**B.M.S COLLEGE OF ENGINEERING, BENGALURU**

Autonomous College under VTU-Belagavi, Karnataka

**VISION**

Promoting Prosperity of mankind by augmenting human resource capital through Quality Technical Education & Training

**MISSION**

Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

**DEPARTMENT OF MECHANICAL ENGINEERING**

# V & VI Semester Scheme & Syllabus

**&**

# VII & VIII Semester Scheme

**With effect from A. Y. 2016 – 17**

**Department of Mechanical Engineering**
**Scheme for V to VI Semester**

**FIFTH SEMESTER**

| Code | Course Title | Teaching Department | Credits | | | | Total Credits | Contact Hours | Marks | | | SEE Hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | | | CIE | SEE | Total | |
| **16ME5DC MAE** | MANAGEMENT & ENTREPRENEURSHIP | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME5DC DM2** | DESIGN OF MACHINE ELEMENTS-II | MECH | 3 | 1 | 0 | 0 | 4 | 5 | 50 | 50 | 100 | 3 |
| **16ME5DC CMD** | COMPUTER AIDED MACHINE DRAWING | MECH | 2 | 0 | 2 | 2 | 6 | 6 | 50 | 50 | 100 | 3 |
| **16ME5DC DOM** | DYNAMICS OF MACHINES | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME5DC FHT** | FUNDAMENTALS OF HEAT TRANSFER | MECH | 3 | 0 | 1 | 2 | 6 | 5 | 50 | 50 | 100 | 3 |
| **16ME5DE *** ** | **ELECTIVE – 1** | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| | | **Total Credits** | **17** | **1** | **3** | **4** | **25** | **25** | **Total** | | **600** | |

| | |
|---|---|
| **16ME5DE *** ** | **ELECTIVE – 1** |

| | Code | Course Title |
|---|---|---|
| **1.** | **16ME5DETOE** | Theory of Elasticity |
| **2.** | **16ME5DENTM** | Non-Traditional Machining |
| **3.** | **16ME5DEAMT** | Advanced Material Technology |
| **4.** | **16ME5DEIFD** | Incompressible Fluid Dynamics |
| **5.** | **16ME5DEENE** | Energy Engineering |
| **6.** | **16ME5DESQC** | Statistical Quality Control |
| **7.** | **16ME5DEAEμ** | Applied Electronics and Microprocessors |
| **8.** | **16ME5DEBHM** | Biomechanics of Human Movement |
| **9.** | **16ME5DEICE** | I.C Engines |

**SIXTH SEMESTER**

| Code | Course Title | Teaching Department | Credits | | | | Total Credits | Contact Hours | Marks | | | SEE Hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | | | CIE | SEE | Total | |
| **16ME6DC TUM** | TURBO MACHINES | MECH | 3 | 0 | 1 | 2 | 6 | 5 | 50 | 50 | 100 | 3 |
| **16ME6DC MEV** | MECHANICAL VIBRATIONS | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME6DC MFE** | MODELLING AND FINITE ELEMENT ANALYSIS | MECH | 3 | 0 | 1 | 2 | 6 | 5 | 50 | 50 | 100 | 3 |
| **16ME6DC MTF** | METAL FORMING | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME6DC COE** | CONTROL ENGINEERING | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME6DL DES** | DESIGN LAB | MECH | 0 | 0 | 1 | 0 | 1 | 2 | 50 | 50 | 100 | 3 |
| **16ME6DE *** ** | **ELECTIVE- 2** | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| | | **Total Credits** | **18** | **0** | **3** | **4** | **25** | **24** | **Total** | | **700** | |

| **16ME6DE *** ** | **ELECTIVE – 2** |
|---|---|

| | Code | Course Title |
|---|---|---|
| **1.** | **16ME6DETOP** | Theory of Plasticity |
| **2.** | **16ME6DEROB** | Fundamentals of Robotics |
| **3.** | **16ME6DECMT** | Composite Material Technology |
| **4.** | **16ME6DESUE** | Surface Engineering |
| **5.** | **16ME6DECFD** | Computational Fluid Dynamics |
| **6.** | **16ME6DERES** | Renewable Energy and Sustainability |
| **7.** | **16ME6DEPOM** | Production and Operation Management |
| **8.** | **16ME6DECAM** | CAD/CAM |

