curve of 100 metres radius, find : 1. gyroscopic couple developed; and 2. effect of reaction gyroscopic couple developed on the body of aeroplane.
45. An aeroplane makes a complete half circle of 50 metres radius, towards left, when flying at 200 km per hour. The rotary engine and the propeller of the plane has a mass of 400 kg with a radius of gyration of 300 mm. The engine runs at 2400 r.p.m. clockwise, when viewed from the rear. Find the gyroscopic couple on the aircraft and state its effect on it. What will be the effect, if the aeroplane turns to its right instead of to the left ?
46. Each paddle wheel of a steamer have a mass of 1600 kg and a radius of gyration of 1.2 m. The steamer turns to port in a circle of 160 m radius at 24 km / h, the speed of the paddles being 90 r.p.m. Find the magnitude and effect of the gyroscopic couple acting on the steamer.

47. The rotor of the turbine of a yacht makes 1200 r.p.m. clockwise when viewed from stern. The rotor hasa mass of 750 kg and its radius of gyration is 250 mm. Find the maximum gyroscopic couple transmitted to the hull (body of the yacht) when yacht pitches with maximum angular velocity of 1 rad /s. What is the effect of this couple ?
48. The rotor of a turbine installed in a boat with its axis along the longitudinal axis of the boat makes 1500 r.p.m. clockwise when viewed from the stern. The rotor has a mass of 750 kg and a radius of gyration of 300 mm. If at an instant, the boat pitches in the longitudinal vertical plane so that the bow rises from the horizontal plane with an angular velocity of 1 rad /s, determine the torque acting on the boat and the direction in which it tends to turn the boat at the instant.
49. The mass of a turbine rotor of a ship is 8 tonnes and has a radius of gyration 0.6 m. It rotates at 1800 r.p.m. clockwise when looking from the stern. Determine the gyroscopic effects in the following cases: 1. If the ship travelling at 100 km / h strees to the left in a curve of 75 m radius, 2. If the ship is pitching and the bow is descending with maximum velocity. The pitching is simple harmonic, the periodic time being 20 seconds and the total angular movement between the extreme positions is 10°, and 3. If the ship is rolling and at a certain instant has an angular velocity of 0.03 rad/s clockwise when looking from stern. In each case, explain clearly how you determine the direction in which the ship tends to move as a result of the gyroscopic action.
50. The turbine rotor of a ship has a mass of 20 tonnes and a radius of gyration of 0.75 m. Its speed is 2000 r.p.m. The ship pitches 6° above and below the horizontal position. One complete oscillation takes 18 seconds and the motion is simple harmonic. Calculate : 1. the maximum couple tending to shear the holding down bolts of the turbine, 2. the maximum angular acceleration of the ship during pitching, and 3. the direction in which the bow will tend to turn while rising, if the rotation of the rotor is clockwise when looking from rear.
51. A motor car takes a bend of 30 m radius at a speed of 60 km / hr. Determine the magnitudes of gyroscopic and centrifugal couples acting on the vehicle and state the effect that each of these has on the road reactions to the road wheels. Assume that : Each road wheel has a moment of inertia of 3 kg-m2 and an effective road radius of 0.4 m. The rotating parts of the engine and transmission are equivalent to a flywheel of mass 75 kg with a radius of gyration of 100 mm. The engine turns in a clockwise direction when viewed from the front. The back-axle ratio is 4 : 1, the drive through the gear box being direct. The gyroscopic effects of the half shafts at the back axle are to be ignored. The car has a mass of 1200 kg and its centre of gravity is 0.6 m above the road wheel. The turn is in a right hand direction. If the turn has been in a left hand direction, all other details being unaltered, which answers, if any, need modification.
52. A rail car has a total mass of 4 tonnes. There are two axles, each of which together with its wheels and gearing has a total moment of inertia of 30 kg-m2. The centre distance between the two wheels on an axle is 1.5 metres and each wheel is of 375 mm radius. Each axle is driven by a motor, the speed ratio between the two being 1 : 3. Each motor with its gear has a moment of inertia of 15 kg-m2 and runs in a direction opposite to that of its axle. The centre of gravity of the car is 1.05 m above the rails. Determine the limiting speed for this car, when it rounding a curve of 240 metres radius such that no wheel leaves the rail. Consider the centrifugal and gyroscopic effects completely. Assume that no cant is provided for outer rail.
53. A racing car weighs 20 kN. It has a wheel base of 2 m, track width 1 m and height of C.G. 300 mm above the ground level and lies midway between the front and rear axle. The engine flywheel rotates at 3000 r.p.m. clockwise when viewed from the front. The moment of inertia of the flywheel is 4 kg-m2 and moment of inertia of each wheel is 3 kg-m2. Find the reactions between the wheels and the ground when the car takes a curve of 15 m radius towards right at 30 km / h, taking into consideration the gyroscopic and the centrifugal effects. Each wheel radius is 400 mm.
54. A four wheel trolley car of total mass 2000 kg running on rails of 1 m gauge, rounds a curve of 25 m radius at 40 km / h. The track is banked at 10°. The wheels have an external diameter of 0.6 m and each pair of an axle has a mass of 200 kg. The radius of gyration for each pair is 250 mm. The height of C.G.

of the car above the wheel base is 0.95 m. Allowing for centrifugal force and gyroscopic couple action, determine the pressure on each rail.

55. A 2.2 tonne racing car has a wheel base of 2.4 m and a track of 1.4 m from the rear axle. The equivalent mass of engine parts is 140 kg with radius of gyration of 150 mm. The back axle ratio is 5. The engine shaft and flywheel rotate clockwise when viewed from the front. Each wheel has a diameter of 0.8 m and a moment of inertia of 0.7 kg-m2. Determine the load distribution on the wheels when the car is rounding a curve of 100 m radius at a speed of 72 km / h to the left.
56. A disc has a mass of 30 kg and a radius of gyration about its axis of symmetry 125 mm while its radius of gyration about a diameter of the disc at right angles to the axis of symmetry is 75 mm. The disc is pressed on to the shaft but due to incorrect boring, the angle between the axis of symmetry and the actual axis of rotation is 0.25°, though both these axes pass through the centre of gravity of the disc. Assuming that the shaft is rigid and is carried between bearings 200 mm apart, determine the bearing forces due to the misalignment at a speed of 5000 r.p.m.
57. A wheel of a locomotive, travelling on a level track at 90 km / h, falls in a spot hole 10 mm deep and rises again in a total time of 0.8 seconds. The displacement of the wheel takes place with simple harmonic motion. The wheel has a diameter of 3 m and the distance between the wheel centres is 1.75 m. The wheel pair with axle has a moment of inertia of 500 kg-m2. Determine the magnitude and the effect of gyrocouple produced in this case.
58. Each road wheel of a motor cycle has a mass moment of inertia of 1.5 kg-m2. The rotating parts of the engine of the motor cycle have a mass moment of inertia of 0.25 kg-m2. The speed of the engine is 5 times the speed of the wheels and is in the same sense. The mass of the motor cycle with its rider is 250kg and its centre of gravity is 0.6 m above the ground level. Find the angle of heel if the cycle is travelling at 50 km / h and is taking a turn of 30 m radius. The wheel diameter is 0.6 m.
59. A racing motor cyclist travels at 140 km/h round a curve of 120 m radius measured horizontally. The cycle and rider have mass of 150 kg and their centre of gravity lies at 0.7 m above the ground levelwhen the motor cycle is vertical. Each wheel is 0.6 m in diameter and has moment of inertia about itsaxis of rotation 1.5 kg-m2. The engine has rotating parts whose moment of inertia about their axis of rotation is 0.25 kg-m2 and it rotates at five times the wheel speed in the same direction. Find : 1. The correct angle of banking of the track so that there is no tendency to side slip, and 2. the correct angle of inclination of the cycle and rider to the vertical. [**Hint.** In calculating the angle of banking of the track, neglect the effect of gyroscopic couple]

Course Articulation Matrix (CAM)													
Course Outcome (CO)		Program Outcome (ABET/NBA-(3a-k))											
		a	b	c	d	e	f	g	h	i	j	k
1. Explain equilibrium of forces and calculate static forces at various points in different types of mechanism	(L3,L2)	L	L	H		M			M			M
2. Identify, describe inertia force in a link and calculate fluctuation of energy in flywheel	(L1, L2,L3)	M	M	H		M			L			M
3. Explain method of balancing of rotating masses and to solve analytically and graphically to balance the systems	(L2,L3)	M	M	H		M			L			M
4. Explain method of balancing of reciprocating masses in internal combustion engine, V engine, radial engine and to solve analytically and graphically to balance the systems	(L2,L3)	M	M	H		M			L			M
5. Describe the various types of governors and to understand method of finding controlling force • Describe gyroscopic couple and to understand effect of gyroscopic couple	(L1,L2)	L	L	L		M						M
L – Low, M – Moderate, H - High													

Course Assessment Matrix (CAM)												
Course Outcome (CO)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
1. Explain equilibrium of forces and calculate static forces at various points in different types of mechanism	(L3,L2)	1	1	3		2			2			2
2. Identify, describe inertia force in a link and calculate fluctuation of energy in flywheel	(L1, L2,L3)	2	2	3		2			1			2
3. Explain method of balancing of rotating masses and to solve analytically and graphically to balance the systems	(L2,L3)	2	2	3		2			1			2
4. Explain method of balancing of reciprocating masses in internal combustion engine, V engine, radial engine and to solve analytically and graphically to balance the systems	(L2,L3)	2	2	3		2			1			2
5. Describe the various types of governors and to understand method of finding controlling force • Describe gyroscopic couple and to understand effect of gyroscopic couple	(L1,L2)	1	1	1		2						2
1 – Low, 2 – Moderate, 3 – High												

Course Title: AUXILIARY SYSTEMS OF AUTOMOTIVE ENGINES			
Course Code: P13AU55	Semester: 5	L:T:P:H- 4:0:0:4	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

Subject requires student to know about

Students must have the back ground knowledge of different types of drives like belt drives, chain drives, gear drives and rope drives.

Course Learning Objectives (CLO):

At the end of the course the student should be able to

a) Analyze the mixture requirement for different operating conditions
b) Explain Constructional and working principles of different types of carburetors
c) Design a carburetor
d) Distinguish between petrol injection and carburetor
e) Differentiate between petrol injection and diesel injection system
f) Explain the constructional and principle of operation of different types diesel injection systems
g) Design considerations for diesel injection system
h) Explain the necessity and working of governors in injection system
i) Explain the purpose and advantages of supercharging and turbo charging
j) Distinguish between types and advantages of different types of cooling and lubrication systems.
k) Calculate the quantity of water required for cooling
l) Modifications required in engine for supercharging
m) Distinguish between Lubricants, lubricating systems, Lubrication of piston rings, bearings, oil consumption

Relevance of the course

Auxiliary Systems of Automotive Engines is a course deals with the different ways through which the fuel is supplied to engines and also deals with purpose and different method of cooling, lubrication and super charging and turbo charging and it is hoped that through this programme student will gain sufficient knowledge to make them employable in automotive industries carburetor and fuel injection system manufacturing industries

.Course content

UNIT- I: Petrol Engine Fuel supply system : – Carburetor, principle, properties of A/F mixtures, mixture requirements – steady state and transient, law of mixture preparation in simple carburetor, complete carburetor, types and different makes of carburetors, fuel feed systems, fuel pumps, filters, design of carburetors, Petrol injection – Disadvantages of carburetor, advantages of petrol injection, different types, theory of mixture control, representative types of petrol injection ,principles-construction & performance (bosch K-jetronic fuel injection system) **11 hrs**

UNIT – II: Diesel engine Fuel supply system:– Cleaning systems, transfer pumps, injection pumps(jerk pump, distributor type and CRDI system, system control using EDC), injectors (mechanical and electronic type) and nozzles . Factors influencing the fuel spray atomization, penetration and dispersion of diesel, rate and duration of injection, injection lag, pressure waves in fuel lines. **11 hrs**

UNIT – III: Cooling system – Necessity, variation of gas temperature, Areas of heat flow, heat transfer, piston and cylinder temperature, Heat rejected to coolant, quantity of water required, cooling systems, air cooling, water cooling, thermodynamics of forced circulation, evaporative cooling and pressure cooling. thermostats, regenerative cooling, comparison of air and water cooling, radiators – types, cooling fan - power requirement, antifreeze solution

governors – types, constructional features and operation (maximum speed governors, minimum-maximum speed governors and variable speed governors. **11 hrs**

UNIT – IV: Lubrication system – Principles of lubrication, mechanism of lubrication,elastohydrodynamic lubrication journal bearing lubrication, functions of the lubricating systems, properties and classification of lubricating oils, oil additives, lubricating systems (splash, pressure feed lubrication, dry sump and wet sump lubrication systems), oil filters (centrifugal oil filters), pumps, crankcase ventilation – types

Ignition: Ignition system, requirements of ignition system , battery ignition system, magnato ignition system , modern ignition system (transistorized coil ignition and capacitive discharge ignition system), spark advance mechanisms. **9hrs**

UNIT – V: Supercharging and Turbocharging: Purpose, types of superchargers,Thermodynamic cycle, effects of supercharging, limits of super charging for petrol and diesel engines. Modifications of an engine for supercharging.

Turbocharging : methods of turbocharging (constant pressure,pulse and pulse converter) two stage turbocharging, miller turbocharging and hyperbar turbocharging. dual stage scroll area turbocharged engine system and variable scroll area turbocharged engine system. **10 hrs**

TEXT BOOKS:

1.Heinz Heisler, Advanced engine technology 2002

2.Mathur,M.L., and Sharma,R.P., "A Course in Internal Combustion Engines", Dhanpat Rai Publications (P) Ltd., 1998.

3.Kirpal singh, "Automobile Engineering Vol I & II", Standard Pub, New Delhi, 2005

4.Ramalingam,K.K, Internal Combustion Engine, Scitech Publication (India) Pvt.Ltd.2000.

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1. Domkundwar, V.M, A Course in Internal Combustion Engines, Dhanpat Rai and Co., 1999.

2. Ganesan, V., Internal Combustion Engines, Tata McGraw-Hill Book Co., 2014.

3. Duffy Smith, Auto Fuel Sytstems, The Good Heart Willcox Company Inc., Publishers, 1987.

4. Edward F, Obert, Internal Combustion Engines and Air Pollution, Intext Education Publishers, 1980.

5 .H.B. Keshwani, " I.C engines", Standard publication, New delhi, !982

6. R.K. Mohanty, " Automobile Engineering Vol. I & II " StandardBook house, New Delhi. 2006

7. Automotive mechanics - William H. Crouse, Tata Mc,Graw Hill

8. Publications Co. New Delh

9. Jack Erjavec, " Automotive technology" 3rd Edition, Chennai Micro Thomson Asia Pvt. Ltd, 2004, dual stage scroll area turbocharged engine system and variable scroll area turbocharged engine system.

Course outcomes (COs)

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

1. **Analyze** the mixture requirements for different operating conditions
2. **Explain** the construction and working of different types of carburetors and petrol and diesel injection systems and governors.
3. **Differentiate** between the petrol and diesel injection systems
4. **Differentiate** between inline, distributor and CRDI injection systems
5. **Design** considerations for carburetor and injection system
6. **Explain** the different cooling, lubrication and ignition systems
7. **Distinguish** between different cooling, different lubrication and different ignition systems

Unit wise plan

UNIT-I

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

- Explain the different ways of fuel supply to SI engines. (L2)
- Explain the mixture requirement for different operating conditions.(L2)
- Explain Constructional and working principles of different types of carburetors. (L3)
- Design a carburetor. (L6)
- Distinguish between petrol injection and carburetor. (L4)
- Explain different injection systems. (L2)
- Explain the constructional and principle of operation of BOSCH K- Jetronic injection system. (L3)

Lesson schedule

1. Carburetor principle, properties of a/f mixtures
2. Mixture requirements – steady state and transient, l
3. Law of mixture preparation in simple carburetor, complete carburetor,
4. Types and different makes of carburetors solex carburetor
5. Carter carburetor and s.u. carburetor
6. Fuel feed systems, fuel pumps, filters,
7. Design of carburetors,
8. Petrol injection – disadvantages of carburetion, advantages of petrol injection
9. Different types petrol injection theory of mixture control
10. Bosch -k jetronics injection system
11. Fuel injection pump

UNIT-II

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

- Explain the constructional and working principle of inline injection and distributor injection systems.(L3)
- Explain the constructional, necessity and working principle of different governors.(L3)
- Explain the constructional and working principle of different feed pumps. (L3)
- Analyze the effect of rate of injection ,duration and pressure of injection .(L4)

Lesson schedule

1. Filters and fuel feed pumps
2. Function and necessity of fuel injection pump
3. Types of fuel injection pumps , inline fuel injection pump
4. Distributor type of fuel injection pump
5. CRDI fuel injection system
6. CRDI fuel injection pumps
7. Ratio of piston displacement to fuel charge volume, delivery characteristics, injection lag, pressure waves in fuel lines
8. Fuel pumps governors – types, constructional features and operation (two hrs)
9. Fuel injection and spray characteristics – factors affecting these parameters

UNIT-III

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

- Explain the necessity of cooling in IC engines. (L2)
- Compare the air and water cooling system advantages and disadvantages. (L2)
- Calculate the quantity of water required for cooling. (L3)
- Explain the advantages of pressurized water cooling system. (L2)
- Distinguish between different types of radiators. (L4)
- List the different antifreeze solutions. (L1)
- Purpose of thermostat in cooling system. (L2)
- Explain the necessity and function of different types of governors. (L3)

Lesson schedule

1. Necessity, variation of gas temperature, Areas of heat flow, heat transfer, piston and cylinder temperature,
2. Heat rejected to coolant, quantity of water required
3. Cooling systems, air cooling, water cooling, thermodynamics of forced circulation,
4. Thermostats, pressurized water cooling, regenerative cooling,
5. Comparison of air and water cooling, radiators – types (two hrs)
6. Cooling fan - power requirement, antifreeze solution
7. Purpose and function of governors
8. Constructional features of different types of governors

UNIT-IV

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

1. Explain the necessity of lubrication in IC engines. .(L2)
2. Explain the functions of lubrication system. .(L2)
3. Explain the properties of lubricants. .(L2)
4. Explain the principle of lubrication. .(L2)
5. Explain the requirements of ignition system.(L3)
6. Explain the different types of ignition systems used in automobile.(L3)

Lesson schedule

1.Principles of lubrication, bearing lubrication,
2.Functions of the lubricating systems properties and classification of lubricating oils
3.Oil additives, lubricating systems,
4.Oil filters, pumps,
5.Crankcase ventilation – types
6.Ignition system ,types and battery ignition
7.Modern ignition systems (2 hours)

UNIT-V-

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

- Explain the necessity of supercharging and turbo charging.(L2)
- Explain the limitations of supercharging. (L3)
- Explain the modifications required in SI and CI engines. (L3)
- Explain the different methods of supercharging and turbo charging. (L2)

Lesson schedule

1.Supercharging and Turbo charging: Purpose, Thermodynamic cycle (two hrs)
2.Effect on performance,
3. Limits of super charging for petrol and diesel e engines.
4.Modifications of an engine for super charging
5.Methods of super charging (three hrs)
6.Super charging and turbo charging of two stroke and four stroke engines

Review questions

1. Discuss the mixture requirements for maximum power and minimum specific fuel consumption
2. Discuss mixture requirement for steady and transient condition
3. Explain the basic working principle of a simple carburetor
4. Explain briefly the different systems used in complete carburetor
5. Sketch and explain the working of solex carburetor
6. Sketch and explain the working of carter carburetor
7. Sketch and explain the working of SU carburetor
8. Sketch and explain the A C mechanical and S.U electrical pump
9. Discuss the different types of fuel filters used in petrol engine
10. Discuss the advantages and disadvantages of carburetor and petrol injection systems
11. Differentiate between direct injection ,indirect injection ,continuous and intermittent injection
12. What are the limitations of petrol injection system
13. With schematic diagram explain the working of K-jetronic fuel injection system
14. Sketch and explain the working of air flow sensor and warm-up regulator used in K-jectronic injection system
15. Discuss the requirements of an ideal injection
16. Sketch and explain the jerk type of fuel injection system
17. Sketch and explain the distributor type of fuel injection system
18. With schematic diagram explain the working of common rail fuel injection system
19. Sketch and explain the high pressure pump used in CRDI system
20. Sketch and explain the fuel injector used in CRDI system
21. Differentiate between the injector used in jerk type pump and CRDI system
22. Discuss the factors influencing the fuel spray atomization
23. Explain the terms rate of injection ,duration of injection and injection lag
24. Explain the variation of gas temperature during engine cycle
25. What is the necessity of cooling of an engine and also discuss the temperature profile across the cylinder barrel wall
26. What are the two main types of cooling systems? Where these systems are used ?
27. Sketch and explain the thermostat with disc valve radiator and bypass flow control
28. Sketch and explain the forced circulation cooling system. What are its merits and demerits ?
29. Discuss the different types of radiator matrices commonly used . What are their relative advantages and disadvantages?
30. Why does the diesel engine need a governor? What are the different types of governors ?
31. Sketch and explain the working of minimum-maximum speed governor
32. Sketch and explain the working of variable speed governor
33. Sketch and explain the working of pneumatic governor
34. Differentiate between maximum, minimum-maximum and variable speed governors
35. Explain the various mechanism of lubrication and their functions.
36. Differentiate between lubrication in parallel surfaces and journal bearings
37. Explain and compare the wet sump and dry sump lubrication systems

38. What are the various desired properties of a lubricant and explain how additives help to achieve the desired properties.
39. Discuss the requirements of an ignition system,spark energy and duration
40. With a neat sketch explain the battery ignition system
41. Explain TCI ignition system with a sketch
42. Explain CDI ignition system with sketch
43. Why spark advance is required? With sketch any one of spark advance mechanism
44. Draw a neat sketch of a spark plug explain its various parts.
45. What are the factors that affect the power output of an engine? Explain how supercharging helps to improve the power output.
46. Briefly explain the working of following

a) centrifugal supercharger b) roots supercharger

47. Mention the effect of supercharging on engine performance.
48. What are the limitations of supercharging in an IC engine? Differentiate between supercharging and turbo charging
49. Differentiate between constant pressure and pulse turbo charging
50. Discuss the advantages and disadvantages of pulse turbo charging
51. Sketch and explain the hyper bar turbo charging
52. Sketch and explain the dual stage scroll area turbocharged engine system
53. Sketch and explain dual stage turbo charging and its advantages

Course Articulation Matrix (CAM)												
Course Outcome (CO)		**Program Outcome (ABET/NBA-(3a-k))**										
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1.Analyze the mixture requirement for different operating conditions (L4)	L4							M		M		
2.**Explain** the construction and working of different types of carburettors and petrol and diesel injection systems.	L2				M			M		M		
3.Differentiate between the petrol and diesel injection systems	L4				M			M	M	M		
4.Explain the design considerations for carburettor and injection system	L2	M			M			M	M	M		
5.Explain the different cooling,lubrication and ignition systems	L2				M	M		M		M		
6.**Differentiate** between inline, distributor and CRDI injection systems	L4				M	M		M	M			
7.**Distinguish** between different cooling, different lubrication and different ignition systems	L4				M	M		M	M			
L- Low, M- Moderate, H-High												

Course Assessment Matrix (CaM)												
Course Outcome (CO)		**Program Outcome (ABET/NBA-(3a-k))**										
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1. analyze the mixture requirement for different operating conditions (L4)	**L4**							2		2		
2.**Explain** the construction and working of different types of carburettors and petrol and diesel injection systems.	**L2**				2			2		2		
3. Differentiate between the petrol and diesel injection systems	**L4**				2			2	2	2		
4.Explain the design considerations for carburettor and injection system	**L2**	2			2			2	2	2		
5.Explain the different cooling,lubrication and ignition systems	**L2**				2	2		2		2		
6.**Differentiate** between inline, distributor and CRDI injection systems	**L4**				2	2		2	2			
7.**Distinguish** between different cooling, different lubrication and different ignition systems	**L4**				2	2		2	2			
1 – Low, 2 – Moderate and 3 – High												

Course Title: **AUTOMOTIVE FUELS AND COMBUSTION**			
Course Code: P13AU56	Semester: V	L – T – P-H: 2 – 2 – 0-4	Credits:3
Contact Period - Lecture:52 Hr.; Exam: 3Hr.		Weightage: CIE: 50Marks; SEE: 50 Marks	

Prerequisites:

subject requires students know about:

- Different types of fuels used in IC engines
- Working principle of two stroke, four stroke, SI & CI engines

Course Learning Objectives (CLOs)

This Course aims to:

I. Explain about available energy sources for ICE.
II. Distinguish between properties of difference fuels.
III. Distinguish the properties of automotive fuels.
IV. Discuss the significance of distillation curves & refining process.
V. Determine the A/F ratio for complete combustion.
VI. Distinguish between different cycles.
VII. To lean burnt combustion process in SI&CI engines.
VIII. Able to define the stages of combustion in CI & SI engine.
IX. To study the different types of SI &CI combustion chamber.
X. Design consideration for SI&CI combustion chamber.
XI. To understand the detonation process in SI&CI engines
XII. Define &differentiate between multi fuel& duel fuel engines.
XIII. Discuss the performance characteristics of multi fuel& duel fuel engines.
XIV. Discuss the same recent developments in the field of IC engines.

Relevance of the Course:

Automotive fuels and combustion course deals with understand the properties of IC engine fuels & their ratio system. Requirements for combustion, A/F ratio calculation. To understand &study the different cycles and to derive the relations MEP & efficiency to study the SI&CI engine combustion process &to understand the detonation & knocking process in SI&CI engines to learn about combustion chamber used discuss the same recent developments in the field of ICE like construction & working of duel & multi fuel, VCR, MCF, miller cycle engine, free piston engine etc.

Course Content

UNIT-1:

Energy Sources: Exhaustible sources - crude oil, Natural gas, Inexhaustible sources - Solar energy, Wind power, Tidal Power, Geo-thermal power. Energy from Bio-gas, Synthetic fuels – Fuel Cells, Hydrogen- only a brief introduction.

Liquid Fuels: Origin of petroleum, its chemistry, normal paraffin's, isoparaffins, olefins, naphthalene and aromatics. Refining of petroleum: Fractional distillation, Cracking, Reforming process, Thermal reforming, polymerization, alkylation, and isomerisation. Properties and tests : Specific Gravity, viscosity, flash and fire points, calorific value, rating of fuels, vapour pressure, cloud and pour point, annealing point, diesel index, carbon residue and ash content determination. **10 Hrs**

UNIT-2:

Combustion of Fuels: Combustion equation, conversion of gravimetric to volumetric analysis. Determination of theoretical minimum quantity of air for complete combustion. Determination of air fuel ratio for a given fuel. Numerical problems, flue gas analysis, gas Chromatograph

Petrol and Diesel Fuels: Properties and rating of fuels, chemical energy of fuels, Reaction Equation, Properties of A/F mixture, Lead free gasoline's, low and ultra – low sulphur diesels, LPG, CNG, Alcohols, Biodiesels, Gaseous Fuel Injections, Dual Fueling and Controls – CNG and Gasoline, Hydrogen and Diesel,

Alcohols and Diesels etc.

Cycle Analysis: Otto, Diesel, Dual, sterling and Brayton cycles, comparison of air standard, fuel air and actual cycles, simple problems on the above topics. Rotary engines. Sterling engine, Stratified charge engine. **12 Hrs**

UNIT-3:

Combustion in S.I Engines: Introduction, ignition limits, homogeneous mixture formation, Initiation of combustion, stages of combustion flame velocities, effect of variables on flame propagation, normal and abnormal combustion, knocking combustion, pre-ignition, knock and engine variables, detonation, effects of engine variables on combustion, control of detonation, features and design consideration of combustion chambers.

Combustion in C.I. Engines : Introduction, mixture requirements, Various stages of combustion, vaporization of fuel droplets and spray formation, air motion, swirl, squish, tumble flow, velocities, delay period correlations, diesel knock and engine variables, features and design considerations of combustion chambers, different types of combustion chambers , heat release correlations. **10Hrs**

UNIT-4:

Dual fuel and Multifuel Engines: Introduction, construction and working of dual fuel and multi fuel engines, Combustion in dual fuel engines, Factor affecting combustion. Main types of gaseous fuels, Supercharge knock control & Performance of diesel fuel engines. Characteristics of multi fuel engines, Modification of fuel system, suitability of various engines as multi fuel unit, performance characteristics of multi fuel engines. **10Hrs**

UNIT-5:

ecent developments in IC Engines: Introduction, Stratified charge engine, methods of Stratified charge gine, lean burn engines, VCR engines, Multi Cycle Engines (MCE), CFR engine, BICERI piston, Miller Cycle ıgines, SAAB SVC engines, HCCI engines, Advantages and disadvantages of VCR & free piston engines. **10 Hrs**

TEXT BOOKS:

1. I.C. Engines By Mathur & Sharma, Dhanpat Rai publications, New Delhi, 2012
2. Internal combustion engine by S S Thipse, JAICO publishing house, Mumbai,2012

REFERENCE BOOKS:

1. V Ganesan, Internal Combustion Engines, Tata McGraw Hill, 2005.
2. John B.Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Book, 1998
3. Obert, E.F., Internal Combustion Engine and Air Pollution, International Text Book Publishers, 1983.
4. Ram lingam, K.K., Internal Combustion Engines, SCITECH PUBLICATIONS (INDIA) Pvt. Ltd., 2014.

Course Outcomes

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

I. Explain available energy sources for internal combustion engine.
II. Determine A/F ratio for an given fuel.
III. Distinguish between different cycle.
IV. Explain stages of combustion in SI & CI engines.
V. Design consideration for SI & CI engine combustion chamber
VI. Explain and differentiate between multifuel and duelfuel engines
VII. Explain the recent developments in IC engines.

