## SEMESTER – VII

## MECHANICAL VIBRATIONS ME – 7001

| | | | |
|---|---|---|---|
| Course Code | **ME – 7001** | Credits : 5 | L-4, T-1, P-0 |
| Name of the Course | **MECHANICAL VIBRATIONS** | | |
| Lectures to be delivered | **65 (1 Hr Each) (L = 52, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION – A**

**Basic Concepts:**

Importance and scope, definition and terminology, representation of harmonic motions, introduction to various types of vibrations and types of excitation.

**SECTION – B**

**Single Degree of Freedom Systems:**

**a) Undamped Free Vibrations:**

D Alemberts Principle, Energy method, Rayleigh method, simple applications of these methods, equivalent spring stiffness.

**b) Damped Free Vibrations:**

Introduction to different types of damping, Viscous damping, sub-critical, critical and overdamping, logarithomic decrement, frequency of damped oscillations.

**c) Forced Vibrations:**

Solution for simple harmonic excitation, steady state vibrations, base excitation, vibration isolation and transmissibility, vibration measuring instruments, whirling of shaft without friction.

**SECTION – C**

**Two Degree of Freedom Systems:**

**a) Undamped Fee Vibrations:**

Normal modes vibrations, natural frequencies, mode shapes, forced harmonic vibrations, torsional vibrations of two rotor systems.

**b) Applications:**

Dynamic vibration absorber, centrifugal pendulum absorber, torsional vibration absorber, untuned vibration damper, gyroscopic effect on rotating shaft.

**SECTION – D**

**a) Multi-Degree of Freedom Systems:**

Undamped free vibrations: Reciprocity theorem, Rayleigh and Dunkerley method, three rotor and geared systems.

**b) Continuous Systems:**

Free vibration of the following for various end conditions:

Vibration of a string, longitudinal vibrations of bar, transverse vibration of beam, torsion of vibrations of circular shaft.

**Suggested Books:**

Mechanical Vibration by S.S.Rattan.
Mechanical Vibration by Grover.
Mechanical Vibration by V.P.Singh.

## SEMESTER – VII

## AUTOMOBILE ENGINEERING ME – 7002

| | | | |
|---|---|---|---|
| Course Code | **ME - 7002** | Credits: 4 | L-3, T-1, P-0 |
| Name of the Course | **AUTOMOBILE ENGINEERING** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**Section – A**

Introduction to Automobiles: Classification, Components, Requirements of Automobile Body: Vehicle Frame. Types; Front Engine Rear Drive & Front Engine Front Drive Vehicles, Four Wheel Drive Vehicles.

Clutches: requirement of Clutches – Principle of Friction Clutch – Wet Type & Dry Types: Single Plate Clutch, Multi plate Clutch, Centrifugal Clutches, Clutch linkages.

**Section – B**

Power Transmission: Object of the Gear Box; Different types of Gear Boxes; Sliding Mesh, Constant Mesh, Synchromesh Gear Boxes; Drive Lines, Universal Joint, Propeller Shaft, Slip Joint; Front wheel drive; Principle, Function, Construction & Operation of Differential; Rear Axles, Types of load coming on Rear Axles, Full Floating, Three Quarter Floating and Semi Floating Rear Axles.

**Section – C**

Suspension Systems: Need of Suspension Systems, Types of Suspension; factors influencing ride comfort, leaf springs, shock absorber.

Steering System: Front Wheel geometry & Wheel alignment viz. Caster, Camber, King Pin Inclination, Toe-in/Toe-out; Conditions for true rolling motions of Wheels during steering: Different type of Steering Gear Boxes; Steering linkages and layout; Rack & Pinion Power Steering Gear.

**Section – D**

Automotive Brakes, Tyres & Wheels: Classification of Brakes; Principle and construction details of Drum Brakes, Disc Brakes; Mechanical, Hydraulic, Pneumatic Brakes; Power Assisted Brakes; Tyres of Wheels; Types of tyre & their constructional details, Tyre rotation; Excessive Tyre wear & their causes.

Automotive Electrical:. Purpose & Operation of lead acid Battery, capacity rating. Purpose and Operations of the Starting System; and charging system.

**Text Books:**

1. Automobile Engineering by Dr. Kirpal Singh, Standard Publishers Distributors.
2. Automobile Engineering by Anil Chhikara, Satya Prakashan, New Delhi.

**Reference Books:**

1. Automotive Mechanics – Crouse/Anglin, TMIL.
2. Automotive Technology – H.M.Sethi, TMH, New Delhi.
3. Automotive Mechanics – S.Srinivasan, TMH, New Delhi.
4. Automotive Mechanics – Joseph Heitner, EWP.
5. Motor Automotive Technology by Anthony E. Schwaller – Delmer Publishers. Inc.
6. The Motor Vehicle – Newton steeds Garrett, Butter Worths.