**Semester: VII (Admission year: 2014 onwards)**

| Code | Course Title | Teaching Department | Credits | | | | Total Credits | Contact Hours | Marks | | | SEE Hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | | | CIE | SEE | Total | |
| **16ME7DC MAA** | MECHATRONICS AND AUTOMATION | MECH | 3 | 0 | 1 | 2 | 6 | 5 | 50 | 50 | 100 | 3 |
| **16ME7DC PMF** | PROJECT MANAGEMENT & FINANCIAL ACCOUNTING | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME7DE ***** | ELECTIVE- 3 | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME7DE ***** | ELECTIVE- 4 | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME7IE ***** | INSTITUTIONAL ELECTIVE | --- | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME7DL NML** | NUMERICAL ANALYSIS LAB | MECH | 0 | 0 | 1 | 0 | 1 | 2 | 50 | 50 | 100 | 3 |
| **16ME7DL ICE** | I.C ENGINES LAB | MECH | 0 | 0 | 2 | 0 | 2 | 4 | 50 | 50 | 100 | 3 |
| **16ME7DC MPW** | PROJECT WORK – PHASE 1 | MECH | 0 | 0 | 4 | 0 | 4 | 0 | 50 | 50 | 100 | 3 |
| | | **Total Credits** | **15** | **0** | **8** | **2** | **25** | **23** | **Total** | | **800** | |

| | |
|---|---|
| **16ME7DE ***** | **ELECTIVE – 3 & 4** |

| | Elective 3 | | | Elective 4 | |
|---|---|---|---|---|---|
| 1. | **16ME7DEFRM** | Fracture Mechanics | 1. | **16ME7DETBD** | Tribology and Bearing Design |
| 2. | **16ME7DEARB** | Advanced Robotics | 2. | **16ME7DETED** | Tool Engineering Design |
| 3. | **16ME7DEADM** | Additive Manufacturing | 3. | **16ME7DEPDM** | Product Design and Manufacturing |
| 4. | **16ME7DEHAP** | Hydraulics & Pneumatics | 4. | **16ME7DENDT** | Non-Destructive Testing |
| 5. | **16ME7DEOPT** | Optimization | 5. | **16ME7DEETF** | Experimental Thermal and Fluid Systems |
| 6. | **16ME7DEDTS** | Design of Thermal Systems | 6. | **16ME7DERAC** | Refrigeration and Air Conditioning |
| 7. | **16ME7DECIM** | Computer Integrated Manufacturing | 7. | **16ME7DEESD** | Engineering System Design |
| 8. | **16ME7DEPSE** | Political Science In Engineering | 8. | **16ME7DEHRM** | Human Resource Management |
| 9. | **16ME7DECOG** | Computer Graphics | 9. | **16ME7DEAIN** | Artificial Intelligence |

**Semester: VIII (Admission year: 2014 onwards)**

| Code | Course Title | Teaching Department | Credits | | | | Total Credits | Contact Hours | Marks | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | | | CIE | SEE | Total | SEE Hrs |
| **16ME8DC ORE** | OPERATIONS RESEARCH | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME8DE ***** | ELECTIVE - 5 | MECH | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME8IE ***** | INSTITUTIONAL ELECTIVE | --- | 3 | 0 | 0 | 0 | 3 | 3 | 50 | 50 | 100 | 3 |
| **16ME8 _ _ ***** | HSS CORE COURSE (PO 6, 8 & 10) | MECH | 2 | 0 | 0 | 0 | 2 | 2 | 50 | 50 | 100 | 3 |
| **16ME8 _ _ ***** | SOFT SKILLS (Placement – Done during the break after 6th Sem) | --- | 2 | 0 | 0 | 0 | 2 | 0 | 50 | 50 | 100 | 3 |
| **16ME8DC XXX** | SEMINAR/INDUSTRIAL VISIT/INTERNSHIP// NSS / NCC / YOGA / SPORTS | MECH | 0 | 0 | 2 | 0 | 2 | 0 | 50 | 50 | 100 | 3 |
| **16ME8DC PRW** | PROJECT WORK – PHASE 2 | MECH | 0 | 0 | 10 | 0 | 10 | 0 | 50 | 50 | 100 | 3 |
| | | **Total Credits** | **13** | **0** | **12** | **0** | **25** | **11** | Total Marks | | **700** | |