Unit wise plan:

UNIT-I:

Topic Learning objectives (TLO)

After learning all the units of Unit-1, the student is able to

- Explain different energy sources available
- Explain the production process of petrol & diesel
- Discuss the properties of automotive fuels
- Explain how fuel properties can be determine

Lesson Schedule

1. Exhaustible sources - crude oil, Natural gas, Inexhaustible sources - Solar energy,
2. Wind power, Tidal Power, Geo-thermal power.
3. Energy from Bio-gas,
4. Synthetic fuels – Fuel Cells, Hydrogen- only a brief introduction.
5. Origin of petroleum, its chemistry, normal paraffin's, isoparaffins, olefins, naphthalene and aromatics.
6. Refining of petroleum: Fractional distillation, Cracking, Reforming process,
7. Thermal reforming, polymerization, alkylation, and isomerisation.
8. Properties and tests : Specific Gravity, viscosity, flash and fire points,
9. calorific value, rating of fuels, vapour pressure,
10. cloud and pour point, annealing point, diesel index, carbon residue and ash content determination.

UNIT-II:

Topic Learning objectives (TLO)

After learning all the units of Unit-2, the student is able to

- Write combustion equation
- Determine the minimum quantity of air required for complete combustion of different fuels.
- Analyze the different gas constituents and exhaust using gas chromatograph, etc.,
- Explain the different fuels suitable for SI & CI engines
- Analyze different thermodynamics cycle

Lesson Schedule

1. Combustion equation, conversion of gravimetric to volumetric analysis.
2. Determination of theoretical minimum quantity of air for complete combustion.
3. Determination of air fuel ratio for a given fuel. Numerical problems, flue gas analysis, gas Chromatograph
4. Properties and rating of fuels, chemical energy of fuels, Reaction Equation,
5. Properties of A/F mixture, Lead free gasoline's, low and ultra – low sulphur diesels, LPG, CNG,
6. Alcohols, Biodiesels, Gaseous Fuel Injections, Dual Fueling and Controls – CNG and Gasoline,
7. Hydrogen and Diesel, Alcohols and Diesels etc.
8. Otto, Diesel, Dual, sterling and Brayton cycles,
9. comparison of air standard, fuel air and actual cycles,
10. simple problems on the above topics.
11. Rotary engines. Sterling engine,
12. Stratified charge engine.

UNIT-III:

Topic Learning objectives (TLO)

After learning all the units of Unit-3, the student is able to

- Explain stages of combustion in SI engine
- Explain the normal & ubnormal combustion
- Explain knocking and pre ignition and effect of different variables on the same.

- Design consideration of combustion chamber
- Explain stage of combustion in CI engine
- Explain different air movements in diesel engines
- Design consideration of combustion chambers

Lesson Schedule

1. Introduction, ignition limits, homogeneous mixture formation, Initiation of combustion,
2. stages of combustion flame velocities, effect of variables on flame propagation,
3. normal and abnormal combustion, knocking combustion, pre-ignition,
4. knock and engine variables, detonation, effects of engine variables on combustion,
5. control of detonation, features and design consideration of combustion chambers.
6. Introduction, mixture requirements, Various stages of combustion,
7. vaporization of fuel droplets and spray formation, air motion, swirl, squish, tumble flow, velocities,
8. delay period correlations, diesel knock and engine variables,
9. features and design considerations of combustion chambers,
10. different types of combustion chambers , heat release correlations

UNIT-IV:

Topic Learning objectives (TLO)

After learning all the units of Unit-4, the student is able to

- Differentiate between dual fuel & multi fuel engines
- Explain combustion in dual fuel & multi fuel engines
- Explain characteristics of multi fuel engines
- Explain modification of engines for dual fuel & multi fuel operations

Lesson Schedule

1. Introduction, construction and working of dual fuel engine
2. construction and working of multi fuel engine
3. Combustion in dual fuel engines,
4. Factor affecting combustion.
5. Main types of gaseous fuels,
6. Supercharge knock control & Performance of diesel fuel engines.
7. Characteristics of multi fuel engines,
8. Modification of fuel system,
9. suitability of various engines as multi fuel unit,
10. performance characteristics of multi fuel engines

UNIT-V:

Topic Learning objectives (TLO)

After learning all the units of Unit-5, the student is able to

- Explain construction & working of stratified charged engine
- Explain purpose and advantages of VCR and free piston engine
- Explain the lean burn engine and their advantages

Lesson Schedule

1. Introduction, Stratified charge engine,
2. methods of Stratified charge engine,
3. lean burn engines,
4. VCR engines,
5. Multi Cycle Engines (MCE),
6. CFR engine, BICERI piston,
7. Miller Cycle Engines,

8. SAAB SVC engines,
9. HCCI engines,
10. Advantages and disadvantages of VCR & free piston engines

Review Questions

Unit 1

1. What are the exhaustible &in exhaustible energy sources
2. What are the primary and secondary energy sources
3. Discuss briefly the possibilities of utilizing the following methods of power generation Solar energy .Magneto hydrodynamics , fuel cells.
4. Explain briefly (a)wind energy,(b)tidal power,(c)geothermal power.
5. What are the advantages and disadvantages of following (a) bio gas (b) synthetic fuels (c) hydrogen.
6. What are the types of fuel cells and explain.

Unit 2

1) Explain and derive an expression for thermal efficiency of otto cycle
2) Explain and derive an expression for thermal efficiency of diesel cycle.
3) Explain the concept of duel cycle.
4) Differenciate between otto &diesel cycle.
5) Describe the stratified charge engine.
6) Describe the brayton cycle in details.
7) Sketch and explain briefly about gas chromatograph.
8) What are the properties of fuels?
9) How SI engine fuels are rated?
10) How CI engines fuels are rated?
11) What is octane& cetane no how is it found
12) Discuss the basic requirements of a diesel fuel
13) Discuss the use of LPG as SI engine fuel
14) Explain (a)ALCOHOL (b) Gaseous fuel (c) Hydrogen (d)CNG (e) LPG
15) Describe the method of producing hydrogen
16) What are properties of A/F mixtures.

Unit 3

1) Discuss &explain homogeneous mixture formation
2) What are the harmful effects of detonation
3) Discuss the effects of engine variables on flame propagation.
4) What are the requirements of a good combustion chamber
5) What are factors which affect detonation in SI engines?
6) What are the features & design considerations of combustion chambers
7) What are the stages in SI engine combustion?
8) Write the difference between normal & abnormal combustion.
9) What are the methods to control of knocking in SI engines
10) Explain the effect of engine variables on knocking.
11) Briefly explain detonation & knocking.
12) Briefly explain the factors affecting of ignition lag
13) What are the advantages &disadvantages of the CI engine compare to the SI engine?
14) Explain the stages of combustion in a CI engine.
15) What is meant by delay period? Describe them.
16) What is the importance of delay period? Should the delay period be zero?
17) Discuss the variables affecting the delay period
18) Explain the phenomenon of diesel knock? Compare with SI engine

19) What are the factors to increase detonation in SI engines tend to reduce knock in CI engines
20) How do the injection timing & the fuel quality affect the engine knock?
21) What are three methods of generating swirl in CI engine combustion chamber
22) How CI engine combustion chamber are classified? What types of swirl is used in this chamber
23) Discuss the advantages &disadvantages of induction swirl
24) Show with sketches how compression swirl is created?
25) Explain the factors &design considerations of combustion chambers

Unit 4

1) What is a dual fuel engines? Where this types of engines find application?
2) Describe with a sketch of dual fuel engine &comment on its performance
3) How dual fuel operation can be achieved?
4) What is a multi fuel engine? Where this type of engine finds applications
5) What are the various ways of achieving multi fuel operations
6) Discuss the performance of multi fuel engines on variable fuels
7) Explain the advantages and disadvantages of dual fuel engines
8) Explain the advantages and disadvantages of multi fuel engines
9) What are the factors affecting on combustion in a dual fuel engine
10) What are the characteristics of multi fuel engines
11) Describe the modification of fuel system in multi fuel engine
12) Explain the supercharged &knock control in dual fuel engines.

Unit 5

1) What is stratified charge engine? Explain briefly
2) What are the important methods of charge stratification?
3) What are the advantages of burning leaner overall fuel air mixtures?
4) Describe the methods of stratifications
5) Explain with neat sketch multi cycle engine (MCE)
6) Explain with neat sketch CFR engine
7) Explain with neat sketch SVC engine
8) Explain the advantages of VCR engine
9) Describe the functions of HCCI engines
10) What is free piston engines? Explain its function
11) Explain the miller cycle engine &free piston engine.

Course Articulation Matrix (CAM)

Course Outcome (CO)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
I. Explain available energy sources for internal combustion engine.								H		M		
II. Determine A/F ratio for an given fuel.		M	M					M		M		
III. Distinguish between different cycle.								M		M		
IV. Explain stages of combustion in SI & CI engines.										M		
V. Design consideration for SI & CI engine combustion chamber				M				M		M		
VI. Explain and differentiate between multifuel and duelfuel engines								M		M		
VII. Explain the recent developments in IC engines.								M		M		M
L – Low, M – Moderate, H - High												

Course Assessment Matrix (CAM)

Course Outcome (CO)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
I. Explain available energy sources for internal combustion engine.								3		2		
II. Determine A/F ratio for an given fuel.		2	2					2		2		
III. Distinguish between different cycle.								2		2		
IV. Explain stages of combustion in SI & CI engines.										2		
V. Design consideration for SI & CI engine combustion chamber				2				2		2		
VI. Explain and differentiate between multifuel and duelfuel engines								2		2		
VII. Explain the recent developments in IC engines.								2		2		2
1 – Low, 2 – Moderate, 3 – High												

Course Title: **DIAGNOSIS AND RECONDITIONING LAB**			
Course Code: **P13AUL57**	Semester: V	L:T:P:H- 0:0:3:3	Credits: 1.5
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.	Weightage : CIE:50%; SEE:50%		

Prerequisites:

The student should have undergone the course on: Auxiliary systems of Automotive vehicle and different operation in various machines and use of different measuring instruments.

Course Learning Objective (CLO):

This Course aims to,

1. Learning calculation of reboring ,brake drum skimming, valve refacing, connecting rod alignment
2. Practically involving in different operation in calibration of FIP
3. Practically involving in principle and different operation of wheel alignment and wheel balancing
4. Practically involving in different operation in body repair and painting
5. To visit at least five different automotive industries

Course Content

PART-A

1. Inspection of vehicles and preparation of test charts.
2. Tuning of Engines: Check for ignition timing, valve tappet clearance, Radiator flushing and check for leaks ete.,
3. Study and practice on :
   - Connecting rod alignment
   - Cylinder reboring machine
   - Valve refacing machine
   - Nozzle grinding machine
   - Brake drum skimming machine
4. Servicing of components like FIP, Carburetor, Fuel pump, Exhaust pipes and Silencer, Lubricating system, Air compressor, shock absorber, Calibrations of FIP.

Part – B

5. Study and practice of wheel alignment (Mechanical and computerized) and wheel balancing
6. Testing of Two wheeled vehicles on chassis dynamometer
7. Study of tyre retreading and vulcanizing
8. Study and practice on body repairs – tinkering and painting
9. Head light focusing test and visibility test
10. Students have to visit at least five different automotive industries in which at least one automotive manufacturing unit. Report to be submitted on Industrial visit.

C-Evaluation Scheme

CIE Scheme

Assessment	**Weightage in Marks**
TEST	20
Assignment/Record	30
Total	**50**

SCHEME OF EXAMINATION:

Semester End Examination (SEE) is a practical examination of three hours duration of 50 marks.

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

Course plan

Session		hours
1	Inspection of vehicles and preparation of test charts.	Three
2	Tuning of Engines: Check for ignition timing, valve tappet clearance, Radiator flushing and check for leaks ete.,	Three
3	Study and practice on Connecting rod alignment Cylinder reboring machine	Three
4	Valve refacing machine Nozzle grinding machine Brake drum skimming machine	Three
5	Servicing of components like FIP, Carburetor, Fuel pump, Exhaust pipes and Silencer, Lubricating system, Air compressor, shock absorber,	Three
6.	Calibrations of FIP	Three
7	Study and practice of wheel alignment (Mechanical and computerized)	Three
8	wheel balancing	Three
9	Testing of Two wheeled vehicles on chassis dynamometer	Three
10	Study of tyre retreading and vulcanizing Study and practice on body repairs – tinkering	Three
11	Painting and Head light focusing test and visibility test	Three
12	Test	Three
13	Repetition of all the experiment and evaluating industrial visit repot	Three

Course Articulation Matrix

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
Learning calculation of reboring ,brake drum skimming, valve refacing, connecting rod alignment	**M**	**L**			**L**						
Practically involving in different operation in calibration of FI	**H**	**M**			**L**						
Practically involving in principle and different operation of wheel alignment and wheel balacing	**H**	**M**			**L**						
Practically involving in different operation in body repair and painting	**H**	**M**			**L**						
To visit at least five different automotive industries	**H**	**M**	**L**		**L**						

Course Assessment Matrix

	Program Outcomes										
Course Outcomes	1	2	3	4	5	6	7	8	9	10	11
Learning calculation of reboring ,brake drum skimming, valve refacing, connecting rod alignment	**2**	**1**			**1**						
Practically involving in different operation in calibration of FI	**3**	**2**			**1**						
Practically involving in principle and different operation of wheel alignment and wheel balacing	**3**	**2**			**1**						
Practically involving in different operation in body repair and painting	**3**	**2**			**1**						
To visit at least five different automotive industries	**3**	**2**	**L**		**1**						

Course Title: FUEL TESTING AND MEASUREMENT LAB			
Course Code: P13AUL58	Semester:V	L:T:P:H- 0:0:3:3	Credits: 1.5
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisities:

Subject requires student to know about
Properties of fuel used in I C engines
Properties of lubricants used in I C engines
Automotive engines operation
Use of different instruments used in automotive industry/ workshop

Course learning objectives (CLOS)

1. **Determine** the properties of any given fuel.
2. **Determine** the properties of any given lubricating oil.
3. **Draw** a valve timing /port timing diagram for an engine
4. **Determine** the coefficient of discharge of venturi meter, orifice meter.
5. **Calibrate** the instruments used in automobile lab like pressure gauge, thermocouple, load cell and micrometer etc.,

Course content

PART -A

1. Determination of flash and fire point of lubricating oil using abel pensky martins apparatus.
2. Determination of calorific value of solid , liquid and gaseous fuels.
3. Determination of viscosity of a lubricating oil using Redwoods, saybolts and torsion viscometer.
4. Valve timing/port opening diagram of an I C engine.
5. Measurement of areas of irregular figures using planimeter.
6. Determination of compression ratio

PART- B

1) Calibration of pressure gauge
2) Calibration of thermocouple
3) Calibration of load cell.
4) Calibration of vernier caliper and micrometer.
5) Measurement of angle using sine bar/ sine center / bevel protractor.
6) Determination of coefficient of discharge of venturi meter, orifice meter.

Scheme of Examination

One question from part –A : 20 marks
One question from part –B : 20 marks
Viva – voce : 10 marks

Semester: VI

Course Title: **AUTOMOTIVE CHASSIS AND SUSPENSION**			
Total Contact Hours: 52	Course Code: **P13AU61**	L:T:P:H- 4:0:0:4	Credits:4
CIE marks: 50: SEE marks: 50		Duration of Exam: 3 Hrs.	

Prerequisites:

Subject requires student to know about

- Basics of Engineering Mathematics and
- Engineering mechanics
- Basics of Automobile

Course Learning Objectives (CLO):

This Course aims to

I. **Identify, Explain** different chassis layouts and frames **solve** for stability and weight distribution and suitability of frames. (L1, L2, L3)

II. **Identify, Describe,** about various Front Axles, factors of wheel alignment Steering Systems and **Calculate** dimensions of Front Axle. (L1, L2, L3)

III. **Identify, Interpret**, about various types Propeller Shaft, Differential And Rear Axles, **solve** numerical. (L1, L2, L3)

IV. **Identify, Compare**, about various types of Brakes, **solve** numerical. (L1, L2, L3)

V. **Identify, Describe**, About Various Types of Suspensions, Wheels and Tyres. **Calculate** dimensions of different suspensions. (L1, L2, L3)

Relevance of the course

Automotive chassis and suspension is a foundation course in BE (automobile engineering) program that helps for the understanding, types of automobiles, the basic principles of operation of chassis and suspension components of automobiles.

Further this course also helps to understand different types, function, materials, construction details, troubles and remedies and calculation of major dimensions of the major chassis and suspension components of automobiles

Course Content

UNIT- 1 - INTRODUCTION, CHASSIS FRAMES

Introduction - General consideration relating to chassis layout, types of automobiles, power plant location, layout of an automobile with reference to power plant, weight distribution, stability, Numerical problems. **Frames** - Types of frames, general form and dimensions, materials, frame stresses, frame sections, cross members, proportions of channel sections, constructional details, loading points, sub frames, passenger car frames, X member type frame, Box section type frame, testing of frames, bending and torsion test, effect of brake application of frame stresses, truck frames, defects, Case studies, Numerical problems. 10 Hrs

UNIT- 2 - FRONT AXLE AND STEERING SYSTEMS

Front Axle Axle parts and materials, loads and stresses, centre sections, section near steering head, spring pads, front axle loads, steering heads, factors of wheel alignment, wheel balancing, centre point steering, correct steering angle. **Steering Systems** steering mechanisms, cornering force, self righting torque, under steer and over steer, Steering linkages, steering gears, special steering columns, power steering, trouble shooting, Case studies, Numerical problems. 11 Hrs

UNIT-3 - PROPELLER SHAFT, DIFFERENTIAL AND REAR AXLE

Propeller shafts: - Construction and types of propeller shafts, whirling of propeller shaft, universal joints, analysis of Hooke's joint- ratio of shafts velocities, maximum and minimum speeds of driven shaft, condition for equal speeds of thee driving and driven shafts, angular acceleration of the driven shaft, maximum fluctuation of speed, double Hooke's joint, Numerical problems. Final drive- construction details, types. **Differential**: - Principle, types of differential gears, conventional and non-slip differentials,

backlash, differential lock, inter-axle differential, transaxle types. **Rear axle**: - Torque reaction, driving thrust, Hotchkiss drive, torque tube drive, construction of rear axle shaft supporting- fully floating and semi floating arrangements axle housings, trouble shooting, Case studies, numerical problems. 10 Hrs

UNIT-4 - BRAKES

Brakes - Necessity, stopping distance and time, brake efficiency, weight transfer, brake shoe theory, determination of braking torque, classification of brakes, types, construction, function, operation, braking systems - mechanical, hydraulic, disc, drum, details of hydraulic system, mechanical system and components, types of master and wheel cylinders, bleeding of brakes, brake drums, brake linings, brake fluid, factors influencing operation of brakes such as operating temperature, lining, brake clearance, pedal pressure, linkages etc, Numerical problems. Brake compensation, Parking and emergency brakes, hill holder, automatic adjustment, servo brakes, Power brakes-Air brakes, wagner air brake, vacuum brakes and electric brakes and components brake valve, unloaded valve, diaphragm, air-hydraulic brakes, vacuum boosted hydraulic brakes, trouble shooting, Case studies, Numerical problems. 11 Hrs

UNIT-5 -SUSPENSION and WHEELS AND TYRES

Suspension - Objects, basic considerations, Types of suspension springs, construction , operation and materials, leaf springs, coil springs, torsion bar, rubber springs, plastic springs, air bellows or pneumatic suspension, hydraulic suspension, constructional details of telescopic shock absorbers, independent suspension, front wheel independent suspension, rear wheel independent suspension, types, stabilizer, trouble shooting, Numerical problems. **Wheels and Tyres** - Types of wheels, construction, structure and function, wheel dimensions, structure and function of tyres, static and dynamic properties of pneumatic tyres, types of tyres, materials, tyre section and designation, factors affecting tyre life, quick change wheels, special wheels, trouble shooting, Case studies. 10 Hrs

TEXT BOOKS:

1. Heldt.P.M.- "Automotive Chassis"- Chilton Co., (Nyack, N.Y., P.M. Heldt, 1945) Literary Licensing, LLC, 2012
2. N.K. Giri, Automotive Mechanics, 8th Edition , Khanna Publications, New Delhi,2008

REFERENCE BOOKS:

1. Kirpal Singh Automobile Engineering Vol. I, 12th edition, Standard publications, New Delhi, 2009
2. K.K.Ramalingam - "Automobile Engineering" – Scitech Publication, Chennai – 2011
3. P.L. Kohli, Automotive chassis and body, TMH
4. Giles.J.G- "Steering, Suspension and tyres"- Iiiffe Book Co., London- 1988.
5. Crouse W.H- "Automotive Chassis and Body"- McGraw-Hill, New York- 1971.

Course Outcomes (COs)

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

1. **Identify, Explain** different chassis layouts and frames and **solve** for stability and weight distribution and suitability of frames. (L1, L2, L3)
2. **Identify, Describe,** about various Front Axles, factors of wheel alignment Steering Systems and **Calculate** dimensions of Front Axle. (L1, L2, L3)
3. **Identify, Interpret**, about various types Propeller Shaft, Differential and Rear Axles, **solve** numerical. (L1, L2, L3)
4. **Identify, Compare**, about various types of Brakes, **solve** numerical. (L1, L2, L3)
5. **Identify, Describe**, About Various Types of Suspensions, Wheels and Tyres. **Calculate** dimensions of different suspensions. (L1, L2, L3)

Evaluation Scheme-CIE Scheme

Assessment	Weightage in marks
Test 1	**35**
Quiz 1	**05**
Test 2	**35**
Quiz 2	**05**
Assignments	**10**
Total	**50**

SEE Scheme

Semester End Examination (SEE) is a written examination of three hours duration of 100 marks with 50% weightage.

Course Unitization for Tests and Semester End Examination

Examination	Portions to be covered	Maximum Marks
CIE - I	40% of the syllabus	50
CIE - II	40% of the syllabus	50
SEE	Complete Syllabus	100

Unit wise plan

UNIT-1

Topic Learning Objectives (TLO): (L1, L2, L3**)**

At the end of this chapter student should be able to **Identify and Explain and/ solve** about

- Components of an automobile, The basic structure
- Conventional construction
- Car body styles,
- Transport vehicles
- Classification of automobiles,
- Automobiles and Chassis requirements.
- Different Chassis layouts and power transmissions
- Different power plant locations
- Distribution of weight in an automobile, Derivation and to solve numerical on the same
- Stability of an automobile on a slope, Derivation and to solve numerical on the same.
- Vehicle dimensions
- Automobile frames, constructional details and proportions
- Functions of the frame, Frame construction
- Loads on the frame
- Materials for frame,
- frame stresses, effect of brake application,
- loading points and sub frames
- Frameless construction
- Passenger car frames and truck frames
- Testing of frames,
- defects in frames
- solve numerical on suitability of frame
- Case studies pertaining to current developments.

Lesson Schedule

1. Introduction and Components of an automobile, The basic structure, Conventional construction
2. Classification of automobiles and chassis based on various considerations Car body styles, Transport vehicles, Vehicle dimensions
3. Requirements of automobiles and Chassis, Chassis layouts - 2×4, 4×4
4. Power plant location, merits and demerits of various types
5. weight distribution in an automobile - Derivation, numerical
6. Stability of an automobile on a slope Derivation, numerical.
7. Automobile frames, constructional details and proportions, Functions of the frame, Frame construction, Loads on the frame, Materials for frame
8. Frame stresses, effect of brake application, loading points and sub frames
9. Passenger car frames and truck frames, Testing of frames, defects of frames
10. solve numerical on suitability of frame, Case studies pertaining to current developments

UNIT – 2

Topic Learning Objectives (TLO): (L1, L2, L3**)**

At the end of this chapter student should be able to **Identify, Explain and/ Solve** about

- Front axle.
- Axle parts and materials, loads and stresses, centre sections, section near steering head, spring pads, front axle loads, steering heads,
- Factors of wheel alignment,
- Factors pertaining to wheels
- Steering geometry,
- Camber, King Pin inclination (Steering Axis Inclination), Combined angle and, Castor, Toe-in in Toe-out Scrub radius, centre point steering,
- Correct steering angle,
- Steering mechanisms. Ackermann Mechanism, Davis Mechanism
- Cornering force, Self-righting torque, under steer and over steer.
- Steering systems, steering linkages
- Steering linkage for vehicle with rigid axle front suspension
- Steering linkage for vehicle with independent front suspension.
- Steering gears
- Worm and wheel steering gear, Cam and double roller steering gear, Worm and nut steering gear, Recirculating ball type steering gear, Rack and pinion steering gear, Steering ratio, Reversibility
- Special steering columns
- Energy absorbing steering column, Tilt wheel steering column, Tilt and telescopic steering columns, Steering column with anti-theft lock .
- Power steering
- Four wheel steering
- Steering adjustments, Adjustment of steering geometry, Adjustment of steering gear, Checking of wheel alignment and steering geometry.
- Trouble shooting
- Numerical problems,
- Case Studies pertaining to current developments

Lesson Schedule

1. Front axle - Axle parts and materials, loads and stresses, centre sections, section near steering head, spring pads, front axle loads, steering heads,
2. Factors of wheel alignment-Factors pertaining to wheels, Steering geometry, Camber, King Pin inclination (Steering Axis Inclination), Combined angle and, Castor, Toe-in in Toe-out Scrub radius, centre point steering, Cornering force, Self-righting torque, Understeer and oversteer
3. Correct steering angle, steering mechanisms. Ackermann Mechanism, Davis Mechanism
4. Numerical problems,
5. Steering systems, steering linkages, Steering linkage for vehicle with rigid axle front suspension, Steering linkage for vehicle with independent front suspension
6. Steering gears, Worm and wheel steering gear, Cam and double roller steering gear, Worm and nut steering gear, Recirculating ball type steering gear, Rack and pinion steering gear, Steering ratio, Reversibility
7. Special steering columns, Energy absorbing steering column, Tilt wheel steering column, Tilt and telescopic steering columns, Steering column with anti-thaft lock .
8. Power steering
9. Steering adjustments, Adjustment of steering geometry, Adjustment of steering gear, Checking of wheel alignment and steering geometry, Trouble shooting
10. Numerical problems,
11. Case Studies pertaining to current developments, Four wheel steering.

UNIT – 3

Topic Learning Objectives (TLO): (L1, L2, L3**)**

At the end of this chapter student should be able to **Identify, Explain and/ Solve** about

- Propeller shaft
- Construction and types of propeller shafts, whirling of propeller shaft,
- Universal joints, analysis of Hooke's joint- ratio of shafts velocities, maximum and minimum speeds of driven shaft, condition for equal speeds of thee driving and driven shafts, angular acceleration of the driven shaft, maximum fluctuation of speed,
- Double Hooke's joint,
- Numerical problems
- Propeller shaft trouble shooting.
- Final drive, Construction details, types.
- Differential
- Principle, types of differential gears, conventional and non-slip differentials, backlash, differential lock, inter-axle differential, transaxle types
- Rear axle, Torque reaction, driving thrust,
- Rear axle drives-Hotchkiss drive, torque tube drive,
- Construction of rear axle shaft supporting- fully floating and semi floating Three quarter floating axle arrangements, axle housings,
- Trouble shooting
- Numerical problems
- Case studies pertaining to current developments

Lesson Schedule

1. Propeller shaft- Construction and types of propeller shafts, whirling of propeller shaft,
2. Universal joints, analysis of Hooke's joint- ratio of shafts velocities, maximum and minimum speeds of driven shaft, condition for equal speeds of thee driving and driven shafts, angular acceleration of the driven shaft, maximum fluctuation of speed,
3. Double Hooke's joint, Numerical problems, Propeller shaft trouble shooting .