**SEMESTER – VII**

**REFRIGERATION AND AIR CONDITIONING ME- 7003**

| Course Code | **ME- 7003** | Credits : 4 | L-3, T-1, P-0 |
|---|---|---|---|
| Name of the Course | **REFRIGERATION AND AIR CONDITIONING** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**Section- A**

Introduction: Definition of refrigeration & air conditioning; necessity; Methods of refrigeration; Coefficient of Performance(COP); Refrigerants Definition, Classification nomenclature, Desirable properties, Comparative study, secondary refrigerant, introduction to eco-friendly refrigerants; introduction to Cryogenics.

Air Refrigeration System: Carnot refrigeration cycle, Brayton refrigeration or the Bell Coleman air refrigeration cycle; Necessity of cooling the aero plane; Boot strap evaporative types, Regenerative type and Reduced Ambient type system, Problems.

**Section- B**

Vapour Compression (VC) Refrigeration System: (A) Simple V.C. Ref. systems- Limitations of Reversed Carnot cycle with vapour as refrigerant; Analysis of VC cycle considering degrees of sub cooling and superheating; VC cycle on p-v, t-s and p-h diagrams; Effects of operating condition on COP; Comparison of VC cycle with Air Refrigeration Cycle. (B) Multi-stage Ref. System – cooling/ or water inter cooler: Multistage compression with flash intercooling and/ or water intercooling; system with individual or multiple expansion valves: Individual compression system with individual or multiple expansion valves; Individual compression system with individual or multiple expansion valves but with and without intercoolers.

**Section - C**

Vapour Absorption Refrigeration System, Basic Systems, Actual system, COP of the system, Relative merits and demerits; Properties of aqua ammonia; Electrolux Refrigeration.

Steam Jet Refrigerating System – Introduction, Analysis, Relative merit and demerits, Performance, Applications.

Cascade Refrigerating Systems- Necessity Selection of Pairs of refrigerants for the system, Concept of cascade temperature, Analysis, Multistaging, comparison with V.C. systems, Application.

**Section – D**

Psychromatry of Air & Air Conditioning Processes: Properties of moist Air, Gibbs Dalton law, Specific humidity, Dew point temperature, Degree of saturation, Relative humidity, Enthalpy, Humid specific heat, Wet bulb temp., Thermodynamics wet bulb temp., Psychrometic chart: psychrometry of air-conditioning processes, Mixing process, Basic processes in conditioning of air.

Air- Conditioning Load Calculations: Outside and inside design conditions: Source of heating load, Sources of cooling load; Heat transfer through structure, Solar radiation, Electrical application Infiltration and ventilation, Heat generation Inside conditioned space: Comfort chart.

**Text Books:**

1. Refrigeration & Air Conditioning- R.C. Jordan and G.B. Priester, Prentice Hall of India.
2. Refrigeration & Air Conditioning-C.P.Arora, Tata-McGraw Hill, New Delhi.

**Reference Books:**

1. A course in Refrigeration & Air Conditioning – Arora & Domukundwar, Dhanpat Rai & Sons,1989.
2. Refrigeration & Air Conditioning- W.F. Stockerand J.W. Jones, Tata-McGraw Hill,New Delhi
3. Refrigeration & Air Conditioning- Manohar Parsad Wiley Estern limited, New Delhi.

**SEMESTER – VII**

# OPERATION RESEARCH ME – 7004

| Course Code | **ME – 7004** | Credits : 4 | L-3, T-1, P-0 |
|---|---|---|---|
| Name of the Course | **OPERATION RESEARCH** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

## Instructions

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.

2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

## Section – A

Definition and characteristics of O.R.; Decision making, Scientific decision making, Approach for scientific decision making in O.R.; Need and Limitations of O.R.
Definition of models: Classification of models, construction of models, approximations of O.R. models.

## Section- B

**Allocation Model**: Analysis of Industrial situations to find characteristics like key decision objective, possible alternatives & restrictions – Three categories of allocation type situation to be considered General Mathematical formulation for linear programming feasible and optimal solutions.
Graphical and simplex techniques to solve linear models, modifications of minimization situation so as to be solvable by simplex method. Duality and degeneracy in simplex method. Applications and limitations of linear optimization models

## Section- C

**Net-work Models :** Transportation models, methods of finding starting solution Vogel's approximation method to find feasible solution in transportation models, methods for finding optimal solution. Assignment model, Hungarian method to find optimal solution in assignment models.
Cyclic shortest route models, traveling salesman's problem and Branch and Bound method to solve it. A cyclic shortest route models and their solution by graphical methods.
Queuing theory, various types of queuing situations and their solutions.