| **16ME8DE ***** | **ELECTIVE –5** |
|---|---|

| | Code | Course Title |
|---|---|---|
| **1.** | **16ME8DEMBD** | Multi Body Dynamics |
| **2.** | **16ME8DEMTD** | Machine Tool Design |
| **3.** | **16ME8DEDOE** | Design of Experiments |
| **4.** | **16ME8DEAMC** | Advanced Material Characterization Techniques |
| **5.** | **16ME8DEPOD** | Gas Dynamics |
| **6.** | **16ME8DEAHT** | Advanced Heat Transfer |
| **7.** | **16ME8DEORB** | Organizational Behaviour |
| **8.** | **16ME8DEMIS** | Management Information Systems |
| **9.** | **16ME8DEAUE** | Automotive Engineering |

# V - Semester Syllabus

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Management & Entrepreneurship** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME5DCMAE** | **3** | **0** | **0** | **0** | **50** | **50** |

**SYLLABUS:**

**Unit – 1**

**Management:** Introduction, Meaning, Nature and functions of management, Roles of Manager, Managerial Skills, Management as a science, art or profession- Management & Administration, Development of Management thought-early management (Taylor & Henri Fayol) approaches and Modern Management (Qualitative, Contingency & Systems) approaches **5 Hours**

**Planning:** Nature & importance of planning, Forms of planning, Types of plans, Importance of Planning, Steps in planning process, Planning premises, Limitations of planning
Decision making, Types of decisions, Steps in decision making, Difficulties in decision making. **5 Hours**

**Unit – 2**

**Organising:** Meaning, Characteristics and Process of organizing, Span of Management, Principles of Organizing, Organization structure, Types of Organizations

**Staffing:** Introduction, Functions of staffing, Importance, Short term, long term manpower planning, Recruitment, Selection, Placement, Induction, Training and Mentoring **6 Hours**

**Unit – 3**

**Directing & Controlling:** Introduction, Requirements of effective direction, Motivation (Maslow, Hezberg, McGregor theory) Leadership styles (Autocratic, Democratic & Free rein)

**Communication:** Importance of Communication, Purposes of communication, Formal & Informal communication, Barriers to communication,

**Co-ordination and Control:** Techniques of co-ordination, Meaning and steps in control process, Essentials of effective control system. **7 Hours**

**Unit – 4**

**Entrepreneurship:** Introduction, Characteristics of a successful entrepreneur, Classification of entrepreneurs, Stages of Entrepreneurship, Role of entrepreneur in economic development, Problems faced by entrepreneurs **6 Hours**

**Unit – 5**

**Small Scale Industry:** Definitions of SSI, Importance of SSI, Definitions of SSI, Problems faced by SSI, Prospects of SSI in a free economy.
Institutions supporting SSIs central and state wise, Industry Associations, Different Schemes, TECKSOK, KIADB; KSSIDC; KSIMC; DIC Single Window Agency; SISI, NSIC, SIDBI, KSFC. **5 Hours**

**Setting up a small business enterprise:** business opportunities, formalities for setting up of a small business enterprise, Preparation of Business Plan, Sickness in SSI **5 Hours**

**TEXT BOOKS:**

1. **Essentials of Management** – Harold Koontz, Heinz Weihrich, Fifth Edition, Tata McGraw Hill
2**. Principles of Management** – P.C. Tripathi, P.N. Reddy, Tata McGraw Hill,
3. **Entrepreneurship Development – Small Business Enterprises** – Poornima M. Charantimath – Pearson Education – 2006

**REFERENCE BOOKS:**

1. **Management Fundamentals – Concepts, Application, Skill Development** – Robert Lusier – Thomson
2. **Essentials of Entrepreneurship and Small Business Management**-Thomas W Zimmerer and Norman M Scarborough, Doug Wilson, Fifth Edition, PHI, New Delhi.
3. **Management** – Stephen Robbins – Pearson Education / PHI – 17th Edition, 2003.