4. Final drive, Construction details, types.
5. Differential-Principle, types of differential gears, conventional and non-slip differentials, backlash, differential lock, inter-axle differential, transaxle types
6. Rear axle, Torque reaction, driving thrust,
7. Rear axle drives-Hotchkiss drive, torque tube drive,
8. Construction of rear axle shaft supporting- fully floating and semi floating Three quarter floating axle arrangements, axle housings,
9. Trouble shooting, Numerical problems
10. Case studies pertaining to current developments

UNIT – 4

Topic Learning Objectives (TLO): (L1, L2, L3**)**

At the end of this chapter student should be able to **Identify, Explain and/ Solve** about

- Principle, Braking requirements, Brake efficiency and stopping distances, fading of brakes. Wheel skidding
- Weight transfer.-Derivation, Numerical
- Types of brakes-Purpose,. Location, Construction, Method of actuation, Extra braking effort.
- Drum brakes-Construction and types, Factors influencing braking effect, Theoretical analysis
- Disc brakes, Construction, Constructional features, Comparison of disc and drum types
- Mechanical brakes-Brake shoe operation, Linkage, Brake compensation, Girling mechanical brake, Construction and working. Brake Compensation.
- Hydraulic brakes-Layout and components, Two shoe leading brake, Brake shoe adjusters, Automatic brake adjusters, , Bleeding of hydraulic brakes, Advantages of hydraulic system, I Brake fluid
- Electric brakes, Servo brake systems-Servo mechanism, Mechanical servo mechanism, Disc brake with servo action, Vacuum servo brakes, Bendix Hydromax brakes Engine exhaust brakes
- Airbrakes-Layout, Unloader valve, Reservoir, Brake valve, Hand control valve, Brake chamber, Slack adjuster, Wagner air brake, Advantages of air brake
- Hand brake, Hill holding device
- Brake drums, Brake shoes, Brake linings-Types, Attachment of brake linings, Disc brake pads
- Antilock Brake Systems (ABS). .
- Inspection of brake system, Adjustment of brakes, Replacing brake lining, Servicing disc brakes
- Brake maintenance, Braking system trouble shooting, Numercals
- Case studies pertaining to current developments

Lesson Schedule

1. Principle, Braking requirements, Brake efficiency and stopping distances, Fading of brakes. Wheel skidding
2. Weight transfer.-Derivation, Numerical
3. Types of brakes-Purpose,. Location, Construction, Method of actuation, Extra braking effort. Drum brakes-Construction and types, Factors influencing braking effect, Theoretical analysis
4. Disc brakes, Construction, Constructional features, Comparison of disc and drum types. Mechanical brakes-Brake shoe operation, Linkage, Brake compensation, Girling mechanical brake, Construction and working. Brake Compensation.
5. Hydraulic brakes-Layout and components, Two shoe leading brake, Brake shoe adjusters, Automatic brake adjusters, , Bleeding of hydraulic brakes, Advantages of hydraulic system, I Brake fluid
6. Electric brakes, Servo brake systems-Servo mechanism, Mechanical servo mechanism, Disc brake with servo action. Vacuum servo brakes. Bendix Hydromax brakes. Engine exhaust brakes

7. Airbrakes-Layout, Unloader valve, Reservoir, Brake valve, Hand control valve, Brake chamber, Slack adjuster, Wagner air brake, Advatages of air brake
8. Hand brake, Hill holding device, Brake drums, Brake shoes, Brake linings-Types, Attachment of brake linings, Disc brake pads
9. Antilock Brake Systems (ABS).
10. Inspection of brake system, Adjustment of brakes, Replacing brake lining, Servicing disc brakes. Brake maintenance, Braking system trouble shooting
11. Numerical, Case studies pertaining to current developments

UNIT – 5

Topic Learning Objectives (TLO): (L1, L2, L3**)**

At the end of this chapter student should be able to Identify, Explain and/ Solve about

- suspension - Objects of suspension, Basic requirements, Function of suspension springs
- Types of suspension springs-Leaf springs- Construction, Types, Helper springs, Material, Tapered leaf springs, Fiber composite leaf springs, Coil springs, Torsion bars, Rubber springs
- Shock absorbers (Dampers)-Introduction, Telescopic type shock absorber, Lever arm type shock absorber, Shock absorber ratio, electronically controlled shock absorbers.
- Independent suspension, Introduction, Front wheel (dead axle) independent suspension, Rear wheel (live axle) independent suspension
- Stabilizer or anti-roll device, Interconnected suspension systems
- Air suspension, Hydrolastic suspension, Hydragas interconnected suspension system
- Suspension system trouble shooting, Numerical problems
- Wheels and tyres- Types of wheels.-Disc wheel, Wire wheel, Light alloy cast or forged wheel
- Wheel dimensions
- Tyre - Desirable tyre properties.
- Types of tyres- Conventional tubed tyre, Tubeless tyre.
- Carcass types.-Comparison of radial-and bias-ply tyres .
- Tyre materials, Considerations in tread design
- Tyre section, Tyre designations.
- Tyre wear indicators, Factors affecting tyre life, Precautions regarding the tyres
- Flat running tyres.
- Wheel and tyre trouble shooting.
- Case studies pertaining to current developments

Lesson Schedule

1. suspension - Objects of suspension, Basic requirements, Function of suspension springs, Types of suspension springs-Leaf springs- Construction, Types, Helper springs, Material, Tapered leaf springs, Fiber composite leaf springs, Coil springs, Torsion bars, Rubber springs
2. Shock absorbers (Dampers)-Introduction, Telescopic type shock absorber, Lever arm type shock absorber, Shock absorber ratio, electronically controlled shock absorbers.
3. Independent suspension, Introduction, Front wheel (dead axle) independent suspension, Rear wheel (live axle) independent suspension
4. Stabilizer or anti-roll device, Interconnected suspension systems
5. Air suspension, Hydrolastic suspension, Hydragas interconnected suspension system
6. Suspension system trouble shooting
7. Numerical problems
8. Wheels and tyres- Types of wheels.-Disc wheel, Wire wheel, Light alloy cast or forged wheel, Wheel dimensions
9. Tyre - Desirable tyre properties, Types of tyres- Conventional tubed tyre, Tubeless tyre. Carcass types.-Comparison of radial-and bias-ply tyres, Tyre materials, Considerations in tread design

10. Tyre section, Tyre designations, Tyre wear indicators, Factors affecting tyre life, Precautions regarding the tyres, Flat running tyres, Wheel and tyre trouble shooting. Case studies pertaining to current developments

Review Questions

UNIT – 1

1. What are the main components of an automobile? Describe all of them briefly.
2. Discuss the functions of the transmission system in automobiles.
3. Compare the merits and demerits of the frameless construction with those of the conventional framed construction.
4. Draw schematic diagrams showing the layout of the transmission system of a rear wheel driven car and also of a four wheel drive vehicle.
5. Describe various component-layouts for automobiles and discuss the advantages and disadvantages of each.
6. How do you classify automobiles? Explain in detail giving examples.
7. Discuss various styles of car bodies giving examples.
8. Name important transport vehicles and describe the salient features of each.
9. Name major components of an automobile.
10. State the advantages of frameless construction. What are its disadvantages?
11. Name a few layouts of automobile components. What advantages are there in case of front wheel drive? What is the main advantage of the four wheel drive vehicle?
12. State various considerations on the basis of which automobiles are classified.
13. Give typical examples of cars with (a) rear wheel drive (b) front wheel drive.
14. What are the salient features of a (a) saloon car (b) coupe (c) estate car (d) van (e) articulated vehicle? Name a few types of transport vehicles.
15. What are different types of frames? What do you mean by Sub frames? Sketch and explain X member type and Box type passenger car frames.
16. With necessary sketch, Derive expressions for stability of a vehicle on a slope.
17. Derive the expressions for weight distribution in case of three wheeled and four wheeled vehicles.
18. Sketch and explain the testing of automotive frames for Linear and Angular Deflections?
19. A vehicle of total weight 49050Nis held at rest on slope of 10^0. It has a wheel base of 2.25m and its centre of gravity is 1.0m in front of the rear axle and 1.5m above the ground level.
    - What are the normal reactions at the wheels?
    - Assume that sliding does not occur first, what will be the angle of slope so that the vehicle will overturn?
    - Assuming all the wheels are to be braked, what will be the angle of the slope so that the vehicle will begin to slide if the coefficient of adhesion between the tyre and the ground is to be 0.35?
20. Explain briefly the various types of chassis construction with the help of suitable diagrams. Make a list of various components mounted on the chassis.
21. Write a brief note on sub-frames.
22. How do you check the alignment of chassis frame? Explain clearly.
23. What are the functions of a frame? Name three types of chassis construction.
24. Name various components mounted on the chassis frame. 4 What are the loads coming on a chassis frame? What is the effect of weight of vehicle and passengers on the frame side members?
25. What type of stresses are produced in the side members while cornering?
26. Why are the side members of a frame upswept at two places?
27. Why is the frame narrow at the front?
28. Which section has maximum resistance to (i) bending (ii) torsion? 10. What are the materials used for chassis frames and body?

UNIT – 2

1. Sketch front axle of a car and show how it is connected with the stub axle.
2. Discuss various factors of wheel alignment.
3. Explain the terms: camber, castor, steering axis inclination and toe-in. What are the effects of each on the steering characteristics of a vehicle?
4. What is perfect steering? Derive expression for the basic condition for a perfect steering mechanism. Discuss in detail the Ackermann steering mechanism.
5. Define cornering force. What is the effect of slip angle, inflation pressure and tyre load on the cornering force? What is self-righting torque?
6. What do you understand from the terms: over steer, under steer, cornering power and slip angle?
7. Discuss a steering linkage for a vehicle with independent suspension.
8. What do you understand by backlash in steering gears? Sketch any one steering gear and explain the constructional features provided to adjust backlash.
9. Sketch a recirculating ball type steering gear and explain its working.
10. Describe in detail the rack and pinion type manual steering gear by means of a simple sketch and discuss its advantages.
11. Discuss various types of special steering columns for safety and ease of operation.
12. Explain the necessity of power steering in an automobile. Sketch any power steering system and explain its working.
13. Discuss in detail various adjustments in the steering geometry and the steering gear.
14. Describe in details the equipment to check wheel alignment and steering geometry.
15. Discuss any type of computerized wheel alignment equipment, describing various steps for inspection of vehicle before proceeding with wheel alignment.
17. Explain the probable causes of various steering troubles and suggest suitable remedies. A car with a wheelbase 2.45 m has pivot centres 1.1m. The track distance between tyre centre lines is 1.2 m. If the angle of lock is 30° and tyre width 100 mm determine the minimum radius of the outer turning circle.
18. A motor car has a wheel base of 2.743 m and pivot centres 1.065 m apart. The front and rear wheel track is 1.217 m. Calculate the correct angle of outside lock and turning circle radius of the outer front and inner rear wheels when the angle of inside lock is 40°.
19. A car using rack and pinion type steering gear has steering wheel of 300 mm diameter and pinion with 5 teeth of 10 mm pitch. Determine the effort required by each hand at the steering wheel to overcome a load of 600 N at the rack
20. State the requirements of a steering system.
21. What is the material used for front axle? How is it manufactured?
22. Why for a front axle do we have I-section in the middle and elliptical section at the ends?
23. What is a stub axle? What is the function of king pin? What is steering axis?
24. What do you understand from wheel alignment'? What is thrust angle? What is ‘tracking’?
25. State factors of wheel alignment.
26. What happens to vehicle steering if the road wheels are not balanced?
27. Name important angles of steering geometry.
28. Define camber, SAI and castor. What is scrub radius?
29. Name the steering geometry parameter to give road feel to the driver.
30. What should be the approximate amount of the following in a car: camber, kingpin inclination, included angle, castor and toe- in?
31. If the kingpin and the wheel centre lines meet below the ground, will the wheels try to toe-in?
32. What is centre point steering?
33. Define perfect steering.
34. What is 'lock* position in steering?

35. Define 'turning circle'. State its approximate value for any (i) car (ii) bus.
36. What is 'toe-out on turns'?
37. Why is it easier to steer a vehicle in reverse than in forward?
38. What is slip angle? Define cornering force and cornering power.
39. What is self-righting torque, pneumatic trail, castor trail? Define 'under steer' and 'over steer'.
40. What is the purpose of ball joints in the steering linkage?
41. What is the function of steering gear? Name any three types of steering gears.
42. What is the function of balls in the recirculating ball type steering gear?
43. Why are the teeth on the nut in the recirculating ball type steering gear made tapered?
44. Which is the most popular steering gear for cars?
45. State the advantages of a rack and pinion type steering gear.
46. Why the pinion is usually placed tilted to rack in the rack and pinion type steering gear?
47. What purpose does a tilt wheel column serve?
48. What is the purpose of a telescopic steering column?
49. What is power steering? Name two basic types of power steering.
50. What are the main components of integral power steering system?
51. What is the purpose served by a variable steering ratio steering gear?
52. Out of the camber and the castor, which is measured first and why?
53. Which angle out of the camber and the castor is adjusted first? Why?
54. Name the various gauges used for the checking of wheel alignment.
55. What do you mean by the terms 'wander' and •shimmy' in steering? How are they caused?

What does the term 'dynamic balance' mean? What is 'wheel tramp' in case of steering?

UNIT – 3

1. Explain with the help of a neat sketch the construction of a propeller shaft.
2. Describe in detail various universal joints used in automobiles.
3. What is a constant velocity joint? Explain in brief the principle of working of any such joint. State also the situations which necessitate the use of these joints.
4. Derive expressions for the following in a Hooke's joint:
5. (i) Velocity ratio (ii) Angular acceleration of the driven shaft.
6. Compare the various types of gearings used for the final drive. Discuss the advantages and disadvantages of each such type. Describe in particular, the types of vehicles in which each of these gearings is used.
7. Explain the necessity of a differential in an automobile. Discuss in detail the construction and operation of the differential.
8. Describe the operation of an non-slip or limited-slip differential explaining clearly the situations necessitating the use of such a differential.
9. Sketch general arrangement of a live rear axle and identity various loads that it has to withstand.
10. Describe clearly the constructional details and operation of various rear axle drives. Illustrate your answer with neat and simple sketches.
11. Discuss in detail different methods of supporting live rear axle shafts. Describe also the advantages and disadvantages of each.
12. Distinguish between "semi-floating" and "fully-floating" rear axles with the aid of suitable sketches and explain their relative merits and demerits.
13. Write an explanatory note on types of rear axle casing.
14. Discuss the common sources of trouble in the propeller shaft and the rear axle. Describe the appropriate remedies in each case.
20. Two shafts, whose axes are inclined at 20° are connected by means of a Hooke's joint. The driving shaft rotates uniformly at 5000 r.p.m. What are the maximum and the minimum velocities of the driven shaft?

15. Two shafts are connected by means of a Hooke's joint. The driving shaft rotates at a uniform speed of 1000 r.p.m., whereas a fluctuation of ± 100 r.p.m. is allowed in the speed of the driven shaft. What is the maximum permissible angle between the shafts?
16. The angle between the axes of two horizontal shafts connected by a Hooke's joint is 20°. The driving shaft speed is uniform and is 200 r.p.m. A flywheel of weight 1kN and radius of gyration 200 mm is attached to the driven shaft. If a steady torque of 1000 Nm resists rotation of the driven shaft determine (i) the torque required at the driving shaft when it has turned through an angle of 45° from the initial position and (ii) the maximum angular acceleration of the driven shaft.
17. How is the length of propeller shaft varied automatically? What is material used for propeller shaft?
18. Define the whirling of shafts. What is critical whirling speed?
19. Which type of propeller shaft is used in case of Ashok Leyland vehicles?
20. What is the advantage of a two-piece propeller shaft?
21. What is the function of Hooke's joint?
22. Why is it desirable to have small operating angle between shafts in case of Hooke's joint?
23. What is the need for a constant velocity universal joint when the cheaper Hooke's joint is available?
24. What is a plunging type joint? Name two basic types of constant velocity joints.
25. How is the drive from propeller shaft turned at right angles?
26. What is ‘hypoid'? What is the advantage of hypoid gear over the straight bevel type?
27. What is the effect of 'offset* in hypoid gears?
28. State the materials used for the pinion and the crown wheel.
29. Why do we use multi-start worms for final drive?
30. Which type of final drive is used most commonly?
31. Why do we have a differential in automobile, when we don't have one in a rickshaw?
32. How will be the torque divided between the wheels when the differential is operating on turns so that the wheels are rotating at different speeds?
33. Does the non-driving axle also require differential? Why?
34. What rotates the differential pinion shaft?
35. What rotates the differential cage? What is a non-slip or limited-slip differential?
36. What are the various loads acting on the rear axles?
37. What is torque reaction'? What is a 'radius rod"? What is a 'pan hard rod'?
38. How many universal joints are used with a torque tube derive? How many on a Hotchkiss drive? Why?
39. Which member takes the torque reaction in Hotchkiss drive? How?
40. What loads are carried by the axle shaft in case of semi- floating axle?
41. Which loads are withstood by the axle shaft in case of a three-quarter floating axle? How are the other loads taken up?
42. What loads does the axle shaft carry in fully-floating axle?
43. What carries the weight of the vehicle in the "full-floating" type of rear axle?
44. Which type of rear axle is best suited for cheap, light vehicles?
45. Which type of rear axle is best suited for heavy vehicles? What is a banjo type axle casing?
46. What is a Salisbury type axle casing?
47. In case of a hammering noise from the rear axle, what may be the possible reason?

UNIT – 4

1. Explain clearly the requirements of automobile brakes.
2. Explain transfer of weight during application. Discuss how it affects wheel skidding.
3. Explain how the wheel skidding is caused and describe the principles of various techniques employed to prevent skidding. Discuss various factors influencing braking effect.
4. Discuss the classification of brakes from different considerations.

5. Briefly describe construction and working of disc brakes. Compare them with the conventional drum type brakes.
6. Discuss the design considerations regarding the discs and the friction pads of disc brakes.
7. Describe any type of mechanical brake with the help of neat sketches.
8. Explain in detail how the compensation is achieved in case of mechanical brakes.
9. Draw a simple diagram to show the layout of a hydraulically operated four wheel brake system and explain its working in detail.
10. With the aid of a diagram explain the function of the main parts of the master cylinder.
11. Draw a neat sketch showing the linkage to operate brake master cylinder and describe the same.
12. Explain the function of a brake shoe adjuster. Describe in detail the construction and working of (i) wheel cylinder ratchet type (ii) double toothed cam type shoe adjuster.
13. Describe with the help of neat diagrams how automatic adjustment in case of both drum and disc types of brakes is done.
14. Make a simple sketch showing hydraulically-operated two-shoe-leading brake assembly and describe its operation. Compare the same with the trailing shoe type.
15. Write a note on 'tandem master cylinder'.
16. What are the advantages of using split brake systems? Discuss any split systems used for light and medium duty vehicles.
17. Discuss thoroughly the procedure for bleeding of hydraulic brakes.
18. Discuss briefly Lucas - Girling wheel slide protection system.
19. What are the essential characteristics required of a good braking fluid? Give complete details.
20. Discuss in detail the braking system employed in case of Maruti 800 cars. Explain in particular the function and working of a proportioning valve.
21. A car whose wheel base is equal to five times the height of its centre of gravity above the ground is moving on a horizontal road when brakes are applied. If the coefficient of limiting friction between the car tyres and the road is 0.5, determine the percentage of weight transferred from the rear to the front axle, or. braking.
22. The wheelbase of a vehicle travelling on a wet road sloping upwards at angle 6 = sin" 0.1, is 5 m. Its centre of gravity is 2 m ahead of the rear axle and 750 mm above the road. The coefficient of adhesion between the vehicle tyres and the road is 0.3. The vehicle employs brakes on all the four wheels. Determine :
23. Ratio of braking forces on front and rear wheels if skidding is to be avoided.
24. Stopping distance for the vehicle travelling at a speed of 45 km/hour when the engine is stopped and the brakes are applied.
25. The wheelbase of a vehicle of weight 20 kN is 5.0 m and its centre of gravity is 1.0 m above the ground. When the vehicle is standing the front axle shared 7 kN, while the rest of the weight is carried by the rear axle. Determine the load on each axle when brakes are applied just to the point of skidding; the retardation achieved is 5.0 m/sec, IRf = 9.04 kN
26. A car using drum brakes has wheel cylinder pistons of 50 mm diameter at the front and 25 mm diameter at the back. The master cylinder piston is of 40 mm diameter. The leverage of brake pedal linkage is 4. If the driver applies a force of 100 N at the pedal, calculate braking force on each axle. Determine also the distance through which the pedal should be pressed so as to move the wheel cylinder pistons through 1 mm.
27. What is the principle of automotive brakes?
28. What do the brakes do to the energy as they stop a moving car? What is a service brake?
29. What are 'primary' and 'secondary' brakes? What is the basis of defining brake efficiency?
30. What are the approximate brake efficiency values in the case of cars and heavy vehicles?
31. What should be the minimum stopping distance for a car running at 80 km ph?
32. Why do we not use brakes with more than 80% efficiency in automobiles?

33. What is the usual percentage of total braking effort provided at the front wheels and why?
34. What is 'fading' of brakes? What is 'transfer of weight' in brakes? What is its effect?
35. On what factors does the force of adhesion between the road wheels and the road depend?
36. How does skidding take place? What is locking of wheel during braking?
37. Enumerate different considerations for classifying the automotive brakes.
38. Out of the transmission and the wheel brakes, which are better and why?
39. What are different methods of brake actuation?
40. What is the difference between 'power-assisted' and 'power-operated' brakes?
41. Name important components of a drum brake. What is a leading shoe?
42. What is a two-shoe-leading brake? What are its advantages and disadvantages?
43. Which type of the brakes out of the following, are used in Hindustan Ambassador "cars : (i) Two shoe leading (ii) Two shoe trailing (iii) One shoe leading and the other trailing.
44. What is the effect of floating the brake expander, instead of fixing it on the back plate?
45. How does floating of the brake shoe anchor influence the braking effect?
46. What is the advantage of a two-shoe trailing brake?
47. Name the factors that influence braking performance.
48. Name important components of a disc brake.
49. What is the advantage of a swinging caliper type disc brake?
50. Name two latest materials for brake discs.
51. How much is approximately the saving in weight by using disc brake instead of drum brake?
52. Out of the disc and the drum brakes, which have better anti-fade characteristics?
53. Why is there greater consistency of braking effect in case of disc brakes compared with the drum brakes?
54. What is 'brake compensation'? Name the simplest type of brake compensator.
55. Approximately how much residual pressure is maintained in hydraulic brakes and why?
56. What are the functions of (i) intake port (ii) by-pass port in a master cylinder?
57. Why do we not fill the master cylinder completely with the brake fluid?
58. What was the need to develop such a complicated master cylinder? Why could a simple barrel with piston not do?
59. Why drum type hydraulic brakes are so designed that there should be residual pressure in the brake lines even when the brakes are in the released position ?
60. Do we maintain the residual pressure in case of disc brakes also? Why?
61. When do we have to pump the brake pedal quickly?
62. What is the purpose of a brake shoe adjuster? Name any two brake shoe adjusters.
63. Do we have brake shoe adjuster in case of disc brakes also? Why?
64. What is a split hydraulic brake system? What is the function of a pressure differential valve?
65. Why do you use proportioning valve in brakes?
66. What is the function of a metering valve in the braking system? What is a combination valve?
67. What are the advantages of hydraulic brakes over mechanical brakes?
68. Why can't water be used as brake fluid? State the main requirements of brake fluid.
69. What would be the result if a petroleum oil is used as brake fluid?
70. What should be the approximate minimum boiling point of a good braking fluid?
71. What are the main constituents of brake fluid?
72. When does the necessity of bleeding the brakes arise ?
73. Write a brief note on electric brakes. How are these compared to the mechanical and hydraulic brakes?
74. What do you understand from the term 'Servo action' in brakes? How is it achieved? Explain clearly how the servo action is provided in case of disc brakes?

75. How is the vacuum from the engine inlet manifold utilized to actuate the vehicle brakes? Explain fully with diagrams.
76. Draw the layout of Mastervac power-assisted brakes. Explain the construction and working of main components of this system.
77. Show by means of a simplified diagram, the layout of 'Bendix Hydromax' brakes. Use clear sketches to explain the working of a hydromax booster.
78. Make a schematic diagram to show the engine exhaust brake and discuss its working.
79. Draw a schematic diagram showing the layout of complete air pressure system of brakes and explain the working of its main units in detail.
80. Explain in detail the construction and operation of a brake chamber, an unloader valve and a brake valve.
81. Discuss clearly how the air brakes are adjusted with the help of a slack adjuster.
82. Discuss briefly: (a) Hand brake (parking brake) (b) Hill holding device
83. Make simple sketches showing various arrangements to provide for alternative foot brake or hand brake operation with the same brake shoes and explain those arrangements in detail.
84. Draw the layout of Tata fail safe parking brake and discuss the same in detaiL
85. Write detailed notes on the construction of brake drums and brake shoes.
86. Explain in detail the necessity and principle of working of an antilock brake system. Describe its main components and discuss various types of such systems in use.
87. Explain in detail the procedure for the inspection of automotive brakes. Mention the precautions to be observed.
88. Explain clearly the minor and major brake adjustments and how the same are carried out.
89. Discuss in detail how you will proceed to replace the worn out brake lining.
90. Write a brief note on brake maintenance.
91. Discuss : (a) Emergency Brake Assist (b) Dynamic Braking system (c) Brake By Wire
92. Discuss how various defects are caused in the braking system of automobiles. Suggest also suitable remedies.
93. What is a servo brake? What is suspended vacuum servo system?
94. What is the function of booster in the Hydromax brakes?
95. Name major components of a compressed air brake system.
96. What is function of unloader valve? Where is it located?
97. What is the function of an air brake valve?
98. What is the extra merit of a dual air brake valve compared to a single diaphragm type?
99. What is the function of air brake chamber? What is the spring brake chamber?
100. What is a slack adjuster? What is its function?
101. On which wheels in a car are the parking brakes generally provided?
102. What are the requirements of a good brake drum? Why are the brake drums usually finned?
103. Which material is generally used for brake drums? Why?
104. State the advantages of integral wheel-brake drum.
105. Upto what temperature the fade does not occur in case of moulded brake lining?
106. What are the advantages of using synthetic resin adhesives for attaching brake linings as compared to the conventional rivetting?
107. In which type of vehicles it is generally preferred to use adhesives for brake lining?
108. What is an ABS? What is 'pressure modulation' with reference to ABS?
109. State the effect of (a) front wheels locking, (b) rear wheels locking.
110. List main parts of an ABS.
111. What is the function of lateral acceleration sensor?
112. Differentiate between functions of one-channel and two-channel systems.
113. Differentiate between functions of three-channel and four-channel systems.

114. Name the various common forms of brake drum wear.
115. How do you adjust the brake shoes? What is major, minor brake adjustment?
116. Approximately what minimum amount of free pedal pay is allowed in case of car brakes?
117. What is the function of Emergency Brake Assist'? What is a dynamic braking system?
118. What is 'brake by wire'? State its two advantages.
119. What happens when the oil leaks into the brake drum and wets the shoe linings?
120. How will it affect the braking performance if the bypass port in the master cylinder is blocked?
121. Out of petrol and alcohol, which should be used for cleaning the brake master cylinder and why?
122. Why are the brakes overheated sometimes?
123. What happens if the rivets attaching the brake lining to the shoe are not chamfered?
124. If only the brake on one of the four brake drums is incorrectly adjusted, how does it affect braking performance?
125. What is the effect of the dust accumulating in the brake drum?
126. Name any three firms manufacturing automotive brakes.

UNIT – 5

1. Write notes on (a) Leaf Springs (b) Helper Springs (c) Tapered leaf springs (d) Torsion bar
2. Explain in detail the function and construction of a leaf spring and show how it is mounted on rear and front. Illustrate your answer with simple sketches.
3. What are the different types of rubber springs? Briefly explain each.
4. Differentiate clearly between the functions of a spring and a shock absorber. Explain the construction and working of a telescopic type of shock absorber with the help of a neat diagram.
5. What is the purpose of independent suspension? Explain various methods to achieve the same in front and rear axles of cars. Describe its advantages and disadvantages also, if any, compared to the conventional rigid axle suspension.
6. What is the function of an anti-roll device in vehicles? Explain clearly how it performs the same in actual practice.
7. Explain briefly the action of air springs. Draw the schematic diagram showing the layout of an air suspension system and describe the same.
8. What is an interconnected suspension system? Discuss the main constructional features of any such system and also its working.
9. Discuss in detail: (a) Fiber composite leaf springs. (b) Electronically controlled shock absorbers, (c) Hydraulic Suspension. (d) Daimler-Benz Suspension
   (e) Hydragas interconnected suspension system. (f) Delphi Magneride
6. Discuss the causes of the common troubles experienced in the suspension system of an automobile and suggest appropriate remedies in each case.
10. What are the objectives of suspension? What do you understand by pitching and rolling?
11. What is brake dip? What is unsprung weight? Why is the unsprung weight kept as low as possible?
12. What is the function of a spring? How does a spring absorb vertical loading?
13. How is the side thrust countered in a vehicle? What is the function of a shackle with a leaf spring?
14. What is the material used for leaf springs? What is the effect of moisture on the leaf springs?
15. If the spring leaves are not lubricated, what may be the result?
16. They say, laminated leaf springs are self-damping. How?
17. What is the purpose served by phosphate paint in leaf springs?
18. What forces are supported by a leaf spring? What are helper springs?
19. State the advantages and disadvantages of a torsion bar, a coil spring and a tapered leaf spring
20. What is a torsion bar? What material is used for making a torsion bar?
21. What are the advantages of rubber suspension? State the advantages of a plastic suspension.
22. What is the function of a shock absorber? How is aeration caused in a shock absorber?
23. What is the effect of aeration in the shock absorber?

24. What is the function of a gas-charged shock absorber?
25. What is an inflatable shock absorber? What is shock absorber ratio?
26. How is the variation in shock absorber damping achieved?
27. What are the advantages of independent suspension over the rigid axle suspension?
28. State the disadvantages of independent suspension. What is wishbone type suspension?
29. Which type of independent suspension is mostly used for front drive vehicles?
30. What are the advantages of MacPherson strut suspension?
31. What is a de Dion axle? State the advantages of an air suspension.
32. What is the function of an anti-roll device? What is an interconnected suspension system?
33. A typical coil suspension spring has 10 effective coils of a mean diameter 125mm and made out of wires of diameter 15mm. The spring is designed to carry a maximum static load of 3531.6N. Calculate the shear stress and the deflection under the above loading. If a maximum shear stress of 637650kPa is allowable in the material, then what is the possible clearance in the spring? Take the value of G = 73575 x 103kPa.
34. Describe the requirements of an automobile wheel. Explain with the help of a suitable sketch the construction of the disc type wheel. Compare the same with the wire type wheel.
35. Discuss with the help of simple sketches, the construction of various types of disc wheels.
36. What is a light alloy? Discuss the merits and demerits of light alloy automobile wheels.
37. State various functions performed by automobile tyre. Discuss the properties expected in the same.
38. Draw cross-section of an automobile tyre and show on it various constructional features.
39. Describe in detail constructional features of the tubed and the tubeless tyres for automotive use. Discuss also their relative merits and demerits.
40. Discuss different tyre-carcass types and the materials used for them. Compare the radial-and bias-ply type carcass tyres.
41. Explain various considerations for the design of tyre treads.
42. Discuss in detail various factors affecting tyre life. How is a tyre manufactured? Explain briefly.
43. What is a 'Denovo'? Describe clearly its various components and state limitations, if any.
44. Write a detailed account of various types of flat-running tyres.
45. Discuss various types of troubles in connection with automobile wheels and tyres.
46. State the functions of a car wheel. Name three types of automobile wheels.
47. What are the advantages of a disc wheel? What is a reversible wheel? What is a divided wheel?
48. Define 'offset' with reference to automobile wheels. What are inset, zeroset and outset wheels?
49. Are well type wheels also used for heavier vehicles? What is the purpose of 'well' in the wheel rim?
50. Why is there a small taper on the sides of a wheel rim?
51. How is the vehicle weight supported in case of a wire wheel?
52. What are the advantages of a wire wheel? Why can't you use wire wheel to mount a tubeless tyre?
53. Name different materials for automobiles wheels. What are the functions of an automobile tyre?
54. Name the light alloys commonly used for automobile wheels.
55. State the advantages of (i) magnesium alloy (ii) aluminium alloy wheels.
56. What is a composite wheel? How do you specify a car wheel?
57. State various desirable properties of an automobile tyre. What is 'ply rating' of a tyre?
58. Should the tyre sidewalls be rigid or flexible? Why?
59. Should the tyre tread be hard or soft? How is a tyre bead formed?
60. What is the purpose of tyre tread sipes ? What is the function of a tyre bead?
61. What is static unbalance? What is dynamic unbalance? How is the wheel wobble caused?
62. What is a tyre carcass? Name different types of tyres based upon the carcass design.
63. Why are the cords of tyre plies not woven like warp and weft of ordinary cloth?
64. What is the function of a breaker belt? State the requirements of material for breaker belts.
65. How does a radial-ply tyre contributes to saving of fuel?