## Section- D

PERT & CPM: Network situations where PERT & CPM can be applied , planning, scheduling & Control, work-breakdown structure.

(a) PERT NETWORKS: Events and activities, construction of network, forward & backward planning, Fulkerson's rules, optimistic, pessimistic & most likely time estimates, frequency distribution, Mean, variance and standard deviation, expected time and latest occurrence time, definitions of stack and critical path.

(b) CPM NETWORKS: Similarity and differences of CPM and PERT construction of network, earliest event time, float, total float, free float, independent float, contracting the network so as to find an optimum project schedule.

Suggested Books:


1. An introduction to operation research by A.H.Taha Mac. Mill. Pub.
2. operation research by P.K.Gupta and D.S.Hira.

# SEMESTER – VII

## MECHATRONICS ME – 7005

| Course Code | ME – 7005 | Credits : 4 | L-3, T-1, P-0 |
|---|---|---|---|
| Name of the Course | MECHATRONICS | | |
| Lectures to be delivered | 52 (1 Hr Each) (L = 39, T = 13 for each semester) | | |
| Semester End Examination | Max. Time: 3 hrs. | Max. Marks: 100 | Min. Pass Marks: 40 |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | Max. Marks: 50 | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.

2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**Section- A**

Introduction and Basics: What is Mechatronics?; A Measurement System with its constituent elements; Open and Closed Loop System; Sequential Controllers; Micro-processor Based Controller; The Mechatronic Approach.

**Section- B**

Hardware of Measurement Systems; Force Fluid Pressure, Liquid Flow, Liquid Level, Temperature, Light Sensors along with Performance terminology ; Data Presentation Elements: Magnetic Recording; data Acquisition System; Testing & Calibration; Problems. Pneumatic, Hydraulic, Mechanical and Electrical actuation System: Pneumatic and hydraulic System; Mechanical Systems, Types of Motion Kinematic Chains, Cams, Gear, Trains, Ratehet & Pawl. Belt & Chain Drivers, Bearings. Mechanical aspect of Motor Selection; Electrical Systems; Mechanical & Solid State Switches; Solenoids; D.C. & A.C. Motors; Stepper Motors; Problems.

**Section- C**

Digital Logic and Programmable Logic Controller: A review of Number System & Logic Gates; Boolean Algebra; Kanaugh Maps; Sequential Logic; Basic Structure of Programmable Logic Controller; Input/ Output Processing; Programming; Timers, Internal Relays ans Counters; Master & Jump Controls; Data Handling; Analogue Input/Output; Selection of a PLC; Problems.

**Section- D**

Microprocessor and Input/Output System: Control, Microcomputer Structure: Microcontroller; Applications; Programming Languages; Instruction Sets; Assembly Language Program; Subroutines; Design and Mechatronics: Design Process; Traditional and Mechantronics Design: Possible Mechatronics design solutions for Timed Switch, Wind Screen Wiper Motion, Bath Room Scale, A Pick & Place Robot, Automatic Camera, Engine Management System & Bar Code Recorder.

**Text Books:**


1. Mechatronics by W. Bolton, Published by Addition Wesley.
2. Mechatronics System Design Devdas Shetty and Richard A Kolx Brooks Cole 1997


**Reference Books:**


1. Introduction to Mechatronics and Measuring System: David G. Alciation and Michal B. Hist and Tata McGraw Hill Edition 2003.
2. Mechtronics – Sensing to Implementation – C.R. Venkatraman, Sapna 2001


Note: In the semester examination, the examiner will set eight questions, at least one question from one unit. The students will be required to attempt only 5 questions.

**SEMESTER – VII**

**AUTOMOBILE ENGINEERING LAB ME-7007**

| Course Code | **ME-7007** | Credits : 2 | **L-0, T-0, P-2** |
|---|---|---|---|
| Name of the Course | **AUTOMOBILE ENGINEERING LAB** | | |
| Lectures to be delivered | **26 hours of Lab sessions** | | |
| Semester End Examination | **Maximum Time: 3 hrs.** | **Max. Marks: 50** | **Min. Pass Marks : 20** |
| Laboratory | **Continuous Assessment (based on Lab work 30%, Lab record 25%, Viva 25%, Attendance 20%)** | **Max. Marks: 50** | **Min. Pass Marks: 25** |

1. To study and prepare report on the constructional details, working principle and operation of the following

(a) Single plate clutch.
(b) Multi plate Clutch

2. To study and prepare report on the constructional details, working principles and operation of the following

(a) Constant mesh Gear Box.
(b) Synchromesh Gear Box.