**E-learning:**

https://india.gov.in/topics/industries/micro-small-medium-enterprises
http://www.archive.india.gov.in/business/starting_business/index.php

**MOOCS:**

https://www.class-central.com/subject/management-and-leadership
https://www.class-central.com/subject/entrepreneurship

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Compare various management approaches, planning and decision strategies |
| CO 2 | Organize the staffing and structure for an organization |
| CO 3 | Make use of communication methods, leadership styles for building effective control in an organization |
| CO 4 | Develop entrepreneurial ideas |
| CO 5 | Identify the institutions supporting the Small scale industries |
| CO 6 | Plan the various steps involved in setting up a business enterprise |

**Scheme of Examination: (SEE)**

Answer five full questions selecting one from each unit.
To set one question each from Unit 2, 3 & 4 and two questions each from units 1 & 5.

| Course | | Credits : 04 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Design of Machine Elements-II** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME5DCDM2** | **3** | **1** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**
Engineering Mechanics,
Strength of Materials,
Design of Machine Elements-I

**SYLLABUS:**

**UNIT – 1**

**Curved Beams**: Expressions for stress in curved beams of standard cross section, Closed rings and links (only numericals) **6 Hours**

**Springs**: Types of springs, Terminology for compression springs, Stresses and Energy stored in Helical coil springs of circular cross section, Stress and deflection in helical coil springs of non-circular cross sections. Tension and compression springs, springs under fluctuating loads, Leaf springs: Stress and deflection in leaf springs. Equalized stresses in spring leaves (nipping) **7 Hours**

**UNIT – 2**

**Clutches & Brakes**: Design of Clutches: Single plate clutch, multi plate clutch and cone clutch. Design of Brakes: Block brakes, Band brakes (Numericals on Single block brake, Simple Band brake, Differential Band brake), Self-locking of brakes, Heat generation in Brakes. **7 Hours**

**UNIT 3**

**Spur & Helical Gears**: Spur Gears: Definitions, 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. **8 Hours**

**Bevel and Worm Gears**: Bevel Gears: Definitions, formative number of teeth, Design based on strength, dynamic and wear loads. Worm Gears: Definitions, Design based on strength, dynamic, wear loads and efficiency of worm gear drives. **8 Hours**

**UNIT 4**

**Lubrication and Bearings**: Lubrication: purpose and requirement, Lubricant types, properties and selection, Classification of Bearings, bearing characteristic number and bearing modulus, coefficient of friction, minimum oil film thickness, Heat generated, Heat dissipated, Numerical on journal bearing and thrust bearing design. **8 Hours**

**UNIT 5**

**Belts Ropes and Chains**: Flat belts: Length & cross section, Selection of V-belts, ropes and chains for different applications. **8 Hours**

**Design Data Hand Books (allowed for reference during examination also):**

1. Machine Design Databook, K. Lingaiah, 2nd Edition, McGraw Hill Education, 2002
2. Design Data Hand Book, K. Mahadevan and K. Balaveera Reddy, CBS Publication, 4th

Ed. 2013

**Text Books:**

1. **Mechanical Engineering Design**: Joseph E Shigley and Charles R. Mischke. McGraw Hill International edition, 6th Edition 2003.
2. **Design of Machine Elements**: V. B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

**Reference Books:**

1. **Machine Design**: Robert L. Norton, Pearson Education Asia, 2001
2. **Design of Machine Elements**: M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayaram and C. V. Venkatesh, Pearson Education, 2006
3. **Machine Design**: Hall, Holowenko, Laughlin (Schaum's Outline Series) Adapted by S. K. Somani, Tata McGraw Hill, New Delhi, Special Indian Edition, 2008.
4. **Machine Design**: J. B. K. Das and P. L. Srinivasa Murthy, Sapna Publications. 2009

**E-Books:**

1. **Shigley's Mechanical Engineering Design [Kindle Edition],** Richard Budynas, McGraw-Hill Higher Education; 10 edition, January 2014.