66. Why does a radial ply-tyre give comfortable ride at high speeds and a cross-ply tyre at low speeds?
67. Why are the steering characteristics of radial ply tyres better than those of cross ply tyres?
68. What is the reason for higher braking efficiency on wet roads in case of radial ply tyres?
69. State the commonly used materials for (i) ply-cords (ii) stabilizer belts (iii) beads (iv) tread.
70. State the factors on which road-grip of a tyre depends.
71. What is 'aspect ratio' of a tyre? What is the advantage of low aspect ratio in automobile tyres?
72. How do you designate a tyre? State various factors affecting tyre life.
73. Should the tyre inflation pressure be checked while it is hot or cold?
74. How does over inflation increase tendency for concussion break?
75. How does a tyre wear in case of (i) overinflation (ii) underinflation?
76. What is the effect of bleeding the tyre? How does heat affect the tyre life.
77. List various irregularities in the vehicle maintenance which lead to deterioration of tyre life.
78. What is the basic advantage of a Dunlop 'Danovo' tyre?
79. Draw the tyre rotation sequence for a (i) car (ii) truck.
80. State reasons for the following tyre defects:(a) Concussion break (b) Rim bruise (c) Sidewall scuffing (d) Tread cracking (e) Ply separation (/) Uneven wear.

Course Articulation Matrix

Course Outcomes	Program Outcomes and Assessment										
	a	b	c	d	e	f	g	h	i	j	k
Identify, Explain different chassis layouts and frames, **solve** for stability and weight distribution and suitability of frames. L1, L2, L3	M	-	-	-	M	-	M	-	-	M	-
Identify, Describe, about various Front Axles, factors of wheel alignment Steering Systems and **Calculate** dimensions of Front Axle. L1, L2, L3	M	-	M	-	M	-	M	-	-	M	-
Identify, Interpret, about Various types Propeller Shaft, Differential And Rear Axles, **solve** numerical. L1, L2, L3	M	-	M	-	M	-	M	-	-	M	-
Identify, Compare, about various types of Brakes, **solve** numerical. L1, L2, L3	M	-	M	-	M	-	M	-	-	M	-
Identify, Describe, About Various Types of Suspensions, Wheels and Tyres. **Calculate** dimensions of different suspensions. L1, L2, L3	M	-	M	-	M	-	M	-	-	M	-
L – Low, M – Moderate, H - High											

Course Articulation Matrix

Course Outcomes	Program Outcomes and Assessment										
	a	b	c	d	e	f	g	h	i	j	k
Identify, Explain different chassis layouts and frames, **solve** for stability and weight distribution and suitability of frames. L1, L2, L3	2	-	-	-	2	-	2	-	-	2	-
Identify, Describe, about various Front Axles, factors of wheel alignment Steering Systems and **Calculate** dimensions of Front Axle. L1, L2, L3	2	-	2	-	2	-	2	-	-	2	-
Identify, Interpret, about Various types Propeller Shaft, Differential And Rear Axles, **solve** numerical. L1, L2, L3	2	-	2	-	2	-	2	-	-	2	-
Identify, Compare, about various types of Brakes, **solve** numerical. L1, L2, L3	2	-	2	-	2	-	2	-	-	2	-
Identify, Describe, About Various Types of Suspensions, Wheels and Tyres. **Calculate** dimensions of different suspensions. L1, L2, L3	2	-	2	-	2	-	2	-	-	2	-
1 – Low, 2 – Moderate, 3 - High											

Course Title: AUTOMOTIVE TRANSMISSION			
Course Code: P13AU62	Semester: 6	L:T:P:H- 4:0:0:4	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

Subject requires student to know about

Students must have the back ground knowledge of different types of drives like belt drives, chain drives, gear drives and rope drives.

Course Learning Objectives (CLO):

At the end of the course the student should be able to

a) Explain the need for transmission
b) Distinguish between positive and non positive drives
c) Explain the Constructional and working principles of different types of clutches
d) Design a clutch for any vehicle
e) Explain the constructional and working principle of different types of fluid flywheel, torque converter and one way clutches
f) Explain the constructional and working principle of different types of gear box
g) Determine the gear ratio, speed of vehicle and number of teeth on driving and driven gears
h) Explain the constructional and principle of operation of different types epicyclic gear box i) Calculating gear ratio for epicyclic gear box
j) Explain the necessity and advantages of automatic transmission
k) Explain the constructional and principle of operation of different types of automatic transmissions and hydraulic control.
l) Distinguish between the terms phase and stage used in torque converter

Relevance of the course

Automotive transmission is a course deals with the different ways through which the power is transmitted from engine to driving wheels and design of above systems and it is hoped that through this programme student will gain sufficient knowledge to make them employable in automotive industries

Course content

UNIT – I

CLUTCH :Necessity of clutch in an automobile, different types of clutches, friction clutches namely Single plate clutch, multi plate clutch, cone clutch, centrifugal clutch, electromagnetic clutch, hydraulic clutches, Clutch - adjustment, Clutch troubles and their causes, requirements of a clutch , Clutch materials, clutch lining ,Vacuum operated clutch, Numerical problems. **11 hrs**

UNIT-2

Fluid Coupling , One way clutches& torque converters: Constructional details of various types, percentage slip, one way clutches (Over running clutch) like sprag clutch, ball and roller one way clutches, necessity and field of application, working fluid requirements, fluid coupling characteristics,

Torque converters, comparison between fluid coupling and torque converters, single stage , two stage and three stage torque converter, 3 and 4 phase torque converters , performance characteristics, slip, principles of torque multiplication . **10 hrs**

UNIT-3

Gear box : Various Resistances to Motion of the Automobile, Traction, tractive effort, The need for transmission, Necessity of gear box, Calculation of gear ratios , Performance characteristics in different gears , Desirable ratios of 3speed & 4 speed gear boxes, Constructional details of , Sliding-mesh gear box , Constant-mesh gear box, synchromesh gear box, five speed and reverse single stage

synchromesh gear box with integral final drive, auxiliary transmissions, compound transmissions ,dual- clutch transmission, continuously variable transmission, numerical problems. **11 hrs**

UNIT-4

Epicyclic Transmission : Principle of operation, types of planetary transmission (dual and compound planetary assemblies), Calculation of gear ratio in different speeds, Wilson planetary transmission, Ford-T model gear box , Pre selective mechanism, Vacuum control, pneumatic control, hydraulic control in the planetary gear system , Over drives. **10 hrs**

UNIT-5

Automatic transmission : Automatic transmission - Principle, general description and Working of representative types like Borge-warner, 4-speed and 6-speed automatic transmission longitudinally mounted four speed automatic transmission, hydramatic transmission, the fundamentals of a hydraulic control system, basic four speed hydraulic control system. **10 hrs**

TEXT BOOKS:

1. N.K Giri, 'Automotive Mechanics', Khanna Publication, New Delhi, 2014
2. Advanced vehicle technology , Heinz Heisler , 2002

REFERENCE BOOKS:

1. Crouse W.H. "automotive transmissions and power trains", McGraw Hill Co. 5th edn, 1976
2. Newton K and Steeds. W. "motor Vehicle", Butter Worth's & Co., Publishers Ltd, 1997
3. Kirpal Singh, "Automobile engineering –. Vol.1, Standard Pub. 2011
4. G.B.S.Narang "Automobile Engineering', Khanna publication, New Delhi
5. Joseph I Heitner, "Automotive mechanics ", Affiliated East West Press, NewDelhi
6. Fundamentals of Automatic Transmission by William Hasselbee.
7. P.M. Heldt,"Torque converters", Oxford & IBH, 1975

Course outcomes:

At the end of course the student will be able to

1)**Explain** the need for transmission and Distinguish between positive and non positive drives .

2) **Explain** the Constructional and working principles of different types of clutches and different types of fluid flywheel, torque converter and one way clutches

3) **Design** a clutch for any vehicle

4) **Explain** the constructional and working principle of different types of gear box and epcyclic gear box

5) **Determine** the gear ratio, speed of vehicle and number of teeth on driving and driven gears

6) **Explain** the necessity and advantages of automatic transmission and **Explain** the constructional and principle of operation of different types automatic transmissions

7) **Distinguish** between the terms phase and stage used in torque converter

Unit wise plan

UNIT-1 -

Topic Learning Objectives (TLO):

- At the end of this chapter student should be able to:
- Explain the requirements of clutch. (L2)
- Derive an expressions for mean effective radius for cone clutch, single plate clutch and multi plate clutch. (L5)
- Explain the Constructional and working principles of different types of clutch. (L3)
- Design a clutch for any vehicles. (L6)

Lesson schedule

1. Necessity of clutch in an automobile
2. Different types of clutches and friction clutches namely Single plate clutch
3. Multi plate clutch and cone clutch
4. Centrifugal clutch and electromagnetic clutch
5.Hydraulic clutches , Clutch - adjustment, Clutch troubles and their causes, 6.Requirements of a clutch and Clutch materials
7. Clutch lining and Vacuum operated clutch
8.Numerical problems (3 hours)

UNIT-II

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

1. Differentiate between fluid flywheel and torque converter. (L4)
2. Explain the constructional and working principle of different types of fluid flywheel, one way clutches and torque converters. (L3)
3. Principle of torque multiplication in torque converter. (L2)
4. Distinguish between the terms phase and stage used in torque converter. (L4)

Lesson schedule

1.Constructional details of fluid flywheel, percentage slip
2.One way clutches (Over running clutch) like sprag clutch, ball and roller one way clutches
3.Necessity and field of application, working fluid requirements, fluid coupling characteristics
4.Introduction to torque converters, comparisons between fluid coupling and torque converters
5.Different methods used to improve the torque converter efficiency
6.Single stage torque converters
7. Two stage torque converters
8.Three stage torque converter,
9.3 and 4 phase torque converters performance characteristics
10.Slip, principles of torque multiplication.

UNIT-III

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

- Analyzing the graphs to know the necessity of gear box. (L4)
- Distinguish between traction and tractive effort. (L4)
- Explain the constructional and working principle of different types of gear boxes used in automobile. (L3)
- Determine the gear ratio, speed of vehicle and number of teeth on driving and driven gears. (L5)

Lesson schedule

1.Various Resistances to Motion of the Automobile, Traction, tractive effort
2.The need for transmissions, Necessity of gear box
3.Calculation of gear ratios for vehicles, Performance characteristics in different gears
4.Desirable ratios of 3speed & 4speed gear boxes
5.Constructional details of , Sliding-mesh gear box ,Constant-mesh gear box,
6.Synchromesh gear box (single stage and double stage)

7.Splitter and range change gear boxes
8.Dual- clutch transmission, continuously variable transmission,
9.Numerical problems (2 hours)

UNIT-1V

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

- Explain the principle and advantages of epicyclic transmission. (L2)
- Determine the speed ratio of epicyclic gear trains. (L5)
- Explain the constructional and working principle of different types of epicyclic gear boxes like Wilson and ford-T model. (L3)
- Explain the vacuum, pneumatic and hydraulic control system used in planetary gear box. (L3)
- Calculate the gear ratios in epicyclic gear box. (L3)

Lesson schedule

1.Principle of operation, types of planetary transmission (dual and compound planetary assemblies)
2.Calculation of gear ratio in different speeds (2 hours)
3.Wilson planetary transmission
4.Ford-T model gear box
5.Pre selective mechanism
6.Vacuum control
7.Pneumatic control
8.Hydraulic control in the planetary gear system
9.Over drives

UNIT-V-

Topic Learning Objectives (TLO):

At the end of this chapter student should be able to:

- Distinguish between manual and automatic transmission. (L4)
- Explain the advantages of automatic transmission. (L2)
- Explain the constructional and working principle of different types of automatic transmissions. (L3)
- Explain the fundamentals of a hydraulic control system. (L2)

Lesson schedule

1.Automatic transmission – Principle
3.General description and Working of representative types like Borge-warner
4.Transaxle three speed automatic transmissions
5.Four-speed and six speed automatic transmission
6.Hydramatic transmission
7.Longitudinally mounted four speed automatic transmission
8.The fundamentals of a hydraulic control system
9. Basic four speed hydraulic control system. (2 hours)

Review Questions:

1. Discuss various factors affecting the torque transmission in a clutch
2. Explain the working of a single plate clutch with help of a simple diagram
3. Derive expressions for effective mean radius and torque transmitted in case of a single plate clutch assuming different conditions
4. What are the centrifugal devices? Describe semi-centrifugal and centrifugal clutches
5. compare hydraulic , mechanical , electrical and vacuum methods of operating clutches

6. Describe briefly an electromagnetic clutch. Discuss the merits and demerits
7. What are the essentials properties, required of a clutch facing material? Explain how these are met with in common materials
8. Discuss in detail the constructional features of a clutch plate? Explain briefly the function of each major component of the clutch plate.
9. Explain in detail various causes of clutch troubles. How can these be remedied?
10. Explain by means of a neat sketch the construction of a fluid flywheel and describe clearly the principle of torque transmission in the same
11. Determine the size of the clutch plate suitable for a car employing a single plate type of friction clutch and developing 37.5 KW at 4200 rpm . The inside diameter of the clutch plate is 0.6 times its outside diameter and is to be ensured that even after a loss of 30 % of the engine torque due to wear of the clutch facing., the clutch does not slip. The intensity of pressure on the facing is mot to exceed 70 KPA. Assume = 0.3
12. Explain briefly the necessity of a transmission in a vehicle.
13. Sketch and explain the construction and working of constant mesh gear box
14. Discuss the purpose of double declutching and its procedure in constant mesh gear box
15. Sketch and explain the working of a synchro mesh gearbox . What are its merits and demerits compared to sliding and constant mesh gear box ?
16. Sketch and explain the interlocking mechanism to ensure only one gear can engaged at a time
17. Explain with neat sketch the working of transfer box
18. With schematic diagram explain the eight speed constant mesh gear box with two speed rear mounted range change
19. Explain the common troubles encountered in gear boxes and suggest suitable remedies
20. Differentiate between auxiliary and compound transmissions
21. Sketch and explain the transverse continuously variable transmission
22. Numerical problems
23. Discuss the advantages and disadvantages of fluid flywheel
24. Explain the principle of torque transmission in fluid flywheel
25. Sketch and explain the sprag and roller type of one way clutch
26. Differentiate between the fluid flywheel and torque converters
27. Sketch and explain the construction and working of single stage torque converter
28. Discuss the performance characteristics of a torque converter and also explain the any one of the arrangement for improving the overall transmission efficiency
29. Differentiate between the terms stage and phase used in torque converter
30. Sketch and explain the two stage torque converter
31. Sketch and explain the three stage torque converter
32. Sketch and explain the three phase single stage torque converter
33. Discuss briefly the principle of torque multiplication in torque converter
34. Sketch a simple epicyclic gear set and explain how six different speeds are obtained
35. Sketch and explain the two speed epicyclic gear box
36. Sketch and explain the construction and working of wilson gear box
37. Sketch and explain the construction and working of ford T-model gear box
38. Discuss the vacuum, pneumatic and hydraulic control mechanism in planetary gear system
39. Explain the working of overdrive unit with sketch
40. Numerical problems
41. Differentiate between the manual and automatic transmission
42. With schematic diagram explain the working of borge-warner automatic transmissions
43. With schematic diagram explain the longitudinally mounted four speed automatic transmissions
44. Explain the principle of a hydraulically controlled gearshift mechanism

45. With schematic diagram explain the working of four speed hydraulic control system
46. With sketch explain the working of hydramatic transmission

Course Assessment Matrix (CAM)												
Course Outcome (CO)		**Program Outcome (ABET/NBA-(3a-k))**										
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1. **Explain** the need for transmission and Distinguish between positive and non positive drives .	L2								**2**	**2**		
2.**Explain** the Constructional and working principles of different types of clutches and different types of fluid flywheel, torque converter and one way clutches	L3				2	**2**		2		**2**		
3**.Design** a clutch for any vehicle.(L6)	L6	**2**		**3**		**2**						
4.**Explain** the constructional and working principle of different types of gear box and epcyclic gear box	L3								**2**	**2**		
5.**Determine** the gear ratio, speed of vehicle and number of teeth on driving and driven gears	L3	**2**		**2**				2				
6.**Explain** the necessity and advantages of automatic transmission and **Explain** the constructional and principle of operation of different types automatic transmissions	L3				**2**	**2**		**2**		**2**		
7.Distinguish between the terms phase and stage used in torque converter (L4}	L4				2	2				2		
1 – Low, 2 – Moderate and 3 – High												

Course Articulation Matrix (CAM)												
Course Outcome (CO)		**Program Outcome (ABET/NBA-(3a-k))**										
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1. **Explain** the need for transmission and Distinguish between positive and non positive drives .	L5								**M**	**M**		
2.**Explain** the Constructional and working principles of different types of clutches and different types of fluid flywheel, torque converter and one way clutches	L3				M	M		M		**M**		
3**.Design** a clutch for any vehicle.(L6)	L3	**M**		**H**		M						
4.**Explain** the constructional and working principle of different types of gear box and epcyclic gear box	L3								M	M		
5.**Determine** the gear ratio, speed of vehicle and number of teeth on driving and driven gears	L3	**M**		**M**				M				
6.**Explain** the necessity and advantages of automatic transmission and **Explain** the constructional and principle of operation of different types automatic transmissions	L3				**M**	**M**		**M**		**M**		
7.Distinguish between the terms phase and stage used in torque converter (L4}	L5				**M**	**M**				**M**		
L- Low, M- Moderate, H-High												

Course Title: DESIGN OF MACHINE ELEMENTS -II			
Course Code: P13AU63	Semester: 6	L:T:P:H- 3:2:0:5	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

Students should have the basic knowledge of Strength of materials, codes & Standards, selection of materials & factor of safety, workshop processes, Theory of Machines, Material Science and Fundamentals of Mechanical Engineering Design.

Course Learning Objectives (CLOs)

At the end of the course the student should be able to

a) Describe the basic types of curved beams and springs
b) Analyze the stresses in the critical section of a curved beam.
c) Emphasize on the conditions for safe operating speeds of an engine using springs for its operations of valves.
d) Illustrate the design procedure to arrive at the proper specifications of springs/gears/clutches
e) Select suitable size, module & type of gears for a required velocity ratio.
f) Calculate the dimensions and suggest suitable materials for any application.
g) Define the terminology of gears and springs.
h) Demonstrate the suitability of a type and class of lubricant for a specific applicat

Relevance of the Course:

4. Yield expertise in understanding the difference between curved and straight beams
5. Design orientation towards the selection of proper type of gear drive based on the speed and space constraints.
6. Design engineering to design the pitch, free length, spring rate, wire size, etc
7. Oriented towards making the students to identify the machine elements in their vehicles, machines, etc. and to innovate or improvise the design.

Course Content

Unit-I

Curved beams: Difference between curved beam and straight beam, stresses in curved beams, assumptions for stress calculations in curved beams, derivation for stresses in curved beams, Stresses in curved beams of standard cross sections used in crane hook, punching presses & clamps, closed rings and chain links.

Springs: Introduction, types of springs, terminology, stresses and deflection in helical coil springs of circular and non-circular cross sections, springs under fluctuating loads, concentric springs. Leaf Springs, stresses in leaf springs, equalized stresses, length of spring leaves. **12 hrs**

Case Study: a) Design of a Spring for a automotive engines,
b) Design of Leaf springs of an Automobile

UNIT-II

Spur & helical gears: Introduction, spur gears, standard proportions of gear systems, stresses in gear tooth, Lewis equation and form factor, design for strength, dynamic load and wear load. Helical Gears: definitions, formative number of teeth, design based on strength, dynamic and wear loads. **10 hrs**

Case Study: a) Design of spur gears for a Compressor Drive Train
b) Design of helical gears for a Automobile Gear Box

UNIT-III

Bevel and worm gears:

Bevel Gears: terminology, formative number of teeth, design based on strength, dynamic and wear loads.

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

Case Study:-Design of Bevel Gears of an Automobile differential **10 hrs**

UNIT-IV

Clutches & Brakes:

Design of clutches: single plate, multi plate and cone clutches.

Design of brakes: Block and Band brakes: self locking of brakes: Heat generation & heat dissipation in brakes. **10 hrs**

UNIT-V

BEARINGS:

Sliding Contact Bearings: Introduction, principle of hydro dynamic lubrication, assumptions in hydrodynamic lubrication, bearing characteristic number and modulus, Sommerfeld number, coefficient of friction, power loss, heat Generated and heat dissipated, bearing materials, lubricants and properties, design of journal bearing and thrust bearing.

Ball and Roller contact Bearings: Introduction, Advantages and disadvantages, types of ball and rolling contact bearings, designation, static & dynamic capacity, Equivalent load, selection of suitable bearings based on rated life. **10 hrs**

Case Study: Design of Hydrodynamic Bearings for a Cam Test Fixture

Text Books

1. V.B. Bhandari, Design of Machine Elements:, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.
2. T Krishna Rao, Design of Machine Elements –II, I K International Publishing house Pvt.Ltd., New Delhi, 2013

References:

1. Machine Design: Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 2008.
2. Robert.L.Norton, Machine Design , An integrated Approach, Pearson Education Asia, 2001
3. Joseph E Shigley and Charles R. Mischke., Mechanical Engineering Design McGraw Hill International edition, 2003.

Design Data Hand Book:

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

Note: All the Case studies are only for CIE Assessment purpose only

Course Outcomes (Cos)

At the end of the course student will be able to:

1. Design the curved beams using the equations of stress

2. Design helical spring and leaf spring using the equations of stress and deflection.

3. Design the spur gears and helical gears using different parameters and check the gears for dynamic and wear load.

4. Design the various types of bevel gears and worm gears for dynamic and wear load using various parameters.

5**. Design** sliding contact and rolling contact bearings to find coefficient of friction, heat generated, heat dissipated and average life of bearings.

8. Analyze and design given machine components and present their designs in the form of a Report

Unit wise plan

Unit-I:

Topic Learning objectives

At the end of Unit -1 student should be able to:

- Distinguish between straight beams & curved beams[L1]
- Calculate the stresses in the critical sections of a curved beam.[L3]
- Identify the right type of section for a specific application.[L1]
- Explain the terminology and notations used in design of springs.[L2]
- Suggest suitable material & the type of spring for a specific application.[L3]
- Use the design equations and obtain the parameters of a spring such as pitch, wire diameter, coil diameter, stiffness, etc.[L3]
- Check for critical frequency of spring and avoid surge in springs.[L3]
- Determine the cross section of a leaf spring & the equalized stress in the leaves by nipping of pre stressing.[L3]

Lesson schedule

1. Introduction Curved beams**:** Difference between curved beam and straight beam, stresses in curved beams, assumptions for stress calculations in curved beams, derivation for stresses in curved beams,
2. Numerical problems on Stresses in curved beams of standard cross sections used in crane hook,
3. Numerical problems on Stresses in curved beams of punching presses
4. Numerical problems on Stresses in curved beams of clamps,
5. Numerical problems on Stresses in closed rings and chain links.
6. Introduction to springs, types of springs, terminology, stresses and deflection in helical coil springs of circular section
7. Numerical problems
8. Numerical problems
9. stresses and deflection in non-circular cross sections and fluctuating loads
10. Numerical problems
11. Leaf Springs, stresses in leaf springs, equalized stresses, length of spring leaves.
12. Numerical problems

Unit-II

Topic Learning objectives

At the end of Unit -2 student should be able to:

- Classify gears according to their geometry, relative position of shaft axes, profile of teeth, Velocity, etc.[L2]
- Define the terminology of gears[L1]
- Identify the weaker of the gear pair and design the drive selecting proper materials & tooth system.[L3]
- Check the design for dynamic & wear considerations[L4]
- Recommend suitable hardness for the satisfactory working of the gears.[L3]
- Describe the helical gear parameters and their importance.[L2]
- Obtain the virtual number of teeth based on helix angle.[L2]
- Design single & double helical (Herringbone) gears for a given speed reduction.[L4}

- Calculate the dynamic & wear load accounting for tooth errors & fatigue load[L3]
- Obtain complete specifications of the helical gear drive such as normal & transverse module, surface hardness, number of teeth, center distance, etc.[L3]

Lesson Schedule

1. Introduction to spur gears, standard proportions of gear systems, stresses in gear tooth
2. Lewis equation and form factor, design for strength, dynamic load and wear load.
3. Numerical problems
4. Numerical problems
5. Numerical problems
6. Introduction to Helical gears, definitions, formative number of teeth,
7. Design based on strength, dynamic and wear loads
8. Numerical problems
9. Numerical problems
10. Numerical problems

UNIT-III

Topic Learning objectives

At the end of Unit -3 student should be able to:

- Describe the bevel gear parameters and their importance.[L2]
- Obtain the formative number of teeth based on semi cone angle.[L3]
- Design acute angled, obtuse angled & right angled bevel gears for a given speed reduction.[L4]
- Show that, in Bevel gears, the equivalent number of teeth is always greater than the actual number of teeth, therefore a given pair of bevel gears will have a larger contact ratio and hence they will run more smoothly than a pair of spur gears with the same number of teeth. [L3]
- Design the bevel gear drive to transmit higher power, with comparatively smaller overall dimensions of the driving system which can be constructed with minimum possible manufacturing cost, runs reasonably free of noise and vibration and which requires little maintenance besides indefinite life considering strength and wear. [L4]
- Calculate the dynamic & wear load accounting for tooth errors & fatigue loads[L3]
- Obtain complete specifications of the worm gear drive such as normal & transverse module, surface hardness, number of teeth, center distance, etc.[L3]
- To check the thermal balance and efficiency of the drive (Self locking).[L3]

Lesson Schedule

1. Introduction to Bevel Gears**,** terminology, formative number of teeth
2. Design based on strength, dynamic and wear loads.
3. Numerical problems
4. Numerical problems
5. Numerical problems
6. Numerical problems
7. **Introduction to worm Gears,** terminology, design based on strength, dynamic, wear loads and efficiency of worm gear drives
8. Numerical problems
9. Numerical problems
10. Numerical problems

UNIT-IV

Topic Learning objectives

At the end of Unit -4 student should be able to:

1. Define the clutch as a mechanical device, which is used to connect or disconnect the source of power from the remaining parts of the power transmission system at the will of the operator. [L1]
2. Discuss that in case of new clutch, the intensity of pressure is approximately uniform, but in an old clutch the uniform wear theory is more approximate [L2]
3. Develop the relationship between axial force, torque, mean radius and stress for friction drives [L3]
4. Show that the uniform pressure theory gives a higher friction torque than the uniform wear theory [L3]
5. Calculate dimensions and number of discs for a multiple disc clutch for a given speed and power requirement. [L3]
6. Design Single, Multi-plate, Cone, and Centrifugal clutches for a given parameters.[L4]
7. Describe brake as a frictional device whose primary function is to control the motion of a machine or a machine member. In doing so, it is called upon to bring to rest a body, which is in motion, or to slow it down or to hold it in state of rest or of uniform motion against the action of external forces or couples [L1]
8. Integrate the mechanical concepts necessary to complete a preliminary design of a Mechanical Brake. [L2]
9. Calculate whether the brake is self-energizing or self-locking and conclude that for a proper operation of the brake, it should be self-energizing and not be self-locking. [L3]
10. Design Block, Internal Expanding and Disk Brakes for a given parameters.[L4]

Lesson Schedule

1. Design of single plate clutch
2. Numerical problems
3. Design of Multiple plate clutch
4. Numerical problems
5. Design of Cone clutch
6. Numerical problems
7. Design of Block and Band Brakes
8. Self locking of Brakes, Heat generation and heat dissipation in brakes
9. Numerical problems
10. Numerical problems

UNIT-V

Topic Learning objectives

At the end of Unit -5 student should be able to:

- Identify types, uses, and characteristics of sliding contact bearings [L1]
- Sketch the mechanism of pressure distribution in a hydrodynamic bearing[L2]
- Distinguish between boundary, thin film & fluid film lubrication.[L2]
- Select the suitable type of lubricant & bearing materials for a given application.[L3]
- Determine the coefficient of viscous friction, the heat generated & dissipated.[L3]
- Analyze the life of an antifriction bearing in millions of revolutions based on the type of service and the loads acting on the shaft.[L5]
- Select a suitable type of bearing from the manufacturer's catalogue which has the desired static & dynamic capacities.[L4]
- Define the Terminology of Rolling Contact Bearing [L1]