3. To study and prepare report on the constructional details, working principles and operation of the following

(a) Rear Wheel Drive Line.
(b) Front Wheel Drive Line.
(c) Differentials

4. To study and prepare report on the constructional details, working principles and operation of the following

(a) Starting System
(b) Ignition System

5. To study and prepare report on the constructional details, working principles and operation of the Charging System

6. To study and prepare report on the constructional details, working principles and operation of the following

(a) Front Suspension System
(b) Rear Suspension System

7. To study and prepare report on the constructional details, working principles and operation of Rack and Pinion Power steering system

8. Adjusting of brake shoes and Bleeding the hydraulic brake system.

**SEMESTER – V**

**REFRIGERATION & AIR CONDITIONING LAB ME – 7008**

| Course Code | **EC – 7008** | Credits : 2 | L-0, T-0, P-2 |
|---|---|---|---|
| Name of the Course | **REFRIGERATION & AIR CONDITIONING LAB** | | |
| Lectures to be delivered | **26 hours of Lab sessions** | | |
| Semester End Examination | **Max. Time = 3 hrs.** | **Max. Marks : 50** | **Min. Pass Marks: 20** |
| Laboratory | **Continuous Assessment (based on Lab work 30%, Lab record 25%, Viva 25%, Attendance 20%)** | **Max. Marks: 50** | **Min. Pass Marks: 25** |

**Instructions for paper setter/Candidates**

Laboratory examination will consist of two parts:

i) Performing a practical examination assigned by the examiner (25 marks).

ii) Viva-voce examination (25 marks).

Viva-voce examination will be related to the practicals performed/projects executed by the candidate related to the paper during the course of the semester.

**LIST OF EXPERIMENTS:**

1. To study the vapour compression Refrigeration Systems and determine its C.O.P.

2. To study water cooler and find its C.O.P.

3. To study the ice-plant, its working cycle and determine its C.O.P and capacity.

4. To determine the By-pass factor of Heating & Cooling coils

5. To study the cut-sectional models of reciprocating and Rotary Refrigerant compressor

6. To study the various controls used in Refrigerating & Air Conditioning System

7. To study the humidification, heating, cooling and dehumidification processes

8. To study Desert cooler & Window Type Air Conditioner

## SEMESTER – VII
## OPTIMIZATION METHODS FOR ENGINEERING SYSTEM ME-7011

| | | | |
|---|---|---|---|
| Course Code | **ME – 7011** | Credits : 4 | L-3, T-1, P-0 |
| Name of the Course | **Optimization Methods for Engineering System** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Introduction: Engineering Application; Statement of the Optimal Problem; Classification; Optimization Techniques;

Classical Method : Single Variable Optimization; Multivariable Optimization Without any Constraints with Equality and Inequality Constraints.

**SECTION B**

One-Dimensional Minimization Method: Unimodal Function; Elimination Method – Dichotomous Search, Fibonocci and Golden Method; Interpolation Method – Quadratic and Cubic Interpolation Method.

Unconstrained Minimization Method: Univariate, Conjugate Directions, Gradient And Variable Metric Method.

**SECTION C**

Constrained Minimization Method: Characteristics of a constrained problem; Direct Method of feasible directions; Indirect Method of interior and exterior penalty functions.

Geometric Programming : Formulation and Solutions of Unconstrained and Constrained geometric programming problem.

**SECTION D**

Dynamic Programming: Concept of Sub-optimization and the principal of optimality: Calculus, Tabular and Computational Method in Dynamic Programming: An Introduction to Continuous Dynamic Programming.

Integer Programming : Gomory's Cutting Plane Method for Integer Linear Programming; Formulation & Solution of Integer Polynomial and Non- Linear problems.

**Text Books:**


1. Optimization (Theory & Application)- S.S. Rao, Wiley Eastern Ltd, New Delhi.
2. Optimization Concepts and Applications in Engineering – Ashok D.Belegundu and Tirupathi R Chandrupatla – Pearson Education 1999, First India Reprint 2002.


**Reference Books:**


1. Optimization: Theory and Practice, C.S.G. Beveridge and R.S. Schechter, McGraw Hill, New York.

**SEMESTER – VII**

**MACHINE TOOL DESIGN** **ME – 7012**

| Course Code | **ME – 7012** | Credits : 4 | L-3, T-1, P-0 |
|---|---|---|---|
| Name of the Course | **MACHINE TOOL DESIGN** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

## SECTION A

Introduction: Kinematics of Different Types of Machine Tools, Selection of Cutting Conditions and Tools, Calculation of Cutting Force on Single Point and Multipoint Tools, Hole Machining, Calculation of Power, Accuracy Requirements and Standards.

## SECTION B

Design of Fed Drives: Feed Drive using Feed Boxes, Axes Feed of CNC Drives, DC and AC Servomotors, Types characteristics Controllers and Their Selection, Ball Screws and Friction Screws- Guide Ways, Linear Motion System, Design Calculations of Drives, Closed Loop Operations of Feed Drives, Linear Indexing Drives.

## SECTION C

Design of Machine Tool Structures: Static and Dynamic Stiffness, Dynamic Analysis of cutting process, Stability, Forced Vibration, Ergonomics and Aesthetics in Machine Tool Design.

Design of Spindle and Spindle: Supports : Function of Spindle, Design Requirement Standard Spindle Noses, Design Calculations of Spindles. Bearing Selection and Mounting,

## SECTION D

Design of Special Purpose Machines : Modular Design Concepts, Standard Modules Example of Design of a Typical SPM with CNC, Transfer Machines.

**Text Books:**


1. " Machine Tool Design" Tata McGraw Hill Book Co. 1991, Metha, N.K.
2. Design Principal of Cutting Machine Tools : Koenigs bergerf. Pergman Press Oxford.


**Reference Books:**


1. "Machine Tool Design", Vol 1 and Vol III, Mir Publishers, Moscow, Macherkan.


**Note: in the semester examination, the examiner will set eight questions, at least one question from each unit. The students will be required to attempt only 5 questions.**

**SEMESTER – VII**

**TOTAL QUALITY CONTROL ME – 7013**

| Course Code | **ME – 7013** | Credits : 4 | L-3, T-1, P-0 |
|---|---|---|---|
| Name of the Course | **TOTAL QUALITY CONTROL** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Quality Control: introduction, objectives, quality of design, quality of production, quality of conformance to design, quality of inspection, process monitoring, quality and productivity, quality cost Advantages of statistical Quality Control in Industry.

Fundamentals of Statistics and Probability in Quality Control: Events and probability, laws of probability, Statistical Distributions: Normal and Poisson distribution, their importance in SQC. Poisson Probability as approximation to Normal Probability, use of Normal and Poisson distribution tables.

**SECTION B**

Control Charts for Variables: Fundamentals of process control, tool of process control, quality characteristic, Design and use of Control for Variables: Trial control limits, control limits for future use, revision of control limits. Cause and effect diagram. Inferences on the state of the process from control charts, Type I and Type II errors and methods to reduce them. Use of X (X bar) charts and R-charts, and R- charts, X (X bar) and σ- charts. Efficiency of a control chart. OC curve of a control chart. Computing average run length for X- chart.

**SECTION C**

Trend Control Charts, Control Charts with Reject limits and Modified Control Charts, Relationship between Specification Limits and Control Chart Limits, Process capability analysis and its importance in quality of conformance.

**SECTION D**

Control Charts for Attributes : Defectives, control charts for fraction defectives and percent fraction defectives and number of defectives. Control charts for number of defects. Comparison of control charts for variables with the charts for variables with the charts for attributes. Computing Average run length for a p-chart.

**Text Books:**


1. Quality control Application – By Hansen BL, PH: Prentice Hall of India.
2. Statistical Quality Control – By E.L. Grant & R.S. Levenworth; Tata McGraw Hill.


**Reference Books :**


1. Quality Control – Paranthaman, D; Tata McGraw Hill, India
2. Quality Planning and Analysis- Juran J.M. and F.M. Gryna (Jr.); Tata McGraw Hill, India
3. Total Quality Control – By Montgomery, D.C. John Wiley & Sons (Asia)


**Note : Statistical Q.C. Tables will be supplied in examination.**

**The paper setter will set Eight question, taking at least one from each unit. Students will be required to answer only five.**

**SEMESTER – VII**

**PUMPS, FANS, BLOWERS AND COMPRESSORS ME – 7014**

| | | | |
|---|---|---|---|
| Course Code | **ME – 7014** | Credits : 4 | L-3, T-1, P-0 |
| Name of the Course | **PUMPS, FANS, BLOWERS AND COMPRESSORS** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Pumps: Theory of centrifugal pump impeller, vortex theory, design of impeller, volute and diffusers, specific speed and design constants.

Design of Mixed Flow Impellers: Geometric relationship, axial flow pump, design, use aerofoil data for impeller design, guided vane, pump casting.

**SECTION B**

Fans: Fan laws, performance coefficient, effect of change in fan speed, density, Series and parallel operation, fan design losses, blade shape, casings.

Propeller Fans: Cross flow fans, principal of operation, application, regulation of volume flow, Sources of vibration in fans, noise, and attenuation testing.

**SECTION C**

Blowers: Types, centrifugal and axial, design procedure, selection, performance, pressure application, control of volume flow.

Performance Estimation: Instrumentation test rig layout, measurement of pressure temperature, use of hot wire anemometer, boundary layer probes, measurement of sound.

**SECTION D**

Compressor: Centrifugal compressor, multistage arrangement, blade design, types diffusers, performance, series and parallel operation.