- Describe that the starting friction in ball and roller bearings is lower than that in an equivalent journal bearing in which metal to metal rubbing takes place at the time of starting.[L2]
- Design and specify commercially available rolling contact bearings for shafts considering both radial and thrust loads [L4]

Lesson Schedule

1. Introduction, principle of hydro dynamic lubrication, assumptions in hydrodynamic lubrication
2. Bearing characteristic number and modulus, Sommerfeld number, coefficient of friction, power loss, heat Generated and heat dissipated
3. Bearing materials, lubricants and properties, design of journal bearing and thrust bearing.
4. Numerical problems
5. Numerical problems
6. Introduction to Ball and Roller contact Bearings,
7. Designation, static & dynamic capacity,
8. Equivalent load, selection of suitable bearings based on rated life.
9. Numerical problems
10. Numerical problems

Review Questions

UNIT-1

1. Distinguish clearly between a straight beam and a curved beam.[L1]
2. With usual notations, derive expressions for stresses in extreme fibers of a curved beam.[L3]
3. A crane hook of trapezoidal crossection (1/2) x (90+40) is subjected to a load of 10 KN passing through the center of curvature of the hook. The inner radius 1s 100 mm. Determine the total stress at the inner fiber.[L4]
4. A chain link made up of 30 mm diameter steel rod has inner radius of curvature 30 mm. The straight side of the link is 50 mm long. Determine the maximum tensile, compressive & shear stress induced in the link while lifting a load of 9 KN.[L4]
5. Derive an expression for shear stress induced & deflection in a helical spring subjected to an axial load.[L2]
6. Write a note on (i) Wahl's stress factor (ii) Surge in helical springs[L1]
7. What is resilience of a spring? Give the energy equations when (i) the kinetic energy of a moving body (ii) the potential energy of a freely falling body is absorbed as resilience.[L2]
8. Design a helical compression spring for a safety valve. The valve must blow off at a pressure of 1.2 Mpa & should lift by 3 mm for 5% increase in pressure. The valve diameter is 60 mm. The maximum allowable shear stress is 400 MN/m^2 & the modulus of rigidity is 82.7 GPa. Take spring index as 8.[L4}
9. A railway wagon weighing 40 KN and moving with a speed of 10 Kmph has to be stopped by four buffer springs in which the maximum compression allowed is 200 mm. Find the number of turns in each spring of mean diameter 150 mm. The diameter of the spring wire is 25 mm. Take G=82.7 Gpa[L4]
10. A locomotive spring has an over all length of 1100 mm and sustain a load of 75 KN at its centre. The spring has 3 full length leaves and 15 graduated leaves with a central band 100 mm wide. All the leaves are to be stressed to 0.4 Gpa when fully loaded. The ratio of total spring depth to width is 2. Determine (i) Width & thickness of leaves (ii) nip or clearance to be provided (iii) Load exerted on the band by the clip bolt after assembly. Take E=206.8 Gpa[L4]

UNIT-II

1. Give the classification of gears [L1]
2. Define (i) Module (ii) Pressure angle (iii) Face with (iv) Circular pitch w.r.t gears [L2]
3. Derive the Lewis equation for beam strength of a spur gear tooth. State the assumptions made[L3}.
4. Write a note on gear tooth failures[L3]
5. Compare the various tooth systems in use and give their relative merits & demerits[L3]
6. What are the desirable properties of gear materials?[L4]
7. Design a pair of spur gears to transmit 9KW at 2000 rpm of cast steel (untreated) pinion. The gear is made of high grade Cast iron (heat treated) and is to rotate at 500 rpm. The pinion has 20 teeth of $14^1/_2{}^o$ involute form.[L5,L6]
8. A compressor running at 400 rpm is driven by a 25 KW, 1200 rpm motor through a pair of $14^1/_2{}^o$ involute spur gear. The centre distance is around 400 mm. The pinion is made of forged steel of static allowable 190 MN/m^2 and 350 BHN. Gear is to be made of cast steel of allowable stress 180 MN/m^2 and 300 BHN. Design the gear for safe continuous operation. Check the gear for endurance, wear & dynamic strength. .[L5,L6]
9. Derive an expression for the virtual number of teeth on a helical gear.[l3]
10. What are herringbone gears? What is their advantage?[L2]
11. How the Lewis equation for beam strength is modified in case of a helical gear?[L3]
12. Design a pair of helical gears to transmit 12 KW at 1200 rpm of forged steel pinion. Velocity ratio required is 3:1. The gear is made of high grade CI. Not less than 21 teeth are to be used on either gear. The teeth are 20^0 stub involute form. Helix angle should not be greater than 26^0.[L5]
13. Design a pair of helical gears to transmit 9 KW at 1500 rpm of the pinion. Gear is to rotate at 500 rpm and the center distance between the gears is 240 mm. The pinion is made of cast steel (untreated) and the gear is made of high grade CI (heat treated). The helix angle is 22.5^0. The teeth are 20^0 FDI form.[L5, L6]

UNIT-III

22. For a bevel gears**,** define the following: a) Pitch angle b) Face angle c) Root angle d) Back cone distance, and e) Crown height. [L1]
23. Derive an expression for the formative number of teeth in bevel gears.[L3]
24. With a neat sketch, explain the following terms w.r.t a bevel gear (i) Cone angle (ii) Back cone radius (iii) Miter gears [L3]
25. Design a pair of bevel gears to transmit 12kw at 300rpm. Of the gear and 1470 rpm of the pinion. The angle between the shaft axes is 90^0. The pinion has 20 teeth and the material for gears is cast steel c-30 untreated. Take service factor as 1.25 and check the gears for wear and dynamic load.[L5]
26. A cast steel (Untreated) pinion having 24 teeth transmits a power of 9 KW through a high grade CI (heat treated) gear at a velocity ratio 3. Pinion rotates at 720 rpm. The angle between the shaft axes is 60^0.The teeth are $14^1/_2{}^0$ system. Design the gears completely. [L5]
27. Explain self locking w.r.t worm gear drives.[L2]
28. Write a note on heat generation & dissipation in a worm gear drive[L3]

UNIT-IV

1.What is clutch? Name the different types of clutches and give one example under each category [L1]

2. What factors should be considered in designing in designing friction clutch? [L3]

3. Explain uniform wear & uniform pressure theories of friction materials. Mention the application of each theory
4. What is equivalent coefficient of friction? When it is used?
5. Write a note on the friction materials used for clutches & brakes.
6. A cone clutch is to be designed to transmit 8 kW at 1,000 r.p.m. Assuming the normal pressure between the contact surfaces not to exceed 0.09 N/mm.^{2}, coefficient of friction between contact surfaces as 0.2 and cone angle to be 24^0, design the main dimensions of the clutch. Calculate the axial force to engage the clutch. Take the width of face = ½ mean radius. [L5,L6]
7. Explain self locking of brakes and the necessary conditions for self locking.
8. Discuss the design procedure for simple band brakes.
9. In a band and block brake, the band is lined with 14 blocks each of which subtends on angle of 150 at the drum centre. One end of the band is attached to the fulcrum of the brake lever and other to a pin 125 mm. from the fulcrum. If the torque applied to the drum is to be 30 N-m., what minimum effort must be applied to the brake lever at a pin 750 mm. from the fulcrum? Assume the coefficient of friction as 0.25.[L6]

Unit-V

1. Enumerate the factors that form and maintain thick oil film in hydrodynamic journal bearing. [L1]
2. Explain wedge film and squeeze film journal bearings. [L2]
3. Explain with sketches theory of hydrodynamic lubrication. [L3]
4. Explain the following terms as applied to journal bearings:
   a. Bearing Characteristic number and b) Bearing modulus. [L2]
5. With usual notations derive the Petroff's equation for coefficient of friction in a lightly loaded journal bearing. State clearly all the assumptions made. [L3,L2[
6. Design a journal bearing for the main bearing of a steam turbine to support a radial load of 10 KN on shaft operating at a speed of 1000 rpm. Assume the bearing to be well ventilated.[L5]
7. A full journal bearing 90mm diameter and 150mm long has a radial load of 2MPa per unit projected area. Shaft speed is 500 rpm. The bearing is operating with SAE20 oil at 50^oC. The specific gravity of the oil at the operating temperature is 0.985. Calculate the following:

   i) The minimum film thickness.

   ii) Heat loss due to friction

   Whether artificial cooling is necessary? [L4]
8. Discuss the relationship between the bearing modulus & coefficient of friction. What is the condition for thick film lubrication?[L3]
9. Define the following terms w.r.t antifriction bearings. (i) Rating life (ii) Static capacity (iii) Dynamic capacity (iv) Equivalent load[L2]
10. Select a deep groove SKF ball bearing for a shaft 50 mm diameter subjected to an axial thrust of 2500 N & a radial load of 4000N. The bearing has to last for at least 7000 hrs. The speed of the shaft is 3000 rpm. Assume the inner ring as stationary.[L4]
11. Write a note on the design of partial journal bearings.[L2]
12. What are rolling contact bearings? Explain with sketches. Discuss their advantages over sliding contact bearings.[L1]
13. Enumerate the merits and demerits of antifriction bearings. [L2]
14. A 60mm shaft is supported between two bearings 400 mm apart and carries a bevel gear of 200 mm pitch diameter, at 150 mm from left end. The gear produces a radial load of 10 kN and a thrust

load of 3000 N, when rotating at 500 rpm. Select a proper type of ball bearing to be used on each of shaft. Desired life is 2 years at 50 hours/week [L3]

Course Articulation Matrix (CAM)

Course Outcomes (CO's)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
Design *the curved beams using the equations of stress*	L3	M				M						
Design helical spring and leaf spring using the equations of stress and deflection	L3	M				M						
Design the spur gears and helical gears using different parameters and check the gears for dynamic and wear load.	L3, L4	M				M						
Design the various types of bevel gears and worm gears for dynamic and wear load using various parameters	L3	M				M						
Design sliding contact and rolling contact bearings to find coefficient of friction, heat generated, heat dissipated and average life of bearings.	L3, L4	M				M						
Analyze and design given machine components and present their designs in the form of a Report	L4	H						M				
L – Low, M – Moderate, H - High												

Course Assessment Matrix (CAM)

Course Outcomes (CO's)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
Design *the curved beams using the equations of stress*	L3, L4	2				2						
Design helical spring and leaf spring using the equations of stress and deflection	L3, L4	2				2						
Design the spur gears and helical gears using different parameters and check the gears for dynamic and wear load.	L3, L4	2				2						
Design the various types of bevel gears and worm gears for dynamic and wear load using various parameters	L3, L4	2				2						
Design sliding contact and rolling contact bearings to find coefficient of friction, heat generated, heat dissipated and average life of bearings.	L3, L4	2				2						
Analyze and design given machine components and present their designs in the form of a Report	L3	3										
1 – Low, 2 – Moderate, 3 – High												

Course Title: AUTOMOTIVE ELECTRICAL AND AUTOTRONICS			
Course Code: P13AU64	Semester: 6	L:T:P:H- 2:2:0:4	Credits:3
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

Subject requires student to know about

- Basics of electrical Engineering
- Basics of electronic science
- Basics of electrical and electronic circuits
- Basics of electromagnetic principles
- Basics of Automobile
- Basic working principles of generator, alternator and electric motors

Course Learning Objectives (CLO):

This Course aims to

i. Explain electrical systems and different accessories used in automotive vehicles (L2)

ii. Explain the construction and working of different types of batteries used in automotive vehicles. (L2)

iii. Explain the construction, working and distinguish the generator, alternator starting motors and starting drives. (L2, L4)

iv. Sketch and explain different types of ignition system used and comparison .(L3,L4)

v. Identify, describe about microprocessor based controllers, transducers and sensors.(L1,L2)

vi. Identify, describe about 8051 microcontroller(L1, L3)

Relevance of the course:

Automotive electrical and Autotronics is a fundamental course in B.E (automobile engineering) program that helps to understand vehicle electrical system, construction and testing of a battery, working of ignition system.

Further this course also helps to understand application of electronic system in automobile and microcontroller based controlling system.

Course Content

UNIT-1

Vehicle Electricals System: History Vehicle Electricals System, electrical power supply in conventional Vehicle Electricals System, Future electrical system, dimensions of wire, plug- in connections, circuit diagrams and symbols.

Storage Battery:

Battery design, method of operation, battery construction, substitute batteries, special cases, drive/traction batteries, electrically powered vehicles, Battery systems. Principle of lead acid cells, plates and their characteristics containers and separators, electrolyte and their preparation, voltmeter, effect of temperature on electrolyte, its specific gravity, capacity and efficiency, methods of charging, defects and remedies of batteries, different types of batteries and their principles like alkaline, lithium and zinc air etc., **10 Hrs**

UNIT-2

Charging and Starting Systems:

Generation of electrical energy in the motor vehicle, Basic Principles, Alternator versions , voltage regulator versions, over voltage protection, cooling and noise, power losses, characteristics curves, alternator operations in the vehicles.

Starter motors: development of starting systems, starting the internal combustion engine, starter motor design, design variations, technology of electrical starting systems, and types of drives.

Development and production of Alternators and Starter motors: quality management, development and production. **11 Hrs**

UNIT-3

Ignition and Automotive Lighting Technology:

Ignition fundamentals, requirements and types of ignition systems, Technical demands, legal frame work, development of lighting technology, physical principles, front and rear lighting system(components), interior lighting system, instrument clusters, display types, special purpose lamps, diagram of typical wiring system, Principle of automobile illumination, head lamp mounting and construction, sealed beam auxiliary lightings, horn, windscreen-wipers, windshield and head lamp cleaning systems. **10Hrs**

UNIT-4

Introduction to Mechatronic System:

Measurement and control systems, their elements and functions, microprocessor based controllers.

Transducers and sensors:

Definition and classification, principle of working and application of light sensors, proximity sensors and Hall effect sensors.

Introduction to Actuation system and signal conditioning. **10hrs**

UNIT 5

8051 Microcontroller:

Introduction, Architecture, Memory organization, Special function registers, Internal architecture, Information flow in instruction execution, pins and signals, Port operation, I/O interfacing, I/O interfacing using external ports, Timers/counters, Interrupts, power down operation **11 hrs**

TEXT BOOKS:

1. "Automotive Electrics Automotive Electronics" Robert Bosch GmbH publication, 2004.
2. Krishna Kant – "Microprocessors and Microcontrollers- Architecture, Programming and System Design 8085,8086,8051,8096" 2nd Edition PHI (Eastern Economy Edition)
3. Mechatronics – W.Bolton, Longman, 2Ed, Pearson publications, 2007

REFERENCE BOOKS:

1. P.M. Kohli, 'Automotive Electrical Equipment", Tata McGraw Hill, New Delhi.
2. . A.P. Young & Griffiths, "Automobile Electrical Equipment", ELBS & Newnes Butterworths, London
3. W. Judge, "Modern Electrical Equipment "
4. Electrical Equipment for Automobiles by Parker and smith S.
5. Kenneth J Ayala – " The 8051 Microcontroller- Architecture, Programming, & Applications" 3rd edition Penram International Publishing (I) Pvt Ltd- Thomson Delmar Learning

Course Outcomes (COs)

At the end of the course student will be able to:

i. Explain electrical systems and different accessories used in automotive vehicles (L2)
ii. Explain the construction and working of different types of batteries used in automotive vehicles. (L2)
iii. Explain the construction, working and distinguish the generator, alternator starting motors and starting drives. (L2, L4)
iv. Sketch and explain different types of ignition system used and comparison .(L3,L4)
v. Identify, describe about microprocessor based controllers, transducers and sensors.(L1, L2)
vi. Identify, describe about 8051 microcontroller. (L1,L3)

Unit wise plan

UNIT-1:

Topic Learning Objectives (TLO):

At the end of the Unit-I student should be able to:

- Explain the history of vehicles in electrical system(L2)
- Draw the circuit diagram and symbols used in electrical wiring system(L1)
- Explain construction and working principles of different types of batteries.(L2)
- Differentiate between different types of batteries used in automotive vehicles.(L4)
- Discuss the different defects and remedies of batteries.(L2)
- Explain the specification and different ways of battery testing and rating.(L2)

Lesson Schedule

1. Introduction to Vehicle Electricals System: History, Fundamentals of Vehicle Electricals System,
2. Dimensions of wire, plug- in connections, circuit diagrams and symbols.
3. Battery design, method of operation, battery construction,
4. substitute batteries, special cases, drive/traction batteries, electrically powered vehicles,
5. Battery systems. Principle of lead acid cells, plates and their characteristics containers and separators,
6. Electrolyte and their preparation, different methods of battery testing , effect of temperature on electrolyte, its specific gravity, capacity and efficiency,
7. Methods of charging, defects and remedies of batteries,
8. Different types of batteries and their principles like alkaline,
9.Lithium
10. zinc air etc.

UNIT – 2:

Topic Learning Objectives(TLO)

At the end of the Unit 2, student will be able to:

- Explain the basic principles of generator of DC and AC currents.(L2)
- Sketch and explain the DC generator and alternator working principle.(L3)
- Distinguish between generator and alternator.(L4)
- Explain the advantages and disadvantages of generator and alternator.(L2)
- Explain the basic requirements of starting motors.(L2)
- Sketch and explain the working of different types of starting motors.(L3)

Lesson Schedule

1.Generation of electrical energy in the motor vehicle, Basic Principles,
2. Alternator versions ,
3. voltage regulator versions, over voltage protection,
4. cooling and noise, power losses, characteristics curves
5.alternator and DC generators operations in the vehicles.
5. Development of starting systems, starting the internal combustion engine,
6.Starter motor design,
7.design variations, Technology of electrical starting systems,
8.types of drives.
9. Development and production of Alternators and
10. Starter motors: quality management,
11. development and production

UNIT – 3:

At the end of Unit-III student should be able to:

- Explain the requirements and basic components of an ignition system.(L2)
- Differentiate between different types of ignition system used in SI engine.(L4)
- Explain the principles of automobile illuminator system.(L2)
- Explain the working of different types of horn, Windscreen-wipers, windshield and head lamp cleaning systems, etc., (L2)

Lesson Schedule

1. Ignition fundamentals, requirements and
2. types of ignition systems,
3. Technical demands, legal frame work, Development of lighting technology,
4. physical principles, Front and rear lighting system(components),
5. interior lighting system, instrument clusters, display types,
6. Special purpose lamps,
7. Diagram of typical wiring system,
8. Principle of automobile illumination, head lamp mounting and construction, sealed beam
9. Auxiliary lightings, horn,
10. Windscreen-wipers, windshield and head lamp cleaning systems.

UNIT-4:

Topic Learning Objectives (TLO): (L1, L2, L3**)**

At the end of this chapter student should be able to **Identify and Explain and/ solve** about

- Evolution of mechatronics
- Measurement system and their elements
- Open loop and closed loop control system
- Advantages of mechatronics
- Microprocessor based controller
- Transducers
- Classification of transducers
- Light sensors
- Hall effect sensors
- Proximity sensors

Lesson Schedule

1. Introduction, evalution of mechtronics
2. Measurement system and their elements with examples
3. Control system with example
4. Advantages of mechatronics and microprocessor based controller system
5. Automatic camera, engine management system
6. Transuducers and classification of transducers
7. Light sensors
8. Hall effect sensors
9. Proximity sensors
10. Introduction to actuation system

UNIT 5:

Topic Learning Objectives (TLO): (L1, L2, L3**)**

At the end of this chapter student should be able to **Identify and Explain and/ solve** about

- Architecture of micro controller
- Memory organization in micro controller
- Special function registers
- Information flow in instruction execution,
- pins and signals,
- Port operation,
- I/O interfacing,
- I/O interfacing using external ports,
- Timers/counters,
- Interrupts,
- Power down operations

Lesson Schedule

1. Introduction to microcomputer, microprocessor and micro controllers
2. Architecture of 8051 microcontroller
3. Memory organization
4. Special function register
5. Information flow in instruction executions
6. Pins and signals
7. Port operation
8. I/o interfacing
9. Timers and interrupts
10. Power down operations

Review Questions:

UNIT-I

1. Explain the construction and working of a lead acid battery (L2)
2. Explain the construction and working of a Ni-Cad battery (L2)
3. Discuss in detail various tests for ascertaining the fitness of a battery to be used in a vehicle (L 2)
4. What are the different troubles experienced in an automotive battery discuss their
5. Describe the chemical reactions that are taking place during charging and discharging process of a lead acid battery (L 2)
6. Describe with neat sketch charging and testing procedure of a lead acid battery (L3)
7. Choose appropriate electrical storage device for following
   i) SI engine car ii) Electrical vehicle iii) Locomotive iv) Hybrid vehicle (L1)
8. What are the advantages claimed for an alkaline battery? Describe briefly its construction (L 2)
9. Describe different methods of battery rating and capacities (L2)
10. Explain with suitable sketches Lithium battery (L2)
11. Describe clearly working of zinc air battery (L2)

UNIT-II

1. Describe in short the necessity of generating system in a vehicle (L 4)
2. Explain with neat sketch the construction and working principle of an alternator (L5)
3. Describe the necessity of voltage regulator used in an alternator generating system (L6)
4. How do you control the generator output in an automobiles? Explain briefly
5. Write in detail the procedure of testing of an alternator (L 7)

6. Illustrate in detail the fault diagnosing procedure for an alternator (L7)
7. Describe the construction and working of a series starter motor (LO 8)
8. Describe the construction and working of a shunt starter motor (L 8)
9. What are the different types of starting motor drives in current practice? explain With suitable sketches
10. Explain why? the bendix drive is suitable for LCV'S (L 8)
11. Describe the construction and working of Bendix drive (LO 8)
12. Describe the construction and working of Positively engaging and disengaging drive (LO 8)
13. Chose appropriate cranking motor drive for following vehicle (LO 8)
    i) Two wheeler ii) Three wheeler iii) Bus iv) Truck
14. Arrange the Differences between positively engaging drive and positively disengaging drive with reference to their construction, working and application point of view (LO

UNIT-III

1.List the requirements of automotive ignition system (L 1)
2.Describe the functions of all the components of ignition system (L 2)
3.With an appropriate circuit diagram illustrate the functioning of conventional ignition system (L 2)
4.With an appropriate circuit diagram illustrate the functioning of programmed ignition system (L2)
5.With an appropriate circuit diagram illustrate the functioning of distributor less ignition
6.system (LO 2)
7. Analyze the Differences between programmed ignition system and distributor less ignition
8.system (L 3)
9.Which one of the ignition system you propose for today's vehicle and why? (L 4)
10. Summarize advantages of distributor less ignition system over the programmed ignition System (L 5)
11. draw a layout of lighting and accessory systems
12. explain earthed and insulted return system
13. Give the advantages and disadvantages of positive and negative earthening
14. Define Luminous flux, Luminous intensity, Illumination intensity, Brightness or luminance, range of a head light, Geometric range, Visual range, Signal identification range, and Glare or dazzle (L1)
15. List possible internal and external lighting systems used in vehicles (L 2)
16. Describe with a neat diagram of head light aiming and leveling (L 3)
17. Explain LED lighting systems in automobiles (L 4)
18. Explain flashing units used in side indicator lamps (L 5)

UNIT 4:

1. Define a system with an example.
2. Define measurement and measurement system.
3. Draw a neat block diagram of a generalized measurement system showing its element.
4. Explain the function of each element of a measurement system.
5. Give an example of a measurement system and compare the same with the elements of a generalized measurement system.
6. Explain the function of a signal conditioner.
7. Explain the function of a display unit.
8. What is meant by control and control system?
9. Is it possible to control the temperature of the environment. If yes how? If no why?
10. How are control systems classified?
11. Define open-loop control system. Explain with a neat diagram an example of an open-loop control system.
12. What are the advantages and disadvantages of open-loop control system?

13. Define closed-loop control system. Explain with a neat diagram at example of a closed-loop control system.
14. Show with a neat diagram the different elements of a closed-loop control system.
15. Explain the functions of each element of a closed-loop control system.
16. Enumerate the differences between open-loop and closed-loop control system.
17. What is meant by sequential control. lllustrate with an example a sequential control system?
18. Explain with a block diagram the working of a microprocessor controlled washing machine.
19. Explain how microprocessors are useful in automatic cameras.
20. Define sensor and transducers. What is the basic difference between them?
21. How are transducers classified?
22. What is meant by primary and secondary transducer? Explain with an example for each.
23. How are transducers classified based on measurand and give example in each?
24. What are the advantage and disadvantages of mechanical transducers?
25. What are the advantages of electrical transducers?
26. List the different types of displacement transducer used. Explain any two of them.
27. Explain with neat sketches the constructional features and working of an LVDT.
28. Explain the working proximity sensor on the principle of eddy current.
29. What is Hall effect and Hall –effect – co-efficient?
30. List out the application of Hall-effect.

UNIT 5:

1. List the differences between microcontrollers and microprocessors.
2. What are the basic units in a digital computers?
3. List some common applications of microcontrollers.
4. Describe the basic unit of a ROM and RAM.
5. Distinguish between assembly language and high level language.
6. What are the features which dictate the choice of a microcontroller for an application?
7. Give the block diagram of 8051 and briefly explain the various parts.
8. Explain how clock pulses are provided in 8051.
9. What is the function of the program counter?
10. What are the flags of 80l5? How can their status be known?
11. Briefly describe the internal RAM available on 8051.
12. How are the flags of 8051 affected when signed arithmetic is used, if 39H is added to FEH.
13. What are the pins of 8051 which are used to interface with external memory.
14. Give the circuit connection to interface an 8K program ROM and an 8K RAM to 8051.
15. If we need to clock O.ls, how many times should the timer be incremented if 11.0592 MHz clock is used.
16. Explain the bit assignments of TMOD SFR.
17. What should be TMOD to configure Timer 0 in Mode 1 and Timer 1 in Mode 2, both with external control.
18. Explain the process of demultiplexing the address and data lines.
19. What are the bit functions of the bits of SCON register.
20. Briefly explain the interrupts available in 8051.
21. What is polling? How is the interrupt priority decided?
22. What are the power saving modes available? How can they be activated?
23. How many ports does 8051 have? What is the configuration of any port?
24. How are interrupt priorities set?

25. What is Stack? How is it initialized? What are the precautions to be taken with stack?
26. Draw the machine cycle for a two byte-two cycle instruction.

Course Articulation Matrix (CAM)

Course Outcomes (CO's)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
Explain electrical systems and different accessories used in automotive vehicles	(L2)				**M**			**M**		**M**		
Explain the construction and working of different types of batteries used in automotive vehicles.	(L2)				**M**			**M**		**M**		
Explain the construction, working and distinguish the generator, alternator starting motors and starting drives.	(L2, L4)				**M**			**M**		**M**		
Sketch and explain different types of ignition system used and comparison	(L3,L4)				**M**			**M**		**M**		
Identify, describe about microprocessor based controllers, transducers and sensors.	(L1, L2)		**M**	**M**	**M**					**M**		
Identify, describe about 8051 microcontroller	(L1,L3)		**M**	**M**	**M**					**M**		
L – Low, M – Moderate, H - High												

Course Assessment Matrix (CAM)

Course Outcomes (CO's)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
Explain electrical systems and different accessories used in automotive vehicles	(L2)				**2**			**2**		**2**		
Explain the construction and working of different types of batteries used in automotive vehicles.	(L2)				**2**			**2**		**2**		
Explain the construction, working and distinguish the generator, alternator starting motors and starting drives.	(L2, L4)				**2**			**2**		**2**		
Sketch and explain different types of ignition system used and comparison	(L3,L4)				**2**			**2**		**2**		
Identify, describe about microprocessor based controllers, transducers and sensors.	(L1, L2)		**2**	**2**	**2**					**2**		
Identify, describe about 8051 microcontroller	(L1,L3)		**2**	**2**	**2**					**2**		
1 – Low, 2 – Moderate, 3 – High												

Course Title: MECHANICAL VIBRATIONS			
Course Code: P13AU65	Semester: 6	L:T:P:H- 3:2:0:5	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

Subject requires students to know about

- Basics of engineering mathematics
- Basic physics

Course Learning Objectives (CLO):

The course aims to:

1. **Formulate** mathematical models of single degree of freedom, free, undamped and damped vibrating systems and **determine** their natural frequencies. **Formulate** mathematical models for damped free vibratory systems.(L5,L6)
2. **Determine** the response of simple single degree of freedom systems subjected to forced vibration.(L5)
3. **Explain** the working principle of vibration measuring instruments. **Determine** the whirling speed of shafts. **Compute** harmonics of general forcing functions using Fourier series.(L2,L5,L6)
4. **Formulate** mathematical models and **Solve** vibration problems related to Two degrees of freedom. **Determine** influence coefficients. (L3,L5,L6)
5. **Solve** multi degree of freedom systems using Rayleigh and Dunkerley, Stodola, Holzer and Matrix iteration methods. (L3).

Relevance of the course

Mechanical Vibrations is a foundation course in B.E Automobile engineering program that helps in understanding vibrations of various components in machines, vibrations due to unbalanced forces in a machine.

Further this course also helps in understanding, solving numerically various systems vibrating with multi degrees of freedom and method of damping the system.

Course Content

UNIT – 1

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

UNIT – 2

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

UNIT – 3

Vibration measuring instruments: Vibrometer, velocity pick-up and accelerometer**. Whirling of Shafts:** Introduction, critical speed of a light shaft having a single disc without damping, critical speed of a light shaft having a single disc with damping.