Axial Flow Compressors: Cascade theory, efficiency, two dimensional cascade, valor triangles and stage loading, stage reactions, losses compressor testing procedure.

**Text Books:**


1. Val. S. Lobanoff, and Robert, R. Ross, “Centrifugal Pumps Design and Application”, Publishing House.
2. Allam Wallis, R, “Axial Flow and Ducts”, John Wiley and Sons.


**Reference Books :**


1. Ronald, P. Lapina, “Estimating Centrifugal Compressor Performance”, Gulf Publishing Company.


**Note : In the semester, examination, the examiner will set eight questions, at least one question each unit. The students will be required to attempt only 5 questions.**

**SEMESTER – VII**

**DESIGN OF AIR CONDITIONING SYSTEM ME – 7015**

| | | | |
|---|---|---|---|
| Course Code | **ME – 7015** | Credits : 4 | L-3, T-1, P-0 |
| Name of the Course | **DESIGN OF AIR CONDITIONING SYSTEM** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Application of air conditioning: Medium and large sized buildings, industrial air conditioning, residential air conditioning, air conditioning of vehicles and aircrafts.

Psychrometry: Psychrometric charts, combined, heat and mass transfer, adiabatic saturation, enthalpy potential.

**SECTION B**

Air conditioning Load: comfort and design conditions, thermal transmission, infiltration and ventilation loads, heating and cooling loads, solar radiation properties, periodic heat transfer through walls and roofs.

Air conditioning system: Thermal distribution system, classic single-zone system, outdoor air control, single-zone system design, multiple-zone, terminal reheat system, dual duct or multi zone system, variable air-volume system, hydronic system, unitary system, passive air conditioning system.

**SECTION C**

Equipment Design: Fan and duct system, fan air-distribution in rooms, ventilation system, diffusers and induction, fan coil units. Cooling and dehumidifying coils – Heat and mass transfer, moisture removal, coil performance.

**SECTION D**

Controls: Pneumatic, electric and electronic controls, thermostats, dampers, outside air control, freeze protection, humidistat, acoustics and noise control.

Refrigerants: Primary and secondary refrigerants, halocarbons, azeotropes, ozone depletion, eco friendly refrigerants.

**Text Books:**


1. Refrigeration and air conditioning-W.F. Stoecker, J.W. Jones, McGraw Hill Book Co.
2. Air conditioning Engineering – W.P. Jones, Edward Arnold.


**Reference Books:**


1. Hand book of air conditioning system design – Carrier Air conditioning Co. McGraw Hill Book Co.
2. Thermal Environmental Engg. – James L. Thelkeld, Prentice Hall, Inc
3. Refrigeration and Air conditioning – C.P Arora, Tata McGraw Hill Pub. Co. Ltd.
4. Refrigeration and Air conditioning – P.L Ballaney, Khanna Publishers


**Note : In the semester examination, the examiner will set eight question, at least one question from each unit. The students will be required to attempt only 5 question.**

**SEMESTER – VII**

**COMPUTER AIDED VEHICLE DESIGN** **ME – 7016**

| | | | |
|---|---|---|---|
| Course Code | **ME – 7016** | Credits : 4 | L-3, T-1, P-0 |
| Name of the Course | **COMPUTER AIDED VEHICLE DESIGN** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Vehicle Frame and Suspension: Study of Loads-Moments and Stresses on Frame Members computer aided design of Frame for passenger and commercial vehicle, Computer aided design of leaf springs-coil springs and torsion bar springs.

**SECTION B**

Front axle and steering system: analysis of Loads- Moments and stresses at different sections of Front axle. Determination of bearing Loads at Kingpin bearings. Wheel spindle bearings. Choice of bearings. Determination of optimum dimension and proportions for steering linkages ensuring minimum error in steering.

**SECTION C**

Clutch: Torque capacity of Clutch. Computer Aided design of clutch components, design details of roller and sprag type of clutches.

**SECTION D**

Drive line and read axle : computer aided design of propeller shaft. Design of final drive gearing. Design details of full-floating, semi-floating and three quarter floating. Rear axle shafts and rear axle housings.

**Text Books :**


1. Dean averns, automobile chassis design, IIliffe Books Ltc 1992.
2. Heldt, P.M. automobile chassis, Chilton Co. New York 1992.


**Reference Books:**


1. Steeds. W, Mechanic of road veicles, IIliffee Books Ltd, London 1990.
2. Giles, J.G. Steering, suspension and Tyres, IIliffee Books Ltd, Lodon, 1988.
3. Newton, steeds & garret,motor vehicle, IIliffee Books Ltd, Lodon, 1982.
4. Heldt P.M. Tqrque Converter, Chilton Books Co. New York, 1982.
5. Giri N.K, Automobile mechanics, Khanna Publisher, New Delhi,1986.


**Note: Use of software package for analysis and design of mechanical system may be used for design problem.**

**SEMESTER – VII**

**FLEXIBLE MANUFACTURING SYSTEMS ME-7017**

| Course Code | **ME – 7017** | Credits : 4 | L-3, T-1, P-0 |
|---|---|---|---|
| Name of the Course | **FLEXIBLE MANUFACTURING SYSTEMS** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Automation: Types of automation, reasons for automating, automation strategies, Detroit-type automation: Automated flow lines, methods of work part transport, Transfer mechanisms, buffer storage, automation for machining operations.

Automated assembly systems: design for automated assembly, types of automated assembly system, part feeding devices, quantitative analysis of the delivery system operation, analysis of a single-station assembly machine, numericals.

**SECTION B**

Group Technology: Part families, part classification and coding. Types of classification and coding system, Machine cell design: The composite part concept, types of cell design. Determining the best machine arrangement, benefits of group technology.

Flexible Manufacturing System: Components of an FMS, types of system, where to apply FMS technology, FMS work stations. Material handling and storage system: Functions of the handling system, FMS layout configuration, Material handling equipment, Computer control system: Computer function, FMS data file, system reports planning the FMS, analysis method for FMS, application and benefits.

**SECTION C**

Robotic technology: Joints and links, common robot configuration, work volume, types of robot control, accuracy and repeatability, other specification, and effectors, sensors in robotics.

**SECTION D**

Robot programming: Types of programming, lead through programming, motion Programming, interlocks, advantages and disadvantages, Robot languages: Motion programming, simulation and off line programming, work cell control.

Robot application: Characteristics of robot applications, robot cell design, types of robot application: Material handling, processing operation, assembly and inspection.

**Text Books:**


1. Automation. Production System and Computer Integrated Manufacturing. Groover M.P, Prentice Hall of India.
2. CAD/CAM – Groover M.P. Zimmers E.W, Prentice Hall of India.


**Reference Books:**


1. Approach to Computer Integrated Design and Manufacturing Nanua Singh, John Wiley and Sons, 1998.
2. Production Management System: A CIM Perpective Browne J, Harhen J, Shivnan J, Addison Wesley, 2nd Ed. 1996.


**Note: In the semester examination the examiner will set 8 question, at least one question from each unit, Student will be required to attempt five question.**

**SEMESTER – VII**

**NON-CONVENTIONAL ENERGY** **ME-7018**

| Course Code | **ME – 7018** | Credits : 4 | L-3, T-1, P-0 |
|---|---|---|---|
| Name of the Course | **NON-CONVENTIONAL ENERGY** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Introduction: Trends of energy consumption sources of energy conventional and renewable, fossil fuel – availability and limitations, need develop new energy sources.

Solar Energy: Solar radiation characteristic, Solar Collectors, Flat Plate and concentrating types, Their comparative study, design and material selection. efficiency, Selective paints and surfaces. Heating of air and water for building and other uses. Thermal storages, Solar Ponds, Solar pumps, solar Cookers etc. Direct Conversion of Solar energy to electricity and its various uses, materials, limitations and costs.

**SECTION B**

Bio-conversion: Generation of bio gas, digesters and then design, selection of material, feed to digester, paralytic gasification, production of hydrogen, Algae production and the their uses.

Wind Energy: Types of rotors, horizontal axis and vertical axis system, system design and site selection.

**SECTION C**

Geo-thermal Energy: Sites, potentiality and limitation, study of different conversion system.

Tidal Energy: Sites potentiality and possibility of harnessing from site, limitations.

**SECTION D**

Occan thermal energy: Principal of utilization and its limitation, description of various system.

Other non-conventional energy sources: Fluidized bed combustions. Heat from waste and other sources.

**Text Books:**

1. Solar Energy Utilization G.D. Rai.
2. Solar Heating and cooling – Duffie and Bakeman.

**Reference Books:**

1. Power Plant Technology – M.M. EL – Wakil, McGraw Hill Book Co.
2. Power Plant Engineering – P.C. Sharma, S.K. Kataria and Sons.

## SEMESTER – VII

## DESIGN OF HEAT EXCHANGERS ME-7019

| Course Code | **ME – 7019** | Credits : 4 | L-3, T-1, P-0 |
|---|---|---|---|
| Name of the Course | **DESIGN OF HEAT EXCHANGERS** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instructions**

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 15% of the total marks of the semester end examination for the course.
2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Classification of Heat exchanger: Introduction; Recuperation and regeneration; Transfer processors; Geometry of construction, tubular heat exchangers, plate heat exchangers, extended surface heat exchanges ; Heat transfer mechanisms, Flow arrangements; Selection of heat exchangers.