Fourier Series and Harmonic Analysis: Analytical methods and numerical methods. **08 hrs**

UNIT – 4

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

10 hrs

UNIT – 5

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

12 hrs

TEXT BOOKS:

1 Mechanical vibrations: G.K. Grover, Nem Chand & brothers, Roorkee.

2 Mechanical Vibrations: V.P. Singh, Dhanpat Rai & Company Pvt. Ltd.

REFERENCES:

1 Mechanical Vibrations: S.S. Rao, Pearson Education Inc, 4th Edition, 2003.

2 Mechanical Vibrations: S. Graham Kelly, Schaum's Outline Series, Tata McGraw Hill, Special Indian edition, 2007.

3 Theory & Practice of Mechanical vibrations: J.S. Rao & K. Gupta, New Age International Publications, New Delhi, 2001.

4 Elements of Vibrations Analysis: Leonanrd Meirovitch, Tata McGraw Hill, Special Indian edition, 2007.

5 Mechanical Vibrations: Austin H Church, John Wiley & Sons.

Course Outcomes

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

1 **Formulate** mathematical models of single degree of freedom, free, undamped and damped vibrating systems and **determine** their natural frequencies. **Formulate** mathematical models for damped free vibratory systems.

2 **Determine** the response of simple single degree of freedom systems subjected to forced vibration.

3 **Explain** the working principle of vibration measuring instruments. **Determine** the whirling speed of shafts. **Compute** harmonics of general forcing functions using Fourier series.

4 **Formulate** mathematical models and **Solve** vibration problems related to Two degrees of freedom. **Determine** influence coefficients.

5 **Solve** multi degree of freedom systems using Rayleigh and Dunkerley, Stodola, Holzer and Matrix iteration methods.

Unit wise plan

UNIT – 1:

Topic Learning Objectives :

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

- **Classify** the vibratory systems.
- **Formulate** the governing differential equations of motion for the single degree of freedom undamped-free vibrating systems using Newton's second law or Energy methods and **Express** their

natural frequencies.

- **Sketch** an equivalent spring-mass vibratory system for a single dof system having multi masses and springs.
- **Formulate** governing differential equations of motion to the single dof damped-free vibratory systems and **Express** their solutions.

Lesson Schedule

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

Unit II:

Topic Learning Objectives :

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

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

Lesson Schedule

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

9	Numerical problems
10	Numerical problems

Unit III:

Topic Learning Objectives :

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

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

Lesson Schedule

1	Introduction to vibration measuring instruments, Seismic instrument, working principles of vibrometer and accelerometer.
2	Numerical problems
3	Numerical problems
4	Introduction to whirling of shafts, critical speed of a light shaft having a single disc without damping, critical speed of a light shaft having a single disc with damping.
5	Numerical problems
6	Numerical problems
7	Introduction to Fourier series and Harmonic analysis.
8	Examples on representation of periodic motion into harmonic series.

UNIT – 4:

Topic Learning Objectives :

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

- **Formulate** governing differential equations of motion for Two degree of freedom systems.
- **Solve** governing differential equations of motion of free vibration of two dof systems in terms of initial conditions and **Express** their equation of motion.
- **Estimate** natural frequencies and corresponding mode shapes of two degree of freedom systems having rectilinear and angular modes as well as combined rectilinear and angular modes.
- **Design** undamped vibration absorber.

Lesson Schedule

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

9	Introduction to influence coefficients, Maxwell's reciprocal theorem.
10	Example problems on determination of influence coefficients.

Unit V:

Topic Learning Objectives :

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

- **Estimate** fundamental natural frequency of multi degree freedom systems using Rayleigh's, Dunkerley's and stodola's numerical methods.
- **Estimate** all natural frequencies and corresponding mode shapes of multi degree freedom systems using Holzer's numerical method.
- **Formulate** equation of motion using influence coefficients and **Estimate** natural frequencies of multi degree freedom systems from matrix iteration method.

Lesson Schedule

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

Review Questions

1 Define the following:

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

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

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

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

method (ii) Energy method.

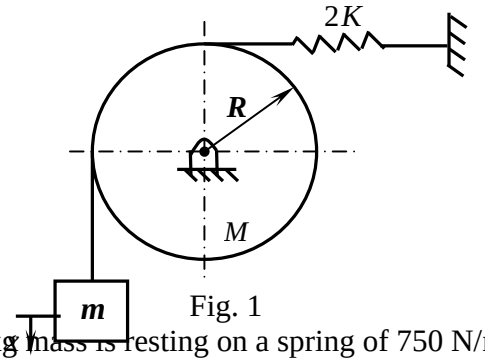


Fig. 1

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

6 Derive an expression for the logarithmic decrement.

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

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

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

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

11 Explain the principles of operation of vibrometer and accelerometer.

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

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

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

15 Determine the natural frequencies and the corresponding modes of vibration of the system shown

in Fig. 2. The string is stretched with a large tension T. Also draw the mode shapes.

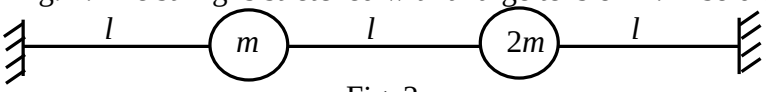


Fig. 2

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

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

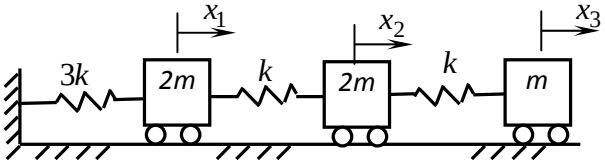


Fig. 3

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

$m_1 = 100$ Kg $\quad$ $m_2 = 50$ Kg

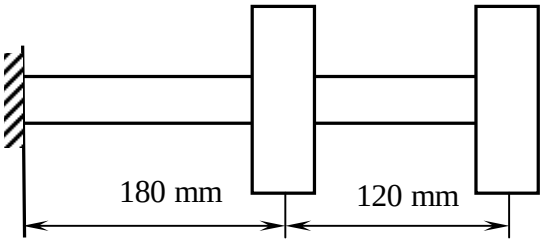


Fig. 4

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

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

Course Articulation Matrix

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

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

Course Title: **AUTOMOTIVE CHASSIS AND TRANSMISSION LAB**			
Course Code: **P13AUL67**	Semester: 6	L:T:P:H- 0:0:3:3	Credits: 1.5
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.	Weightage : CIE:50%; SEE:50%		

Prerequisites:

Subject requires student to know about

- Basic knowledge of an automobile and its layout
- Basic knowledge of requirements of an automobile
- Basic knowledge of Chassis types and components
- Basic knowledge of transmission types and parts

Course Learning Objective (CLO):

This Course aims to,

1. **Interpret** technical specifications and **description** of types of chassis and transmission components of automobiles. L3,L2
2. **Understand** and **Relate** Trouble shooting charts for major parts of chassis and transmission components of automobiles.L1,L2
3. Gain **knowledge** about, and **Analyze** by Testing and servicing of electrical components and microprocessors related to automobiles. L1,L4
4. Dismantle and assemble of major systems of chassis and transmission components and **identifying** remedies for the possible problems **Comparing** with trouble shooting charts.L1,L2
5. **Understand** seating arrangements for driver and passengers and comfort levels. **Learn** mechanisms of door and seat adjustments mechanisms in automobiles.L1

Relevance of the Course:

- The automotive chassis and transmission Laboratory is a foundation course in BE (Automobile Engineering) program that builds the program design and implementation competence in student through learning through observation about various chassis and transmission components, its types, materials and functions by practical experience.
- The course aims at developing the understanding, of major systems of chassis and transmission components of automobiles through Dismantling and assembling, their basic specifications, Trouble shooting charts and Testing and servicing of electrical components. Further, it also helps them to understand and learn about seating arrangements, seat adjustments mechanisms and mechanisms of door.

Course Content

Unit-1 Writing technical specifications and description of all types of chassis and transmission components of automobiles, including body and interiors (two wheeler, four wheeler and heavy vehicle – one each)

Unit-2 Trouble shooting charts for major parts of chassis and transmission components of automobiles like clutch, gear box, differential, brakes, and wheels with tyres, steering system and suspension

Unit-3 Testing and servicing of electrical components like battery, starting system, ignition system, central locking system, lighting system, and alternator. Experiments on microprocessors related to automobiles

Unit-4 Dismantle and assemble of major systems of chassis and transmission components of automobiles (clutch system, Gear boxes, Propeller shaft, Differential, Front and Rear axles, brake system, steering system and suspension system) and identifying remedies (like backlash adjustment, brakes adjustment, bleeding of brakes) for the possible problems based on trouble shooting charts

Unit-5 Sketching of seating arrangements, seats for commercial vehicle and study the comfort levels provided for driver and passengers. Sketching of different mechanisms of door, seat adjustments mechanisms in automobiles.

Text Books/References:

- Service Manuals of the automobiles
- Automotive Mechanics by William H. Crouse
- Automotive Chassis – P.M. Heldt, Chilton and Co.
- Automotive Transmissions and power trains - William H. Crouse, 5th edn., TMH
- Automotive chassis and body – P.L. Kohli, TMH
- Hand book of vehicle body design – SAE publication
- Vehicle body Engineering by Giles J pawlowski
- Automotive Mechanics – N.K. Giri , Khanna Publications, New Delhi,2004

Course Outcomes (CO):

At the end of the course the student should be able to,

a) **Interpret** technical specifications and **description** of types of chassis and transmission components of automobiles. L3,L2
b) **Understand** and **Relate** Trouble shooting charts for major parts of chassis and transmission components of automobiles.L1,L2
c) Gain **knowledge** about, and **Analyze** by Testing and servicing of electrical components and microprocessors related to automobiles. L1,L4
d) Dismantle and assemble of major systems of chassis and transmission components and **identifying** remedies for the possible problems **Comparing** with trouble shooting charts.L1,L2
e) **Understand** seating arrangements for driver and passengers and comfort levels. **Learn** mechanisms of door and seat adjustments mechanisms in automobiles.L1

A. Evaluation Scheme

CIE Scheme

Assessment	**Weightage in Marks**
TEST 1	20
TEST 2	20
RECORD	10
Total	**50**

SEE Scheme

Semester End Examination (SEE) is a practical examination of three hours duration of 50 marks.

Sl. No.	**Marks allotment**		
1	Procedure and Conduction	ONE Question from Chapter 1, 2	10Marks
		ONE Question from Chapter 3	20Marks
		ONE Question from Chapter 4	
		ONE Question from Chapter 5	10 Marks
2	Viva		10 Marks
Total Marks			50 Marks

Unit wise Plan

UNIT-1

Writing technical specifications and description of all types of chassis and transmission components of automobiles, including body and interiors (two wheeler, four wheeler and heavy vehicle – one each)**.**

3 hrs

Topic Learning Outcomes (TLO's):

At the end this lab, student should be able to:

- **Interpret** technical specifications and **comprehend** of different types of automobiles. L3,L2
- **Interpret** and **know** different types of chassis and transmission components of automobiles. L3,L2

UNIT-2

Trouble shooting charts for major parts of chassis and transmission components of automobiles like clutch, gear box, differential, brakes, and wheels with tyres, steering system and suspension. **6 hrs**

Topic Learning Outcomes (TLO's):

At the end this lab, student should be able to

- **Understand** and **Relate** Trouble shooting charts for major parts of chassis and transmission components of automobiles.L1,L2

UNIT-3

Testing and servicing of electrical components like battery, starting system, ignition system, central locking system, lighting system, and alternator. Experiments on microprocessors related to automobiles.

3 × 2 hrs

Topic Learning Outcomes (TLO's):

At the end this lab, student should be able to:

- Gain **knowledge** about, and **Analyze** by Testing and servicing of electrical components of automobiles. L1,L4
- Gain **knowledge** about, and **Analyze** by Testing and servicing of centre locking systems of automobiles. L1,L4
- Gain **knowledge** about, and **Analyze** by Testing and servicing of microprocessors related to automobiles. L1,L4

UNIT-4

Dismantle and assemble of major systems of chassis and transmission components of automobiles (clutch system, Gear boxes, Propeller shaft, Differential, Front and Rear axles, brake system, steering system and suspension system) and identifying remedies (like backlash adjustment, brakes adjustment, bleeding of brakes) for the possible problems based on trouble shooting charts. **3 × 7 hrs**

Topic Learning Outcomes (TLO's):

At the end this lab, student should be able to:

- Dismantle and assemble of major systems of chassis and transmission components and
- **identifying** remedies for the possible problems **Comparing** with trouble shooting charts.L1,L2

UNIT-5

Sketching of seating arrangements, seats for commercial vehicle and study the comfort levels provided for driver and passengers. Sketching of different mechanisms of door, seat adjustments mechanisms in automobiles. **3 hrs**

Topic Learning Outcomes (TLO's):

At the end this lab, student should be able to:

Understand seating arrangements for driver and passengers and comfort levels. **Learn** mechanisms of door and seat adjustments mechanisms in automobiles.L1

Lesson Schedule

UNIT-1

1. Technical specifications of different types of automobiles.
   Technical specifications of different types of chassis and transmission components of automobiles.

UNIT-2

1. Trouble shooting charts for major parts of chassis and transmission components of automobiles like clutch, gear box, differential, brakes, and wheels with tyres, steering system and suspension.

UNIT-3

1. Testing and servicing of electrical components like battery, starting system, ignition system, central locking system, lighting system, and alternator.
2. Experiments on microprocessors related to automobiles

UNIT-4

Dismantle and assemble of major systems of chassis and transmission components of automobiles like:

1. Clutch system,
2. Gear boxes,
3. Propeller shaft,
4. Differential,
5. Front and Rear axles, brake system,
6. steering system and
7. suspension system

   and identifying remedies (like backlash adjustment, brakes adjustment, bleeding of brakes) for the possible problems based on trouble shooting charts

UNIT-5

1. Sketching of seating arrangements,
   Seats for commercial vehicle and
   Study the comfort levels provided for driver and passengers.
   Sketching of different mechanisms of door, seat adjustments mechanisms in automobiles

Review Questions and / Questions for viva

1. What is the need of clutch in the automobile?
2. What is the maximum torque for clutch is usually designed?
3. What is the major factor limiting clutch capacity?
4. Why should the inertia of rotating parts of clutch be minimum?
5. What are the disadvantages of a cone clutch?
6. Why is there an upper limit of stiffness for the clutch springs?
7. What is the function of thrust bearing in a clutch?
8. What is the purpose of pressure plate in a clutch?
9. In a clutch with coil springs, how will the axial clamping load vary with wear of clutch facing?
10. What are the advantages of a friction clutch with a diaphragm spring over the one in which coil springs are
11. What is the advantage of hydraulically operated clutch, compared to mechanically operated type?
12. What is the purpose of installing coil springs in the clutch plate?
13. Why do we have cushioning springs in the clutch friction plate?
14. Why are the clutch friction plates perforated?
15. What is the material for clutch facing?
16. Why is asbestos being phased out as material for clutch facings?
17. What are the advantages and disadvantages of glueing and riveting the friction facings on clutch plates?
18. What is 'clutch free pedal play'? Approximately, how much it is kept at the clutch pedal?
19. What happens when the driver is in the habit of keeping his foot on the clutch pedal constantly during driving?
20. What will be the most likely result of dropping the clutch in too quickly?
21. What are the advantages and disadvantages of a fluid flywheel?
22. What happens if clutch free pedal play is excessive?
23. What is likely result if clutch free pedal play is less?
24. What is the necessity of a gear box at all in the automobile when the engine speed can be varied by means of accelerator?
25. 'It is easier to drive over sandy road in top gear than in low gear*. True or false?
26. What is a counter gear?

27. 'All the gears on the lay shaft in a gear box are always rotating when the drive gear is in motion." True or false?
28. What are the approximate gear ratios provided in a three forward speed gear box?
29. Does the countershaft stand still or rotate when the transmission of the car is being driven in high gear?
30. Which is better — a gear shift lever on the steering column, or on the top of transmission case ?
31. What is a synchronizer?
32. Why synchromesh device is usually not employed for the reverse gear?
33. How is the lubrication of a gear box done?
34. Should the grease be used ordinarily for gear box lubrication?
35. What is a transfer box? Where is it used?
36. What are the possible causes of hard gear?
37. What may be the possible reasons when the gear slips out of engagement?
38. What should be the cause when the vehicle is running with excessive noise in the gear box?
39. What are the three active members of a planetary gear set?
40. In an epicyclic gear set, what is the driven member in forward drive?
41. In an epicyclic gear set, what is the driving member in forward drive?
42. How many gear reductions are possible in a Wilson gear box ?
43. By what means are the members of an epicyclic gear box made stationary?
44. What is the advantage of the epicyclic gear box over the ordinary crash type gear box?
45. What are the advantages and disadvantages of freewheeling?
46. What provision is made for reversing the car which is fitted with a free wheel?
47. What is the basic difference between a fluid flywheel and a torque converter?
48. Name the three operating members of a torque converter.
49. Why is it necessary to have oil under pressure in a torque converter?
50. What force in the torque converter rotates the turbine?
51. During torque conversion what is the direction of oil flow at the turbine outlet?
52. What is the function of stator in a torque converter?
53. Approximately how much torque multiplication occurs at stall?
54. When does maximum torque multiplication occur in a torque converter?
55. What is a coupling point?
56. Why do some torque converters use lock-up clutch?
57. Name the main components of an automatic transmission.
58. Name the material used for (i) converter housing (ii) oil pan (Hi) case.
59. What is an overdrive? What are its advantages?
60. What are the various positions of a control lever for automatic transmissions?
61. What is a continuously variable transmission?
62. Name any two cars using CVT.
63. What is the main limitation of a CVT?
64. Name the factor limiting the capacity of a CVT for torque transmission.
65. What is a toroidal transmission ?
66. State main disadvantages of a toroidal transmission.
67. What is AMT?
68. What is the full form of DCT?
69. How is the length of propeller shaft varied automatically?
70. What is the material used for propeller shaft?
71. Define the whirling of shafts.
72. What is critical whirling speed?
73. Which type of propeller shaft is used in case of Ashok Leyland vehicles?

74. What is the advantage of a two-piece propeller shaft?
75. What is the function of Hooke's joint?
76. Why is it desirable to have small operating angle between shafts in case of Hooke's joint?
77. What is the need for a constant velocity universal joint when the cheaper Hooke's joint is available?
78. What is a plunging type joint?
79. Name two basic types of constant velocity joints.
80. How is the drive from propeller shaft turned at right angles?
81. What is ‘hypoid'?
82. What is the advantage of hypoid gear over the straight bevel type?
83. What is the effect of 'offset* in hypoid gears?
84. State the materials used for the pinion and the crown wheel.
85. Why do we use multi-start worms for final drive?
86. Which type of final drive is used most commonly?
87. Why do we have a differential in automobile, when we don't have one in a rickshaw?
88. How will be the torque divided between the wheels when the differential is operating on turns so that the wheels are rotating at different speeds?
89. Does the non-driving axle also require differential? Why?
90. What rotates the differential pinion shaft?
91. What rotates the differential cage?
92. What is a non-slip or limited-slip differential?
93. What are the various loads acting on the rear axles?
94. What is ‘torque reaction'?
95. What is a 'radius rod"?
96. What is a 'pan hard rod'?
97. How many universal joints are used with a torque tube derive? How many on a Hotchkiss drive? Why?
98. Which member takes the torque reaction in Hotchkiss drive? How?
99. What loads are carried by the axle shaft in case of semi- floating axle?
100. Which loads are withstood by the axle shaft in case of a three-quarter floating axle? How are the other loads taken up?
101. What loads does the axle shaft carry in fully-floating axle?
102. What carries the weight of the vehicle in the "full-floating" type of rear axle?
103. Which type of rear axle is best suited for cheap, light vehicles?
104. Which type of rear axle is best suited for heavy vehicles?
105. What is a banjo type axle casing?
106. What is a Salisbury type axle casing?
107. In case of a hammering noise from the rear axle, what may be the possible reason?
108. What are the objectives of vehicle suspension?
109. What do you understand by pitching and rolling of a vehicle?
110. What is brake dip?
111. What is unsprung weight?
112. Why is the unsprung weight kept as low as possible?
113. What is the function of a spring?
114. How does a spring absorb vertical loading?
115. How is the side thrust countered in a vehicle?
116. What is the function of a shackle with a leaf spring?
117. What is the material used for leaf springs?
118. If the spring leaves are not lubricated, what may be the result?

119. They say, laminated leaf springs are self-damping. How?
120. What is the effect of moisture on the leaf springs?
121. What is the purpose served by phosphate paint in leaf springs?
122. What is the effect of shot peening on spring levels?
123. How is the fatigue strength of a leaf spring increased?
124. What forces are supported by a leaf spring?
125. What are helper springs?
126. State the advantages of a tapered leaf spring.
127. State the advantages and disadvantages of a coil spring.
128. What is a torsion bar?
129. What material is used for making a torsion bar?
130. State the advantages and disadvantages of a torsion bar.
131. What are the advantages of rubber suspension?
132. State the advantages of a plastic suspension.
133. What is the function of a shock absorber?
134. How is aeration caused in a shock absorber?
135. What is the effect of aeration in the shock absorber?
136. What is the function of a gas-charged shock absorber?
137. What is an inflatable shock absorber?
138. What is shock absorber ratio?
139. How is the variation in shock absorber damping achieved?
140. What are the advantages of independent suspension over the rigid axle suspension?
141. State the disadvantages of independent suspension.
142. What is wishbone type suspension?
143. Which type of independent suspension is mostly used for front drive vehicles?
144. What are the advantages of MacPherson strut suspension?
145. Which type of independent suspension is used in Maruti 800 car?
146. What is a de Dion axle?
147. What is the function of an anti-roll device?
148. What is an interconnected suspension system?
149. State the advantages of an air suspension.
150. State the requirements of a steering system.
151. What is the material used for front axle? How is it manufactured?
152. Why for a front axle do we have I-section in the middle and elliptical section at the ends?
153. What is a stub axle?
154. What is the function of king pin?
155. What is steering axis?
156. What do you understand from * wheel alignment'?
157. What is thrust angle?
158. What is ‘tracking’?
159. State factors of wheel alignment.
160. What happens to vehicle steering if the road wheels are not balanced?
161. Name important angles of steering geometry.
162. Define camber, SAI and castor.
163. What is scrub radius?
164. Name the steering geometry parameter to give road feel to the driver.
165. What should be the approximate amount of the following in a car: camber, kingpin inclination, included angle, castor and toe- in?

166. If the kingpin and the wheel centre lines meet below the ground, will the wheels try to toe-in?
167. What is centre point steering?
168. Define perfect steering.
169. What is 'lock* position in steering?
170. Define 'turning circle'. State its approximate value for any (i) car (ii) bus.
171. What is 'toe-out on turns'?
172. Why is it easier to steer a vehicle in reverse than in forward?
173. What is slip angle?
174. Define cornering force and cornering power.
175. What is self-righting torque?
176. What is (i) pneumatic trail (ii) castor trail?
177. Define 'under steer' and 'over steer'.
178. What is the purpose of ball joints in the steering linkage?
179. What is the function of steering gear?
180. Name any three types of steering gears.
181. What is the function of balls in the recirculating ball type steering gear?
182. Why are the teeth on the nut in the recirculating ball type steering gear made tapered?
183. Which is the most popular steering gear for cars?
184. State the advantages of a rack and pinion type steering gear.
185. Why is the pinion usually placed tilted to rack in the rack and pinion type steering gear?
186. What purpose does a tilt wheel column serve?
187. What is the purpose of a telescopic steering column?
188. What is power steering?
189. Name two basic types of power steering.
190. What are the main components of integral power steering system?
191. What is the purpose served by a variable steering ratio steering gear?
192. Out of the camber and the castor, which is measured first and why?
193. Which angle out of the camber and the castor is adjusted first? Why?
194. Name the various gauges used for the checking of wheel alignment.
195. What do you mean by the terms 'wander' and •shimmy' in steering? How are they caused?
196. What does the term 'dynamic balance' mean?
197. What is 'wheel tramp' in case of steering?
198. What is the principle of automotive brakes?
199. What do the brakes do to the energy as they stop a moving car?
200. What is a service brake?
201. What are 'primary' and 'secondary' brakes?
202. What is the basis of defining brake efficiency?
203. What are the approximate brake efficiency values in the case of cars and heavy vehicles?
204. What should be the minimum stopping distance for a car running at 80 km. p.h.?
205. Why do we not use brakes with more than 80% efficiency in automobiles?
206. What is the usual percentage of total braking effort provided at the front wheels and why?
207. What is 'fading' of brakes?
208. What is 'transfer of weight' in brakes? What is its effect?
209. On what factors does the force of adhesion between the road wheels and the road depend?
210. How does skidding take place?
211. What is locking of wheel during braking?
212. Enumerate different considerations for classifying the automotive brakes.
213. Out of the transmission and the wheel brakes, which are better and why?

214. What are different methods of brake actuation?
215. What is the difference between 'power-assisted' and 'power-operated' brakes?
216. Name important components of a drum brake.
217. What is a leading shoe?
218. What is a two-shoe-leading brake? What are its advantages and disadvantages?
219. Which type of the brakes out of the following, are used in Hindustan Ambassador "cars : (i) Two shoe leading (ii) Two shoe trailing (iii) One shoe leading and the other trailing.
220. What is the effect of floating the brake expander, instead of fixing it on the back plate?
221. How does floating of the brake shoe anchor influence the braking effect?
222. What is the advantage of a two-shoe trailing brake?
223. Name the factors that influence braking performance.
224. Name important components of a disc brake.
225. What is the advantage of a swinging caliper type disc brake?
226. Name two latest materials for brake discs.
227. How much is approximately the saving in weight by using disc brake instead of drum brake?
228. Out of the disc and the drum brakes, which have better anti-fade characteristics?
229. Why is there greater consistency of braking effect in case of disc brakes compared with the drum brakes?
230. Which car in India has the distinction of using the disc brakes first?
231. What is 'brake compensation'?
232. Name the simplest type of brake compensator.
233. Approximately how much residual pressure is maintained in hydraulic brakes and why?
234. What are the functions of (i) intake port (ii) by-pass port in a master cylinder?
235. Why do we not fill the master cylinder completely with the brake fluid?
236. What was the need to develop such a complicated master cylinder? Why could a simple barrel with piston not do?
237. Why drum type hydraulic brakes are so designed that there should be residual pressure in the brake lines even when the brakes are in the released position ?
238. Do we maintain the residual pressure in case of disc brakes also? Why?
239. When do we have to pump the brake pedal quickly?
240. What is the purpose of a brake shoe adjuster?
241. Name any two brake shoe adjusters.
242. Do we have brake shoe adjuster in case of disc brakes also? Why?
243. What is a split hydraulic brake system?
244. What is the function of a pressure differential valve?
245. Why do you use proportioning valve in brakes?
246. What is the function of a metering valve in the braking system?
247. What is a combination valve?
248. What are the advantages of hydraulic brakes over mechanical brakes?
249. Why can't water be used as brake fluid?
250. What would be the result if a petroleum oil is used as brake fluid?
251. State the main requirements of brake fluid.
252. What should be the approximate minimum boiling point of a good braking fluid?
253. What are the main constituents of brake fluid?
254. When does the necessity of bleeding the brakes arise?
255. What is a servo brake?
256. What is suspended vacuum servo system?
257. What is the function of booster in the Hydromax brakes?

258. Name major components of a compressed air brake system.
259. What is function of unloader valve? Where is it located?
260. What is the function of an air brake valve?
261. What is the extra merit of a dual air brake valve compared to a single diaphragm type?
262. What is the function of air brake chamber?
263. What is the spring brake chamber?
264. What is a slack adjuster? What is its function?
265. On which wheels in a car are the parking brakes generally provided?
266. What are the requirements of a good brake drum?
267. Which material is generally used for brake drums? Why?
268. Why are the brake drums usually finned?
269. State the advantages of integral wheel-brake drum.
270. Upto what temperature the fade does not occur in case of moulded brake lining?
271. What are the advantages of using synthetic resin adhesives for attaching brake linings as compared to the conventional rivetting?
272. In which type of vehicles it is generally preferred to use adhesives for brake lining?
273. What is an ABS ?
274. What is 'pressure modulation' with reference to ABS ?
275. State the effect of (a) front wheels locking, (b) rear wheels locking.
276. List main parts of an ABS.
277. What is the function of lateral acceleration sensor ?
278. Name four main manufacturers of antilock brake systems.
279. Differentiate between functions of one-channel and two-channel systems.
280. Differentiate between functions of three-channel and four-channel systems.
281. Name the various common forms of brake drum wear.
282. How do you adjust the brake shoes?
283. What is major brake adjustment?
284. What is minor brake adjustment?
285. Approximately what minimum amount of free pedal pay is allowed in case of car brakes?
286. What is the function of Emergency Brake Assist' ?
287. What is a dynamic braking system ?
288. What is 'brake by wire' ? State its two advantages.
289. What happens when the oil leaks into the brake drum and wets the shoe linings?
290. How will it affect the braking performance if the bypass port in the master cylinder is blocked?
291. Out of petrol and alcohol, which should be used for cleaning the brake master cylinder and why?
292. Why are the brakes overheated sometimes?
293. What happens if the rivets attaching the brake lining to the shoe are not chamfered?
294. If only the brake on one of the four brake drums is incorrectly adjusted, how does it affect braking performance?
295. What is the effect of the dust accumulating in the brake drum?
296. Name any three firms manufacturing automotive brakes.
297. State the functions of a car wheel.
298. Name three types of automobile wheels.
299. What are the advantages of a disc wheel?
300. Define 'offset' with reference to automobile wheels.
301. What are inset, zeroset and outset wheels?
302. What is a reversible wheel?