Basic design methods of heat exchanges: introduction; Arrangement of flow path in heat exchangers; basic equations in design; Overall heat transfer coefficient; Log mean temperature difference method for heat exchanger analysis, the –NTU method for heat exchanger analysis, Heat exchanger design calculation, Variable overall heat transfer coefficient, Heat exchange design methodology.

**SECTION B**

Design Correlations for Condensers and Evaporators ; Introduction ; Condensation, Film condensation on a single horizontal tube-laminar film condensation, forced convection, Film condensation in tube bundles-effect of condensate inundation. Effect of vapor shear; Combined effect if inundation and vapor shear, Condensation inside tubes-condensation in vertical tubes, Flow boiling-subcooled, flow pattern, flow boiling correlations.

Shell-and-tube heat exchanger: introduction basic components-shell types, tube bundle types, tubes and tube passes, tube layout, baffe type and geometry, allocation of stream; basic design procedure of a heat exchanger-preliminary estimation of unit size, rating of preliminary design.

**SECTION C**

Compact heat exchanger, Introduction; Plate-fin heat exchanger, tube-fin heat exchangers, Heat transfer, pressure, drop for finned-tube exchangers, pressure drop for plate-fin exchanger.

Gasketed-Plate heat exchangers: Introduction; Mechanical features-plate pack and frame, plat types; Operational characteristics-main advantages, performance limits, Passes and flow arrangements, Application-corrosion, maintenance, Heat transfer and pressure, drop calculations-heat transfer area, mean flow channel gap, channel equivalent diameter, heat transfer coefficient, channel pressure drop, port pressure drop, overall heat transfer coefficient, heat transfer surface area, performance analysis , Thermal performance.

**SECTION D**

Condensers and Evaporators: introduction; Shell-and-tube condensers-horizontal shell-side condensers, vertical tube-side condensers, horizontal in-tube condensers ; steam turbine exhaust condensers ; Plate condensers ; Air-cooled condensers ; Direct contact condensers ; Thermal design of shell-and-tube condensers.

**Text Books:**


1. Heat Exchangers, Sadik kakac, Hongtan, CRC Press.
2. Principals of heat transfer, F.Krieth & M.S. Bohn, Asian Books Pvt. Ltd, Delhi.


**Reference Books:**


1. Heat exchangers, Design and Theory Source Books, N.H. Afgan and Schliinder (Editors). McGraw Hill Book Company.
2. Compact heat Exchanger, W.M. Kays A.L. London, McGraw Hill book Company.

**SEMESTER – VII**

**EXPERIMENTAL STRESS ANALYSIS** **ME-7020**

| | | | |
|---|---|---|---|
| Course Code | **ME – 7020** | Credits : 4 | L-3, T-1, P-0 |
| Name of the Course | **EXPERIMENTAL STRESS ANALYSIS** | | |
| Lectures to be delivered | **52 (1 Hr Each) (L = 39, T = 13 for each semester)** | | |
| Semester End Examination | **Max. Time: 3 hrs.** | **Max. Marks: 100** | **Min. Pass Marks: 40** |
| Continuous Assessment (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%) | | **Max. Marks: 50** | |

**Instruction:**

**1. For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C, & D will have to question from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

**2.For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the section A, B, C, & D of the question paper and all the subparts of the question in Section E. Use of non-programmable calculators is allowed.

**SECTION A**

Basic Laws of Stress transformation, principal stresses and principal planes, cauchy's stress quards. Strain analysis, strain equations of transformation, Principal strain, Cauchy's strain quadratic, stress – Strain relationship.

Two dimensional Photoelasticity: stress optic law, optics of polarcope, plane and circular polariscopes, dark and light field arrangements fringe multiplication fringe sharp ending, compensation techniques, commonly employed photoelastic materials.

**SECTION B**

Three Dimensional Photo Elasticity: Neuman's strain optic relationship, stress freezing in models materials for three dimensional photo elasticity, shear difference method of stress separation. Birefringent Coatings: Sensitivity, reinforcing effects and thickness of birefringent coatings.

**SECTION C**

Electric Resistance strain Gauges: Gauges construction and installation, temperature compensation, gauge sensitiveness, gauge factor, corrections for transverse strain effects. Factors affecting gauge relation. Reosettes Rosetre analysis potentiometer and wheatstone bridge circuits for strain measurements.

**SECTION D**

Brittle Costings: Introduction, coatings stresses and failure theories, different types of crack patterns, crack detection. Composition of brittle coating, coating cure, influence of atmospheric conditions, effect of biaxial stress field.

**Book Suggested:**

1. Experimental Stress Analysis – Dally & Riby, McGraw Hill, N.York 1987.
2.Theory of Elasticity & Plasticity – Khanna Publishers, New Delhi 1979.
3. Theory of Plasticity – J. Chakrabarty, McGraw Hill, International Editions, 1987.