303. What is a divided wheel?
304. Are well type wheels also used for heavier vehicles?
305. What is the purpose of 'well' in the wheel rim?
306. Why is there a small taper on the sides of a wheel rim?
307. How is the vehicle weight supported in case of a wire wheel?
308. What are the advantages of a wire wheel?
309. Why can't you use wire wheel to mount a tubeless tyre?
310. Name different materials for automobiles wheels.
311. Name the light alloys commonly used for automobile wheels.
312. State the advantages of (i) magnesium alloy (ii) aluminium alloy wheels.
313. What is a composite wheel?
314. How do you specify a car wheel?
315. What are the functions of an automobile tyre?
316. State various desirable properties of an automobile tyre.
317. What is 'ply rating' of a tyre?
318. Should the tyre sidewalls be rigid or flexible? Why?
319. Should the tyre tread be hard or soft?
320. How is a tyre bead formed?
321. What is the purpose of tyre tread sipes ?
322. What is the function of a tyre bead?
323. What is static unbalance? What is dynamic unbalance?
324. How is the wheel wobble caused?
325. What is a tyre carcass?
326. Name different types of tyres based upon the carcass design.
327. Why are the cords of tyre plies not woven like warp and weft of ordinary cloth?
328. What is the function of a breaker belt?
329. State the requirements of material for breaker belts.
330. How does a radial-ply tyre contributes to saving of fuel?
331. Why does a radial ply-tyre give comfortable ride at high speeds and a cross-ply tyre at low speeds?
332. Why are the steering characteristics of radial ply tyres better than those of cross ply tyres?
333. What is the reason for higher braking efficiency on wet roads in case of radial ply tyres?
334. State the commonly used materials for (0 ply-cords (ii) stabilizer belts (Hi) beads (iv) tread.
335. State the factors on which road-grip of a tyre depends.
336. What is 'aspect ratio' of a tyre?
337. What is the advantage of low aspect ratio in automobile tyres?
338. How do you designate a tyre?
339. State various factors affecting tyre life.
340. What are the specified inflation pressures in case of (i) Hindustan Ambassador car, (ii) Maruti Car (Hi) Ashok Leyland bus?
341. Should the tyre inflation pressure be checked while it is hot or cold?
342. How does over inflation increase tendency for concussion break?
343. How does a tyre wear in case of (i) overinflation (ii) underinflation?
344. What is the effect of bleeding the tyre?
345. List various irregularities in the vehicle maintenance which lead to deterioration of tyre life.
346. How does heat affect the tyre life.
347. What is the basic advantage of a Dunlop 'Danovo' tyre?

348. Draw the tyre rotation sequence for a (i) car (ii) truck.
349. State whether true or false :

(a) Ply rating refers to the actual number of cord plies in tyre.
(b) Higher aspects ratios are used in case of tyres for sports cars.
(c) One side and both sides wear of tyre tread are caused on account of the same reason.
(d) The high tyre pressure causes the tyre to wear more at the centre of the tread.

350. State reasons for the following tyre defects :
(a) Concussion break (b) Rim bruise (c) Sidewall scuffing (d) Tread cracking (e) Ply separation (/) Uneven wear.

Course Articulation Matrix

Course Outcomes	Program Outcome - (General)										
	a	b	c	d	e	f	g	h	i	j	k
Interpret technical specifications and **description** of types of chassis and transmission components of automobiles. L3,L2							M				
Understand and **Relate** Trouble shooting charts for major parts of chassis and transmission components of automobiles.L1,L2							M			M	
Gain **knowledge** about, and **Analyze** by Testing and servicing of electrical components and microprocessors related to automobiles. L1,L4		M					M			M	M
Dismantle and assemble of major systems of chassis and transmission components and **identifying** remedies for the possible problems **Comparing** with trouble shooting charts.L1,L2	M		M				M			M	M
Understand seating arrangements for driver and passengers and comfort levels. **Learn** mechanisms of door and seat adjustments mechanisms in automobiles.L1			M				M			M	M

Course Assessment Matrix (CAM)

Course Outcomes	Program Outcome - (General)										
	a	b	c	d	e	f	g	h	i	j	k
Interpret technical specifications and **description** of types of chassis and transmission components of automobiles. L3,L2							2				
Understand and **Relate** Trouble shooting charts for major parts of chassis and transmission components of automobiles.L1,L2							2			2	
Gain **knowledge** about, and **Analyze** by Testing and servicing of electrical components and microprocessors related to automobiles. L1,L4		2					2			2	2
Dismantle and assemble of major systems of chassis and transmission components and **identifying** remedies for the possible problems **Comparing** with trouble shooting charts.L1,L2	2		2				2			2	2
Understand seating arrangements for driver and passengers and comfort levels. **Learn** mechanisms of door and seat adjustments mechanisms in automobiles.L1			2				2			2	2

Course Title: **AUTOMOTIVE ELECTRICALS AND AUTOTRONICS LAB**			
Course Code: **P13AUL68**	Semester: 6	L:T:P:H- 0:0:3:3	Credits: 1.5
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.	Weightage : CIE:50%; SEE:50%		

Course Content

ELECTRICAL SYSTEM LAB

1. **Testing of Basic Electrical components**
   a) Switches, Relays, Resistors

2. **Battery Test**
   a) High discharge test – Multi meter
   b) Open voltage circuit test – cell tester
   c) Specific gravity test – Hydro meter
   d) Temperature correction test
   e) Battery leakage test
   f) Battery drain test
   g) Capacity test
   h) Types of charging (Trickle chargers)
   i) Jump starters

3. **Charging system**
   a) Voltage output test
   b) Current output test
   c) Circuit and ground resistance
   d) AC generator service

4. **Electrical Accessories**
   a) Wind shield wiper / washer systems
   b) Wiper system service

5. **Dynamo Armature Test:**
   a) Open test
   b) Ground test
   c) Armature shorts
      i) Field coils for open circuit test
      ii) Testing field coils for short circuit
      iii) Test insulated Brush holder for ground

6. **Kirloskar generator performance test for lamp loading**
7. **Battery charger- front and rear wind shield cleaning**
8. **Head lamp testing and cleaning system**
9. **Study of Automotive wiring system**
10. **Testing of Alternator and starting motors.**

AUTOTRONICS LAB

1. Interfacing LEDs and blinking them for specific amount of time
2. Interfacing 16 X 2 LCD panel and displaying characters
3. Interfacing keypad (4 X 4) and displaying key pressed
4. Interfacing temperature sensor and displaying the temp value
5. Interfacing displacement senor and displaying amount of displacement
6. Interfacing stepper or DC motor and controlling speed and direction of rotation

REVIEW QUESTIONS

1) Testing of given electrical components and report it (a) switches (b)relays (c) resistors
2) To check battery and discuss the types of batteries used in automobiles
3) To conduct the specific gravity test & to compare the standard ones
4) What are the troubles of batteries? Explain in detail
5) By using multi meter to conduct the HRD test &describe the same
6) To check &conduct the open voltage test by using given instruments
7) To inspect the battery temperature &correct it its required
8) To check the electrolyte &to conduct leakage test
9) What are the types of battery charging systems? Explain about trickle charging
10) To check &conduct the battery capacity test using the instruments
11) Explain jump starters &discuss their applications
12) Explain the following charging tests (voltage output, current output, charging circuits & ground resistance, AC generator)
13) Servicing the given wind shield wiper &washer system.
14) what are the factors depending on WS wiper & washer system.
15) To conduct the dynamo armature tests of following (a) open test (b) ground test (c) armature shorts
16) To conduct the test on KIRLOSKAR generator performance for lamp loading
17) To inspect the rear wind shield cleaning &correct it
18) Inspect &Test the head lamp &cleaned it
19) To study the automotive wiring system in vehicles
20) Tests the given alternator &starting motors

Course Title: NON TRADITIONAL MACHINING			
Course Code: P13AU661	Semester: 6	L:T:P:H- 4:0:0:4	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

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

Course Learning Objectives (CLO) :

I. **Discuss** the difference between conventional and non conventional machining process.

II. **Characterize** the USM and AJM with the effect of parameters and process characteristics.

III. **Explain** the working principle ECM and CHM with the effect of parameters and process characteristics.

IV. **Discuss** about the working principle of EDM with the effect of parameters and process characteristics

V. **Describe** the working principle PAM and LBM with the effect of parameters and process characteristics.

This Course Aims to:

Relevance of the Course:

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

Course Content

Unit -1: Introduction to Mechanical Process: Need for nontraditional machining processes, Process selection- classification on-comparative study of different processes, comparison between conventional and Non-conventional machining process selection. Ultrasonic Machining-Definition-Mechanism of metal removal- elements of the process-Tool feed mechanism, theories of mechanics of causing effect of parameter, application **10 hrs**

Unit -2: Abrasive Jet Machining and Thermal Metal Removal Processes: Principles — parameters of the process applications-advantages and disadvantages. Electric discharge machining-Principle of operation — mechanism of metal removal basic EDM circuitry-spark erosion generators — Analysis of relaxation type of circuit-material removal rate in relaxation circuits — critical resistance parameters in Ro Circuit-Die electric fluids-Electrodes for spark erosion- surface finish, applications, pollution and safety issues. **10 hrs**

Unit -3: Electro chemical and Chemical Processes and machining: Electro Chemical machining (ECM) Classification of ECM process-Principle of ECM-Chemistry of the ECM process- parameters of the process-determination of the metal removal rate —dynamics of ECM process-Hydrodynamics of ECM process-polarization-Tool Design-advantages and disadvantages-applications. Electro Chemical grinding-Electro Chemical holding. Electrochemical deburring. Introduction-fundamental principle types of chemical machining Maskants - Etchenes- Advantages and disadvantages-applications, environmental issues. **11 hrs**

Unit -4: Laser Beam Machining and Ion Beam Machining Introduction-principles of generation of lasers, Equipment and Machining Procedure-Types of Lasers-Process characteristics-advantages and limitations- applications. Introduction-Mechanism of metal removal and associated equipment-process characteristics applications, safety issues.

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

Unit -5: Plasma arc Machining and Electron beam machining: Introduction-Plasma-Generation of Plasma and equipment — Mechanism of metals removal, PAN parameters-process characteristics — type of torches, applications. Thermal & Non thermal type-Process characteristics —applications, safety issues. **10 hrs**

TEXT BOOKS:

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

REFERENCES:

1 Production Technology: HMT TATA McGraw Hill. 2001

2 Modern Machining Process: ADITYA 2002

3 Non-Conventional Machining: P.K.Mishra The Institution of Engineers (India) Test book series, Narosa Publishing House 2005.

Course Outcomes:

1 **Discuss** the difference between conventional and non conventional machining process.

2 **Characterize** the USM and AJM with the effect of parameters and process characteristics.

3 **Explain** the working principle ECM and CHM with the effect of parameters and process characteristics.

4 **Discuss** about the working principle of EDM with the effect of parameters and process characteristics

5 **Describe** the working principle PAM and LBM with the effect of parameters and process characteristics.

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

Unit wise plan

Unit I:

Topic Learning Objectives (TLO): (L1,L2,L3)

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

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

Unit II

Topic Learning Objectives (TLO): (L1,L2,L3):

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

- **Explain** principles of abrasive jet machining.
- **Discuss** advantages and disadvantages of AJM.

- **Explain** electric discharge machining.
- **Describe** mechanism of EDM.

Lesson schedule

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

Unit III

Topic Learning Objectives (TLO): (L1,L2,L3)

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

- **Classify** ECM process.
- **Explain** principle of ECM.
- **Describe** electro chemical grinding.

Lesson schedule

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

Unit IV

Topic Learning Objectives (TLO): (L1,L2,L3)

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

- **Explain** laser beam machining process.
- **Discuss** types of lasers.
- **Describe** mechanism of IBM.
- **Explain** types of high velocity forming processes.
- **Explain** plasma arc machining process.
- **Discuss** parameters of PAN.
- **Describe** types of electron beam machining.
- **List** applications of EBM.

Unit V

Lesson schedule

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

Review Questions

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

COURSE ARTICULATION MATRIX

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

COURSE ARTICULATION MATRIX

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

Course Title: OPERATION RESEARCH			
Course Code: P13AU662	Semester: 6	L:T:P:H- 4:0:0:4	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Course Learning Objectives (CLOs)

This course aims to:

1. Introduce students to use quantitative methods and techniques for effective decisions–making;
2. Fundamentals of OR, formulation of linear programming problems.
3. Graphical solution, Simplex method, duality principles.
4. Various types of transportation and assignment problems
5. Replacement of machines at suitable time, queing model, Network analysis(PERT/CPM)

Course Content

Unit-I

Introduction: Definition, scope of Operations Research (O.R), limitations, OR Models, Characteristics and phases of OR. Mathematical formulation of L.P. Problems, Graphical solution methods.

Linear Programming Problems: The simplex method - slack, surplus , Concept of duality, dual simplex method, degeneracy. **11hrs**

Unit-II

Transportation Problem: Formulation of transportation model, Basic feasible solution using different methods, Optimality Methods, Unbalanced transportation problem, Degeneracy in transportation problems, Applications of Transportation problems.

Assignment Problem: Formulation, maximization, unbalanced assignment, traveling salesman problem**. 10hrs**

Unit-III

Sequencing: Johnsons algorithm, n - jobs to 2 machines, n jobs 3machines, n jobs n machines without passing sequence. 2 jobs n machines with passing. Graphical solutions

Queuing Theory, Queuing system and their characteristics. The M/M/1 Queuing system, Steady state performance, analysis of M/M/1 queuing model. **11 Hrs**

Unit-IV

PERT-CPM Techniques: Network construction, determining critical path, floats, scheduling by network, project duration, variance under probabilistic models, prediction of date of completion, crashing of simple networks. **10hrs**

Unit-V

Game Theory: Formulation of games, Two person-Zero sum game, games with and without saddle point, Graphical solution (2x n , m x 2 game), dominance property.

Inventory: Deterministic models with and without shortages; replenishment, mean time, ordering cost, carrying cost, Economic order quantity(EOQ), **10hrs**

Text Books:

1. S.D.Sharma, “Operation Research”, Kedaranath&Ramnath Publications, 5th edition 2005
2. KantiSwaroop, “Operation Research”, Sultan Chand Publications 8th edition 2000.
3. Operations Research and Introduction, TahaH . A. – Pearson Education edition
4. Operations Research, S. D. Sharma –KedaranathRamnath& Co 2002.

References:

1. Philip Ravindran, "Operation Research", Wiley Publications, 2nd edition 1987.
2. Hamid Taha, "Introduction to Operation Reaserch", Pearson 7th edition,2005.

Course Outcomes(COs)

After learning all the units of the course student should be able to:

1. Formulate and solve linear programming models.
2. Solve transportation and waiting line models.
3. Obtain PERT network and recognize Critical path for a given project
4. Apprehend proper strategy for a given game
5. Recognize the replacement period of a machine/equipment and EOQ

Unit wise plan

Unit-I:

Topic Learning Objectives (TLOs)

After learning all the topics of unit – I, the student is able to**:**

- Understand about the OR, importance of OR, scope of the OR
- Explain the OR model formulation , characteristics of OR
- Understand the various phases of OR formulation of LP problems
- Analyse the solutions of LP problems.

Lesson Schedule

1. **Introduction:** Definition, scope of Operations Research (O.R),
2. limitations, OR Models,
3. Characteristics and phases of OR.
4. Mathematical formulation of L.P.
5. Problems, Graphical
6. Problems, Graphical
7. solution methods.
8. Linear Programming Problems: The simplex method - slack,
9. surplus , Concept of duality,
10. dual simplex method, degeneracy
11. Problems

Unit-II-

Topic Learning Objectives (TLOs)

After learning all the topics of unit – II, the student is able to:

- Understand the concept of LP problems
- Explain formulation of transportation model
- Analyse the solution for transportation problems
- Understand the concept of assignment problem
- Explain the formulation of assignment problems
- Analyse the solution for assignment problems

Lesson Schedule

1. **Transportation Problem**: Formulation of transportation model,
2. Basic feasible solution using different methods,
3. Optimality Methods,
4. Unbalanced transportation problem,
5. Degeneracy in transportation problems,

6. Applications of Transportation problems.
7. **Assignment Problem**: Formulation,
8. maximization,
9. unbalanced assignment,
10. traveling salesman problem

Unit-III

Topic Learning Objectives

After learning all the topics of unit – III, the student is able to:

- Understand the sequence of operations of different models
- To find the optimum sequences
- To find the total elapsed time of given sequences
- Understand the concept of queuing systems & their characteristics
- Explain the various models/types of queuing models
- Analyse the solution for queuing models

Lesson Schedule

1 Johnsons algorithm, n - jobs to 2 machines,
2 n jobs 3machines, n jobs n machines without passing sequence.
3 jobs n machines with passing
4 Graphical solutions
5 Problems
6 Queuing Theory
7 Queuing system and their characteristics
8 The M/M/1 Queuing system,
9 Steady state performance,
10 analysis of M/M/1 queuing model
11 Problems

Unit-IV-

Topic Learning Objectives

After learning all the topics of unit – IV, the student is able to:

- Understand the networks & their types
- Explain the various types of networks
- Analyze the solutions for the networks
- Discuss about the crashing of simple networks

Lesson Schedule

1. **PERT-CPM Techniques:** Network construction,
2. determining critical path,
3. floats, scheduling by network,
4. project duration,
5. variance under probabilistic models,
6. variance under probabilistic models
7. prediction of date of completion,
8. prediction of date of completion
9. crashing of simple networks.

Unit-V

Topic Learning Objectives:

After learning all the topics of unit – V, the student is able to:

1. Understand the principle &concepts of game theory
2. Explain the various types of games
3. Analyse the solutions for the game problems
4. Understand the meaning &necessary of inventory
5. Explain the various types of costs & invented models
6. Analyse the solutions for inventory models

Lesson Schedule

1. **Game Theory**: Formulation of games,
2. Two person-Zero sum game,
3. Two person-Zero sum game
4. games with and without saddle point
5. Graphical solution (2x n , m x 2 game),
6. dominance property.
7. **Inventory:** Deterministic models with and without shortages;
8. replenishment, mean time,
9. ordering cost, carrying cost,
10. Economic order quantity(EOQ),

Review questions:

1. Define operation research.
2. Discuss the origin and development of operations research with a suitable classification.
3. Define model. Discuss the steps of modelling.
4. Discuss the scope of operations research.
5. Explain the terminologies of linear programming model.
6. List and explain the assumptions of linear programming problems.
7. Define the following:
   (a)alternate optimum solution
   (b)Unbounded solution
   (c)infeasible solution
   (d)Degenerate solution
   (e) slack variable
   (f) Surplus variable
   (g)Artificial variable
   (h) Basic variable
   (i)Criterion value

1. A firm manufactures three products A.B&C. their profits per unit are RS 300 Rs 200 and RS 400 respectively. The firm has two machines and the required processing time in minutes on each machine for each product is given in the following table:
   Machines I & II have 2000 and 2500 minutes respectively. The company must manufactures 100 A's, 200 B's and 50 C's. But, the firm must produce a minimum of 50 units of the product A. develop a LP model for this manufacturing situation to determine the production volume of each product such that the total profit is maximized.
2. The manager of an oil refinery has to decide o the optimal mix of two possible blending processes. The inputs and outputs per production run of the blending process are as follows:

	Input		Output	
Process	crude A	crude B	Gasoline G_1	Gasoline G_2
1	5	3	5	8
2	4	5	4	4

The maximum amounts of availability of crude A and B are 200 units, respectively Market requirements show that atleast 100 units of gasoline G_1 80 units' gasoline G_2 must be produced. The profit per production run from process 1 and process 2are Rs3,00,000 and Rs 4,00,000, respectively. Formulate this problem as a LP model to determine the number of production runs of each process such that the total profit is maximized.

3. Solve the following LP problem graphically:
   Maximize $Z=20X_1+80X_2$ subject to
   $4X_1+6X_2<=90$
   $8X_1+6X_2<=100$
   $5X_1+4X_2<=80$
   X_1 and $X_2>=0$
4. Solve the following LP problem graphically:
   Maximize $Z=20X_1+10X_2$subject to
   $X_{1=}+2X_2<=40$
   $3X_1+X_2>=30$
   $4X_1+3X_2>=60$
   X_1 and $X_2>=0$
5. Write the dual of the following LP problem:
   Minimize $Z=3X_1-2X_2+4X_3$ subject to
   $3X_1+5X_2+4X_3>=7$
   $6X_1+X_2+3X_3>=4$
   $7X_1-2X_2-X_3<=10$
   $X_1-2X_2+5X3>=3$
   $4X1+7X_2-2X_{3=}>=2$
   $X_{1,}X_2$ and$X_3>=0$
6. Write the dual of the following LP problem:
   Maximize Z=5X1+6X2 subject to
   4x1+7x2=20
   5x1+2x2=10
   6x1+8x2=25
   X1 and x2 >=0
7. Consider the following LP problem
   Maximize z=3x1+2x2-5x3 subject to
   X1+X2<=2
8. Obtain the duality of the following LPP

	products		
machines	A	B	C
I	4	3	5
II	2	2	4

9. Consider the following LP problem
   Maximize z=3x1+2x2-5x3 subject to

X1+X2<=2
2x1+x2+6x3<=6
X1-X2+3X3=0
X1,X2 and X3>=0

10. Obtain the duality of the following LPP
    Max z=x1-x2+3x3 subject to,
    X1+x2+x3<=10,
    2x1-x3<=2,
    2x1-2x2+3x3<=6,
    X1, x2, x3>=0
11. Obtain the dual of the following LPP
    Max z=3x1+x2+2x3-x4 subject to the constraints,
    2x1-x2+3x3+x4=1,
    X1+x2_x3+x4=3
    X1,x2,x3>=0
    And x4 is unrestricted.
12. A company manufactures 3 products A,B&C. the profits are Rs.3,Rs.2 and Rs.4 respectively. The company has two machines and given below is the required processing time in minutes for each machine on each product.
    Machines I & II have 2000 and 2500 minutes respectively. The company must manufactures 100 A's, 200 B's and 50 C's but no more than 150 A's. find the number of units of each product to be manufactured by the company to maximize the profit. Formulate the above as a LP model.
13. A company produces two types of leather belts A and B.A is superior quality and B is of inferior quality. The respective profits are RS.10 and Rs.5 per belt. The supply of raw material is sufficient for making 850 belts per day . For belt A, a special type of buckle is required and 500nare available per day there are 700 buckles available for belt B per day . belt A needs twice as much time required for belt B and the company can produce 500 belts if all of were of type A .formulate the LP model for the above problem.
14. What do you understand by transportation model?
15. Define feasible solution, non-degenerate solution and optimal solution in a transportation problem.
16. Explain the following briefly with examples:
    (i)north-west corner rules
    (ii)least cost method
    (iii) Vogel's approximation method.
17. Explain an algorithm to solving a transportation problem.
18. Discuss the similarity between transportation problem and assignment problem.
19. Discuss the steps of Hungerian method.
20. Describe assignment problem giving a suitable example.
21. Solve the following assignment problem.

A	B	C	D
1	4	6	3
9	7	10	9
4	5	11	7
8	7	8	5

.

22. Solve the following TP where the cell entries denote the unit transportation costs(using least cost method)

	DESTINATION					
ORIGIN		A	B	C	D	SUPPLY
	P	5	4	3	6	20
	Q	8	3	5	7	30
	R	5	9	4	6	50
	DEMAND	10	40	20	30	100

23. Solve the following TP.

	Destination					
Factory		A	B	C	D	Supply
	1	1	2	3	4	6
	2	4	3	2	0	8
	3	0	2	2	1	10
	Demand	4	6	8	6	

Max z=x1-x2+3x3 subject to,
X1+x2+x3<=10,
2x1-x3<=2,
2x1-2x2+3x3<=6,
X1, x2, x3>=0

24. Determine the optimal sequence of jobs which minimizes the total elapsed time based on the following information.

Jobs	1	2	3	4	5
Machine A	3	8	7	5	2
Machine B	3	4	2	1	5
Machine C	5	8	10	7	6

Also calculate the total elapsed time and idle time for each machine.

25. Use graphical method to minimize the time needed to process the following jobs on the machines shown below. Calculate the total time needed to complete both the jobs.

Job 1	Sequence	A	B	C	D	E
	Time (in hours)	2	3	4	6	2
Job 2	Sequence	C	A	D	E	B
	Time (in hours)	4	5	3	2	6

26. Eight jobs each of which must go through the machines A, B and C in the order ABC. Determine a sequence for the jobs and total elapsed time.

Jobs	1	2	3	4	5	6	7	8
Machine A	4	6	7	4	5	3	6	2
Machine B	8	10	7	8	11	8	9	13
Machine C	5	6	2	3	4	9	15	11

27. Find the sequence that minimizes the total elapsed time required to complete the following tasks. Each job is processed in the order ACB.

					Jobs			
		1	2	3	4	5	6	7
	A	12	6	5	11	5	7	6
Machines	B	7	8	9	4	7	8	3
	C	3	4	1	5	2	3	4

35. Discus the application of queuing theory.
36. List and explain the terminologies used in queuing system.
37. What is Kendall notation? Give the classification of queuing system based on Kendall notation.
38. The arrival rate of customers at a banking counter follows poisson distributed with a mean of 30 per hour. The service rate of the counter clerk also follows poisson distribution with a mean of 45 per hour.
    (a)What is the probability of having 0 customers in the system (p0)?
    (b) What is the probability of having 8 customers in the system (p8) ?
    (c) What is the probability of having 12 customers in the system (p12)?
    (d) Find Ls, Lq, Ws and Wq.
39. Patients arrive at a clinic according to a poisson distribution at the rate of 30 patients per hour. The waiting room does not accommodate more than 14 patients. Examination time per patients is exponential with mean rate 20 per hour.
    (i) Find the effective arrival rate at the clinic.
    (ii)What is the probability that an arriving patient will not wait? Will he find a vacant seat in the room?
    (iii) what is the expected waiting time until a patient is discharged from the clinic?
40. A stenographer has 5 persons for whom she performs stenographic work. Arrival rate is poisson and service times are exponential. Average arrivals rate is 4 per hour with an average service time of 10 minutes. Find,
    (i)the average waiting time of an arrival
    (ii)the average length of waiting line
    (iii)the average time on arrival spent in system.
41. Define project and give some application areas of project management. explain different phases of project management.
42. Distinguish between CPM and PERT.
43. Define the following :(a)total float,(b) free float ,and(c)critical path.
44. What are the time estimates used in PERT?
45. Consider the following data of a project.

Activity	Predecessors	Duration (weeks)		
		a	m	b
A	-	3	5	8
B	-	6	7	9
C	A	4	5	9
D	B	3	5	8
E	A	4	6	9
F	C,D	5	8	11
G	C,D,E	3	6	9
H	F	1	2	9

46. Explain the following terminologies of game theory
    (a)players
    (b)strategy
    (c)maximum principle
    (d)minimax principle
    (e)saddle point
    (f)value of the game
    (g)two person zero sum game
    (h)dominance property
47. The following table gives the running costs per year and resale price of a certain equipment, whose purchase price is Rs.5,000

year	1	2	3	4	5	6	7	8
Running cost	1500	1600	1800	2100	2500	2900	3400	4400
Resale value	3500	2500	1700	1200	800	500	500	500

    In what year is the replacement due?
48. The following table gives the running cost per year and resale price of a certain machine, whose purchase price is Rs.50,000.

Year	1	2	3	4	5	6	7	8
Running cost (in 1000)	15	16	18	21	25	29	43	40
Resale value (in 1000)	35	25	17	12	8	5	5	5

49. List and explain different types of maintenance. Discuss the reasons for replacements.
50. Define economic life of equipment.
51. What are the reasons for stocking items in inventory?
52. List and explain different types of costs in inventory systems.
53. Name the types of models of inventory system and explain them in detail.
54. Derive the EOQ formula for the purchase model without shortages.
55. Beta industry estimates thet it will sell 24,000 units of its product for the forthcoming year. The ordering costs isRs 50 per order and carrying cost per unit per year is 20% of the purchase price per unit. The purchase price per unit is RS 50. Find the economic order size ,the number of orders per year and the time between successive orders.
56. The annual consumptions of an item are 2000 units .the ordering cost is Rs 100 per order. the carrying cost is Rs 0.80 per unit ,per year. Assuming working days as 200, lead time as 20 days, and safety stock as 100 units ,calculate (i) EOQ(ii) the number of orders per year (iii) Re-order level (iv)the total annual ordering and carrying costs

Course assessment Matrix(CAM)														
Course Outcome - CO			**Program Outcome** (ABET/NBA-(3a-k))											
			a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
1	Formulate and solve linear programming models	**L1**	1	3	1	-	1	-	1	-	-	3	-	1
2	Solve transportation and waiting line models	**L2**	1	3	1	-	1	-	1	-	-	-	-	1
3	Obtain PERT network and recognize Critical path for a given project	**L3**	1	3	1	-	1	-	1	-	-	-	-	1
4	Apprehend proper strategy for a given game	**L4**	1	2	1	2	1	-	1	-	2	-	-	1
5	Recognize the replacement period of a machine/equipment and EOQ	**L**	1	3	1	1	1	-	1	-	2	-	-	1
	1-Low, 2-Moderate, 3-High													

Course assessment Matrix(CAM)														
Course Outcome – CO			**Program Outcome** (ABET/NBA-(3a-k))											
			a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
1	Formulate and solve linear programming models	**L1**	**L**	**H**	**L**	**-**	**L**	**-**	**L**	**-**	**-**	**H**	**-**	**L**
2	Solve transportation and waiting line models	**L2**	**L**	**H**	**L**	**-**	**L**	**-**	**L**	**-**	**-**	**-**	**-**	**L**
3	Obtain PERT network and recognize Critical path for a given project	**L3**	**L**	**L**	**L**	**-**	**L**	**-**	**L**	**-**	**-**	**-**	**-**	**L**
4	Apprehend proper strategy for a given game	**L4**	**L**	**H**	**L**	**M**	**L**	**-**	**L**	**-**	**M**	**-**	**-**	**L**
5	Recognize the replacement period of a machine/equipment and EOQ	**L**	**L**	**H**	**L**	**L**	**L**	**-**	**L**	**-**	**M**	**-**	**-**	**L**
	L-Low, M-Moderate, H-High													

Course Title: CAD/CAM			
Course Code: P13AU663	Semester: 6	L:T:P:H- 4:0:0:4	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

Prerequisites:

Subject requires student to know about

Engineering Mathematics, Manufacturing Technology-I & Manufacturing Technology- II and Computer Aided Machine Drawing.

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

Course Learning Objectives (CLO):

This Course Aims to:

1. Describe the fundamental theory and concepts of the CAD/CAM. Explain the Basic hardware structure and components used in CAD systems.
2. Compare the different types of modeling techniques and explain the central role solid models Play in the successful completion of CAD/CAM-based product development. Develop transformations for 2D geometric modeling.
3. Describe the principles of Computer Aided Designing systems and the concepts of Geometric Modeling, solid modeling, and feature-based design modeling.
4. Explain the basic concepts of NC and CNC programming and machining.
5. Compare and distinguish the difference between the operation and programming of a CNC machine tool using manual programming and the operation and programming of CNC machine tool using CAM systems.
6. Apply both practices (manually and CAM) to develop the G-code program. And explain the basics of FEA and Robotics.

Relevance of the Course:

Department of Automobile engineering offers elective course in CAD/CAM keeping in mind the growing importance of application of computers in the field of Automobile engineering. The course teaches the students how to apply the computer tools in the creation, design, improvement, analysis of automobile and mechanical products, processes and systems and in the field of manufacturing. The students also know the areas like Computer aided design; computer integrated manufacturing Finite Element Analysis and Robotics.

Course Content

UNIT-1 : **Introduction and hardware for CAD:**

Role of computers in design and manufacturing. Influence of computers in manufacturing environment. Product cycle in conventional and computerized manufacturing environment. Introduction to CAD and CAM. Advantages and disadvantages of CAD and CAM.

Display Units CRT, DVST, Raster scan and their image generation techniques, Latest display system types. Input devices Mouse, Joystick, Digitizer, Tablet, & Etc. Output devices pen plotters, laser printer, color laser printer, Electrostatic printer**.** **10 Hours**

UNIT-2: Computer graphics and geometric modeling techniques:

Software configuration of a graphic system, functions of graphics software. Graphic primitives, 2-D transformation, homogeneous transformation, concatenation, problems on transformations.

Geometric modeling, wire frame, surface & solid modeling. Introduction Drawing interchange files DXF, IGES and STEP. Representation of curves and surfaces, Cubic splines, Bezier curves, B-splines and Nurbs, Bi-cubic polynomial surface patches, Bezier bi-cubic surface patches, cubic B-spline surfaces. **11 Hours**

UNIT-3: Numerical Control (NC) and CNC machine tools:

Basic components of an NC Systems , NC procedure , NC co-ordinate systems , open loop & closed loop system (position controlled NC) NC motion control systems, application of NC. Advantage & limitations

of NC. Functions of CNC, CNC machining centers, CNC turning centers, high speed CNC machine tools. **10 Hours**

Unit -4: CNC HARDWARE BASICS AND CNC TOOLING: Structure of CNC machine tools, spindle design, drives, Actuation systems, Feedback devices, Axes-standards.

Cutting tool materials, Tool representation, Milling tooling system, Tool presetting, ATC, work holding devices.

Introduction to Finite element analysis: Introduction, basic concepts, discretization, element types, nodes and degrees of freedom, mesh generation, constraints, loads, Pre-processing and application to static analysis. (Discussions pertaining to specific contents only). **10 Hours**

Unit -5: CNC PROGRAMMING: Part program fundamentals, steps involved in development of a part program. ISO Codes, Manual part programming on milling & turning, turning center programming using ISO codes(Simple Excercises).

INTRODUCTION TO ROBOTICS: Introduction, Robot Configuration, Robot Motions, End effectors,Robot Sensor, Robot Applications. (Discussions pertaining to specific contents only) **11Hours**

TEXT BOOKS:

1. "CAD/CAM Principles and Applications" by P.N. Rao, Tata McGraw Hill, New Delhi, 2002.
2. "CAD/CAM" by Mikell P Groover, Emory W.Zimmers, Jr.Prentice-Hall lndia, 2003.

REFERENCE BOOKS:

1. Principles of Interactive Computer Graphics by Newman and Sproull, Tata McGraw Hill, 1995.
2. NC Machine Programming and Software Design – Chno-Hwachang, Michel. A. Melkanoff, Prentice Hall, 1989.
3. Computer Graphics by Steven Harrington, McGraw Hill Book Co.2001.
4. CAD/CAM – Ibrahim Zeid, Tata McGraw Hill, 1999.
5. Computer Aided Manufacturing by P.N. Rao, N.K. Tewari and T.K. Kundra Tata McGraw Hill 1999.
6. **Introduction to the Design and Analysis of Algorithms –** S.E.Goodman,S.T.Headetmiemi,McGraw Hill Book Company -1988.
7. **CAD/CAM/CIM-**P.Radhakrishnan,S.Subramanyan and V.Raju,New Age International Publishers,2nd Edition,2006.

Course Outcomes (CO'S):

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

1. Describe the fundamental theory and concepts of the CAD/CAM. Explain the Basic hardware structure and components used in CAD systems.
2. Compare the different types of modeling techniques and explain the central role solid models Play in the successful completion of CAD/CAM-based product development. Develop transformations for 2D geometric modeling.
3. Describe the principles of Computer Aided Designing systems and the concepts of Geometric Modeling, solid modeling, and feature-based design modeling.
4. Explain the basic concepts of NC and CNC programming and machining.
5. Compare and distinguish the difference between the operation and programming of a CNC machine tool using manual programming and the operation and programming of CNC machine tool using CAM systems.
6. Apply both practices (manually and CAM) to develop the G-code program. And explain the basics of FEA and Robotics.

Unit wise plan

UNIT-1 :

Topic Learning Objectives (TLO): L1, L2

At the end of this chapter student should be able to:

1. Define CAD/CAM (L1).
2. Explain briefly computer monitoring and computer control (L2)
3. Explain the influence of computers on the manufacturing environment (L2).
4. Show the product cycle in computerized manufacturing environment, with the help of a neat block diagram (L3).
5. Differentiate between product cycle in conventional and computerized manufacturing systems with the help of neat diagrams (L2).
6. List out the design related tasks performed by modern computer. Explain with the block diagram (L2).
7. Explain how cad technology can help the engineer/designer (L2).
8. Name the advantages and disadvantages of using CAD/CAM (L1).
9. Explain briefly the different software's used for CAD and CAM (L2).
10. List the Input, Output and display devices used for CAD and describe any one device in each of the categories input, output and display device (L2).
11. Describe briefly the various storage devices used in computers (L2).
12. Describe the basic techniques to generate images on the CRT screen (L2).
13. Explain with a block diagram, the organization of a CPU (L2).
14. Explain the stroke writing and raster scan used in CAD environment (L2).
15. Explain the different types of plotters used in CAD and their principles (L2).

Lesson Schedule

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

UNIT-2:

Topic Learning Objectives (TLO): L1, L2, L3

At the end this chapter student should be able to:

1. Explain the functions of graphics package in CAD system (L2).
2. Explain briefly about 2D transformations. A line is defined by end points (1, 1) and (3, 4) in a 2D graphics system. By Scaling transformations obtain the different possible mirror images for the line. Use a scale factor of 1 (L2).
3. Explain about CSG solid modeling approach (L2).
4. Explain 3D-transformations using 3x3 matrices briefly (L2).
5. Compare the feature of wire frame and solid models (L3).
6. A triangle is defined in a Two-dimensional IGS system by its vertices (0, 2), (0, 3) and (1, 2) perform the following transformations on this triangle.

   a) Translate the triangle in space by 2-Units in the X-direction and 5-Units in the Y-direction.

b) Scale the original triangle by a factor of 1.5.
c) Rotate the original triangle by 45^0 (CCW) about the origin. (L2).

7. Describe) Translation ii) Rotation iii) Scaling iv) Reflection with reference to 2D and 3D transformations (L2).
8. List the three types of geometrical modeling systems. (L).
9. Explain CSG and B-Rep approaches of solid modeling (L2).
10. Explain the basic features of IGES, STEP, DXF and DMIS with respect to exchange of modeling data (L2).
11. Discuss the different sections in the organization of exchange of modeling data in IGES format (L2).
12. Describe 2D transformation matrices (L2).

Lesson Schedule

1. **Computer graphics and geometric modeling techniques:** Software configuration of a graphic system,
2. Functions of graphics software. Graphic primitives,
3. 2-D transformation, homogeneous transformation,
4. Concatenation, problems on transformations.
5. Problems on transformations.
6. Geometric modeling, wire frame,
7. Surface & solid modeling.
8. Introduction drawing interchange files DXF, IGES and STEP.
9. Representation of curves and surfaces, Cubic splines, Bezier curves,
10. B-splines and Nurbs, Bi-cubic polynomial surface patches,
11. Bezier bi-cubic surface patches, cubic B-spline surfaces.

UNIT-3-

Topic Learning Objectives (TLO): L1, L2, L3

At the end this chapter student should be able to:

1. Explain briefly the basic NC motion control systems with appropriate sketches (L3).
2. Discuss the basic components of NC systems (L2).
3. List the advantages and limitations of NC systems (L1).
4. List the functions and advantages of NC machines in comparison to the conventional machines (L2).
5. Discuss briefly the advantages and disadvantages of CNC technology (L2).
6. Define CNC.Explain the principle functions of CNC system with neat sketches (L3).
7. Define direct numerical control (DNC).List the two configurations of DNC.Explain the functions of DNC computer (L1, L2).
8. Explain briefly about the different components of a DNC system and give the meaning of different types of DNC systems (L2).
9. Compare the NC, CNC and DNC systems (L3).
10. Discuss the features of machine control unit (L2).
11. Explain briefly machining centers and their features (L2).
12. List the typical applications of high speed machining (L1).
13. Explain about CNC turning centers and their classifications in detail (L2).
14. Explain the salient features of horizontal and vertical axis machining centre and list their applications (L2).
15. Distinguish between high speed machining and conventional machining (L2).

Lesson Schedule

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

Unit -4 -

Topic Learning Objectives (TLO): L1, L2, L3

At the end this chapter student should be able to:

1. List the requirements of structure in the case of CNC machine tools (L1).
2. Name the design criteria to be used in designing CNC machine tools (L1).
3. Describe briefly about the type of electric drives used in CNC machine tools (L2).
4. List different types of nut arrangements used in recirculating ball screws. Give a comparative evaluation (L1).
5. Describe in brief on encoders used in CNC machine tools (L2).
6. Explain briefly the basis of designating the coordinate axes in CNC machine tools (L2).
7. Explain the ISO nomenclature of tungsten carbide inserts and tool holders (L2).
8. Sketch and explain milling tooling system (L3).
9. Discuss with a neat sketch Automatic tool change used in a NC machine tool (L2).
10. Explain with a neat sketch any two work holding device (L2).
11. Describe the different types of elements used in FEM analysis and their applications (L2).
12. Describe in brief, the basic steps involved in FEA procedure (L2).
13. List few FEA packages and in brief explain about ANSYS products (L2).
14. Explain the FEM technique with suitable example, applied to a static case (L3).
15. Explain the functions served by pre-processor and post-processor in FEM (L2).
16. Illustrate the various finite elements used for a descritization process (L2).
17. Describe degrees of freedom and types of elements for FEM (L2).
18. Explain preprocessing, processing (solver), and post processing with respect to finite element analysis (L2).

Lesson Schedule

1. **CNC HARDWARE BASICS, CNC TOOLING AND FEA:** Structure of CNC machine tools,
2. Spindle design, drives, Actuation systems,
3. Feedback devices, Axes-standards.
4. Cutting tool materials, Tool representation, Milling tooling system,
5. Tool presetting, ATC, work holding devices.
6. **Introduction to Finite element analysis**: Introduction,
7. Basic concepts, discretization,
8. Element types, nodes and degrees of freedom,
9. Mesh generation, constraints, loads,
10. Pre-processing and application to static analysis.

Unit -5-

Topic Learning Objectives (TLO): L1, L2, L3

At the end this chapter student should be able to:

1. Discuss the steps involved in the development of a NC part program with a flow chart (L3).
2. Explain the following with respect to turning centre programming i) Axes system ii) Diameter programming (L2).
3. Explain the following with respect to turning centre programming i) Tool Nose radius ii) Tools (L2).
4. Explain the function of the preparatory functions. Give the functioning of any one G code used for the purpose (L3).
5. List any six preparatory and miscellaneous codes, with brief description of each code (L2).
6. Explain with neat sketches the different robot physical configurations (L2).
7. Explain the following with respect to Robots i) Arm and Body motions ii) Wrist Motions iii) Work volume iv) Precision of movement (L2)
8. Define a ROBOT. Sketch and explain four robot configurations (L2).
9. List and explain the different types of grippers used in robots (L2).
10. Describe the concept of robot work cell and interlocks with the help of an example (L2).
11. Describe 'End effectors' and 'Sensors' with respect to industrial robot (L2).
12. Explain in brief, robot applications categorically (L2).

Lesson Schedule

1. **CNC PROGRAMMING:** Part program fundamentals,
2. Steps involved in development of a part program. ISO Codes,
3. Simple programming exercises in drilling including canned cycle
4. Simple programming exercises in turning using ISO codes.
5. Simple programming exercises in milling using ISO codes.
6. Simple programming exercises in drilling turning and milling using ISO codes.
7. **INTRODUCTION TO ROBOTICS:** Introduction,
8. Robot Configuration,
9. Robot Motions, End effectors,
10. Robot Sensor, Robot Applications.
11. Review.

Review questions

UNIT-1

1. Define CAD/CAM (L1).
2. Explain briefly computer monitoring and computer control (L2)
3. Explain the influence of computers on the manufacturing environment (L2).
4. Show the product cycle in computerized manufacturing environment, with the help of a neat block diagram (L3).
5. Differentiate between product cycle in conventional and computerized manufacturing systems with the help of neat diagrams (L2).
6. List out the design related tasks performed by modern computer. Explain with the block diagram (L2).
7. Explain how cad technology can help the engineer/designer (L2).
8. Name the advantages and disadvantages of using CAD/CAM (L1).
9. Explain briefly the different software's used for CAD and CAM (L2).
10. List the Input, Output and display devices used for CAD and describe any one device in each of the categories input, output and display device (L2).

11. Describe briefly the various storage devices used in computers (L2).
12. Describe the basic techniques to generate images on the CRT screen (L2).
13. Explain with a block diagram, the organization of a CPU (L2).
14. Explain the stroke writing and raster scan used in CAD environment (L2).
15. Explain the different types of plotters used in CAD and their principles (L2).

UNIT-2

1. Explain the functions of graphics package in CAD system (L2).
2. Explain briefly about 2D transformations. A line is defined by end points (1, 1) and (3, 4) in a 2D graphics system. By Scaling transformations obtain the different possible mirror images for the line. Use a scale factor of 1 (L2).
3. Explain about CSG solid modeling approach (L2).
4. Explain 3D-transformations using 3x3 matrices briefly (L2).
5. Compare the feature of wire frame and solid models (L3).
6. A triangle is defined in a Two-dimensional IGS system by its vertices (0, 2), (0, 3) and (1, 2) perform the following transformations on this triangle.
   a) Translate the triangle in space by 2-Units in the X-direction and 5-Units in the Y-direction.
   b) Scale the original triangle by a factor of 1.5.
   c) Rotate the original triangle by 45^0 (CCW) about the origin. (L2).
7. Describe) Translation ii) Rotation iii) Scaling iv) Reflection with reference to 2D and 3D transformations (L2).
8. List the three types of geometrical modeling systems. (L).
9. Explain CSG and B-Rep approaches of solid modeling (L2).
10. Explain the basic features of IGES, STEP, DXF and DMIS with respect to exchange of modeling data (L2).
11. Discuss the different sections in the organization of exchange of modeling data in IGES format (L2).
12. Describe 2D transformation matrices (L2).

UNIT-3

1. Explain briefly the briefly the basic NC motion control systems with appropriate sketch (L3).
2. Discuss the basic components of NC systems (L2).
3. List the advantages and limitations of NC systems (L1).
4. List the functions and advantages of NC machines in comparison to the conventional machines (L2).
5. Discuss briefly the advantages and disadvantages of CNC technology (L2).
6. Define CNC.Explain the principle functions of CNC system with neat sketches (L3).
7. Define direct numerical control (DNC).List the two configurations of DNC.Explain the functions of DNC computer (L1).
8. Explain briefly about the different components of a DNC system and give the meaning of different types of DNC systems (L2).
9. Compare the NC, CNC and DNC systems (L3).
10. Discuss the features of machine control unit (L2).
11. Explain briefly machining centers and their features (L2).
12. List the typical applications of high speed machining (L1).
13. Explain about CNC turning centers and their classifications in detail (L2).
14. Explain the salient features of horizontal and vertical axis machining centre and list their applications (L2).
15. Distinguish between high speed machining and conventional machining (L2).

UNIT-4

1. List the requirements of structure in the case of CNC machine tools (L1).
2. Name the design criteria to be used in designing CNC machine tools (L1).
3. Describe briefly about the type of electric drives used in CNC machine tools (L2).
4. List different types of nut arrangements used in recirculating ball screws. Give a comparative evaluation (L1).
5. Describe in brief on encoders used in CNC machine tools (L2).
6. Explain briefly the basis of designating the coordinate axes in CNC machine tools (L2).
7. Explain the ISO nomenclature of tungsten carbide inserts and tool holders (L2).
8. Sketch and explain milling tooling system (L3).
9. Discuss with a neat sketch Automatic tool change used in a NC machine tool (L2).
10. Explain with a neat sketch any two work holding device (L2).
11. Describe the different types of elements used in FEM analysis and their applications (L2).
12. Describe in brief, the basic steps involved in FEA procedure (L2).
13. List few FEA packages and in brief explain about ANSYS products (L2).
14. Explain the FEM technique with suitable example, applied to a static case (L3).
15. Explain the functions served by pre-processor and post-processor in FEM (L2).
16. Illustrate the various finite elements used for a descritization process (L2).
17. Describe degrees of freedom and types of elements for FEM (L2).
18. Explain preprocessing, processing (solver), and post processing with respect to finite element analysis (L2).

UNIT-5

1. Discuss the steps involved in the development of a NC part program with a flow chart (L3).
2. Explain the following with respect to turning centre programming i) Axes system ii) Diameter programming (L2).
3. Explain the following with respect to turning centre programming i) Tool Nose radius ii) Tools (L2).
4. Explain the function of the preparatory functions. Give the functioning of any one G code used for the purpose (L2).
5. List any six preparatory and miscellaneous codes, with brief description of each code (L2).
6. Explain with neat sketches the different robot physical configurations (L2).
7. Explain the following with respect to Robots i) Arm and Body motions ii) Wrist Motions iii) Work volume iv) Precision of movement (L2)
8. Define a ROBOT. Sketch and explain four robot configurations (L2).
9. List and explain the different types of grippers used in robots (L2).
10. Describe the concept of robot work cell and interlocks with the help of an example (L2).
11. Describe ‘End effectors’ and ‘Sensors’ with respect to industrial robot (L2).
12. Explain in brief, robot applications categorically (L2).

Course Articulation Matrix (CAM)

Course Outcome (CO)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
Describe the fundamental theory and concepts of the CAD/CAM. Explain the Basic hardware structure and components used in CAD systems.	L1, L2	**M**							**M**			
Compare the different types of modeling techniques and explain the central role solid models Play in the successful completion of CAD/CAM-based product development. Develop transformations for 2D geometric modeling.	L1, L2	**M**					**M**		**M**			
Describe the principles of Computer Aided Designing systems and the concepts of Geometric Modeling, solid modeling, and feature-based design modeling.	L1, L2	**M**					**M**		**M**			
Explain the basic concepts of NC and CNC programming and machining.	L1, L2	**M**							**M**			
Compare and distinguish the difference between the operation and programming of a CNC machine tool using manual programming and the operation and programming of CNC machine tool using CAM systems.	L1, L2	**M**	**M**	**L**		**L**	**M**		**M**	**L**		
Apply both practices (manually and CAM) to develop the G-code program. And explain the basics of FEA and Robotics.	L1, L2, L3	**H**	**M**	**M**		**M**	**M**		**M**	**M**		
L – Low, M – Moderate, H - High												

Course Assessment Matrix (CAM)

Course Outcome (CO)		Program Outcome (ABET/NBA-(3a-k))										
		a	b	c	d	e	f	g	h	i	j	k
Describe the fundamental theory and concepts of the CAD/CAM. Explain the Basic hardware structure and components used in CAD systems.	L1, L2	**2**							**2**			
Compare the different types of modeling techniques and explain the central role solid models Play in the successful completion of CAD/CAM-based product development. Develop transformations for 2D geometric modeling.	L1, L2	**2**					**2**		**2**			
Describe the principles of Computer Aided Designing systems and the concepts of Geometric Modeling, solid modeling, and feature-based design modeling.	L1, L2	**2**					**2**		**2**			
Explain the basic concepts of NC and CNC programming and machining.	L1, L2	**2**							**2**			
Compare and distinguish the difference between the operation and programming of a CNC machine tool using manual programming and the operation and programming of CNC machine tool using CAM systems.	L1, L2	**2**	**2**	**1**		**1**	**2**		**2**	**1**		
Apply both practices (manually and CAM) to develop the G-code program. And explain the basics of FEA and Robotics.	L1, L2, L3	**3**	**2**	**2**		**2**	**2**		**2**	**2**		
1 – Low, 2 – Moderate, 3 – High												

Course Title: FINITE ELEMENT METHODS			
Course Code: P13AU664	Semester: 6	L:T:P:H- 4:0:0:4	Credits:4
Contact period : Lecture: 52 Hrs., Exam 3 Hrs.		Weightage : CIE:50%; SEE:50%	

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

Course Content

Unit -1

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

Unit -2: INTERPOLATION MODELS: Displacement function, selection of the order of displacement function, convergence criteria, geometric isotropy, Pascal's triangle for 2D polynomial, Different co-ordinate systems used in FEM, Interpolation or shape functions for 1D linear and quadratic bar elements and 2D linear triangular (CST) element in cartesian and natural co-ordinate systems. Lagrangian polynomial – Shape functions for linear quadrilateral element (QUAD 4) and quadratic quadrilateral element (9-noded), Iso-parametric, sub-parametric and super-parametric elements, Concept of Jacobian matrix, Jacobian matrix for CST. **12 hrs**

Unit -3: ELEMENT STIFFNESS MATRIX AND LOAD VECTORS: Strain displacement matrix, Stiffness matrix and load vector for linear and quadratic bar element and CST element. Assembly of elements by direct stiffness method, special characteristics of stiffness matrix, Treatment of boundary conditions- elimination and penalty methods. Analysis of axially loaded uniformly tapered and stepped bars. **10 hrs**

Unit -4: ANALYSIS OF PLANE TRUSSES AND BEAMS: Local and global coordinate systems, stiffness matrix for plane truss element, analysis of truss members. Hermite shape function for beam element in Cartesian coordinates, Stiffness matrix and load vector for beam element, element shear force and bending moment, analysis of beams. **10 hrs**

Unit -5

ANALYSIS OF HEAT TRANSFER PROBLEMS: Steady state heat transfer, 1D heat conduction- governing equation, boundary conditions, one-dimensional element, Galerkin's approach to heat conduction, heat flux boundary condition. 1D heat transfer in thin fins- Formulation of equations. Simple numerical of 1D heat transfer problems on composite walls and fins with conduction and convection. **10 hrs**

TEXT BOOKS:

1 Introduction to the Finite Element Method: C. S. Desai and J.F. Abel, EWP an East-West Edition
2 Introduction to Finite Elements in engineering: T R Chandrupatla and A D Belegundu, PHI.
3 The Finite Element Method in engineering: S S Rao, Elsevier.

REFERENCES:

1 The FEM its basics and fundamentals: O.C.Zienkiewicz, Elsevier, 6e.

2 Finite Element Method: J.N.Reddy, McGraw –Hill International Edition.
3 Finite Element Methods: by Daryl. L. Logon, Thomson Learning 3rd edition.
4 Fundamentals of Finite Element Analysis: David V. Hutton,–Tata McGraw Hill Publishing Co. Ltd, New Delhi.

Course Outcomes

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

1 **Explain** the concept of finite element method as well as finite element discretization process. **Apply** Gauss elimination algorithm to **solve** linear algebraic equations and Gauss quadrature technique for numerical integration.

2 **Develop** interpolation models for different types of elements that satisfy convergence criteria and geometric isotropy. **Use** isoparametric concept in the finite element analysis.

3 **Formulate** element stiffness matrices and load vectors for different elements by **applying** variational principle.

4 **Use** developed finite element models in the **determination** of stresses, strains and reactions of axially loaded bars, trusses and transversely loaded beams.

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

Unit wise Plan

Unit I

Topic Learning Objectives :

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

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

Lesson Schedule

1. Need for use of FEM, Advantages and disadvantages of FEM, Engineering Applications of FEM, Steps involved in FEM
2. Discretization process – types of elements (1D,2D,3D), size of the elements, location of nodes, node numbering scheme, Method of solution of linear algebraic equations – Gauss elimination method.

3. Gauss elimination method, numericals
4. Numericals
5. Numerical integration by Gaussian quadrature (one point and two point formula).
6. Numericals
7. Numericals
8. Basic elastic equations – body force and traction force, strain-displacement relations.
9. Basic elastic equations – contd.
10. Principle of minimum potential energy and derivation of potential energy functional for a 3D elastic body, concept of plane stress and plane strain and their stress-strain relations.

Unit II –

Topic Learning Objectives

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

- Explain the convergence criteria for interpolation functions.
- Derive shape functions for bar elements, CST and QUAD elements.
- Explain iso-parametric formulation and its advantage.

Unit III:

Topic Learning Objectives

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

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

Lesson Schedule

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

Unit IV:

Topic Learning Objectives

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

- Explain the concept of local and global coordinate systems.
- Derive stiffness matrix for truss element.
- Derive shape functions, stiffness matrix and load vectors for beam element.

- Solve problems on truss and beam elements.

Lesson Schedule

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

Unit V:

Topic Learning Objectives

- Derive governing FE equation for 1D heat transfer problem using functional approach. and Galerkin's method.
- Explain boundary conditions used in heat transfer problems.
- Solve problems on 1D heat transfer.

Lesson Schedule

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

Review Questions

1	List the advantages and disadvantages of FEM over other numerical methods.
2	Explain the steps involved in FEM
3	Giving suitable example, explain the following: (i) Essential and nonessential boundary conditions and (ii) Boundary value and initial value problems
4	Write note on node numbering scheme for the minimization of bandwidth of stiffness matrix
5	Solve the following system of simultaneous equation by Gaussian elimination method: $2x_1 + x_2 + 3x_3 = 10;\ 4x_1 + x_2 + x_3 = 5;\ 3x_1 + 2x_2 + x_3 = 3$
6	What is meant by body force and surface force? Give examples.
7	With examples explain Plane stress and Plane strain. Give stress-strain relations.
8	Derive equilibrium equation for a 3D body subjected to surface forces.

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

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

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

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

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

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

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

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

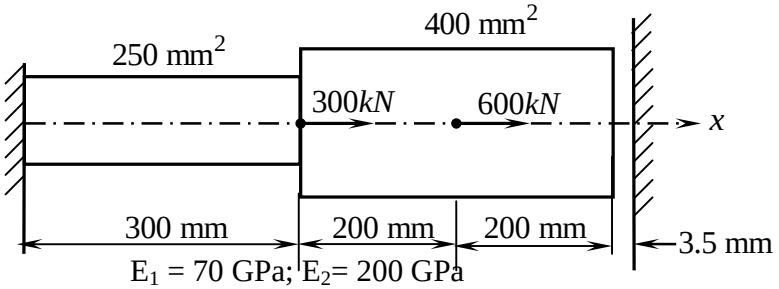
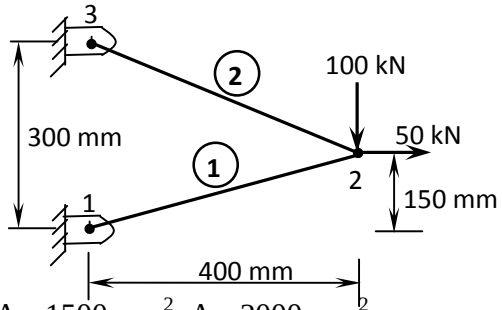


Fig. 1

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



E=200 GPa, A_1=1500 mm^2, A_2=2000 mm^2

Fig. 2

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

18 The beam shown in Fig. 3, determine the unknown deflections and slopes. Also determine the vertical deflection at the mid-point of the beam having distributed load of 12kN/m.

Assume E=200 GPa and $I = 4\times10^6 mm^4$.

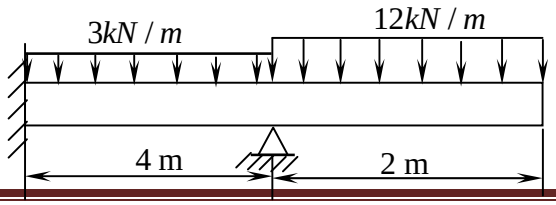


Fig. 3

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

20 The left surface of the plane wall of thickness 1.2 m is maintained at a constant temperature of 200^oC and the right side surface is exposed to cold air at -15^oC. The heat transfer coefficient associated with the outside surface is $h=40W/m^{2o}C$. The thermal conductivity is $K_{xx} = 25W / m^oC$ and there is a uniform generation of heat inside the wall of $Q = 400W / m^3$. Determine the temperature distribution through the wall using two elements of equal length.

Course Articulation Matrix

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

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