**MOOCs:**

1. http://nptel.iitg.ernet.in/
2. http://www.nptelvideos.in/2012/12/design-of-machine-elements.html

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Solve for stresses in curved beams, springs, clutches and brakes |
| CO 2 | Deduct equations for stresses in curved beams, springs and gears |
| CO 3 | Estimate the load carrying capacities of curved beams, helical and leaf springs and bearings. |
| CO 4 | Classify clutches, brakes and gears |
| CO 5 | Design gears, springs, clutches, brakes and bearings |
| CO 6 | Choose power transmission elements like belt drives, chain drives, rope drives and the bearings for different applications |

**Scheme of Examination (SEE):**

- *Students to answer five full questions selecting one from each unit.*
- *To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.*

| Course | | Credits : 06 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Computer Aided Machine Drawing** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME5DCCMD** | **2** | **0** | **2** | **2** | **50** | **50** |

**SYLLABUS:**

**UNIT – 1**

**Sections of Solids:** Sectioning, Sectional view, Representation of section plane, Hatching, Sectioning of engineering objects when the axis is inclined to one plane of projection and perpendicular to the other. Solids involving Square, Pentagonal, Hexagonal prisms, Square, Pentagonal, Hexagonal pyramids, Cylinder, Cone and Tetrahedron**.** **10 Hours**

**UNIT – 2**

**GD & T:** Terms and definitions, Common symbols & Terminology, Fundamental Rules (Drawing),Feature definition, With Size and Without Size, Material Condition (Maximum, Least, Regard of Material Condition),Limit Tolerancing, Dimension Origin, Limits of Size, Rule 1 or Envelope Principle, Go- No Go Gauges

Datum Reference Frame, Form Tolerances, Orientation Tolerances, Profile Tolerances, Position Tolerances Overview **14 Hours**

**UNIT – 3**

**Assembly Drawing:**

Part-1: Assembly of Socket and Spigot cotter joint, Protected type flanged coupling

Part-2: Machine vice, Plummer block, Tail stock, Steam stop valve, Ram's bottom safety valve, Petrol engine connecting rod **28 Hours**

**LAB: Using Computer Aided Software (2 Hours Per week)**

3D Modelling from Orthographic views: Given the 2 or 3 views of a machine component, Generation of the object in 3D environment using software.

Assembly and extraction of views of the following assemblies in 3D using software.

(a) Socket and Spigot cotter joint
(b) Protected type flanged coupling
(c) Machine vice
(d) Plummer block **26 Hours**

**CIE:**

Component-1
Test 1: Unit 1 (Manual Drafting).....15 Marks
Test 2: Unit 2 (Manual Drafting).....15 Marks
Test 3: Unit 3 (Manual Drafting).....15 Marks
****Average of best TWO tests is taken as component-1 for 15 Marks.**

**Component-2**
Self Study 10 Marks
**Component-3**
Lab Test: 15 Marks
**Component-4**
Assignment (Drawing Sheets) 10 Marks
**Total** **50 Marks**

**Text books:**

**1. Machine Drawing"** by K.R. Gopalkrishna, 20th Edition, Subhas stores, 2007.
**2. "Machine Drawing"** by N.D.Bhat & V.M.Panchal, 42nd Edition, Charotar Publishing House, 2007.
**3. Geometric Dimensioning and Tolerancing: Applications and Techniques for Use in Design: Manufacturing, and Inspection** by James D. Meadows, Dekker Mechanical Engineering – 1995

**Reference Books:**

**1. "Machine Drawing with Auto CAD".** Goutam Pohit & Goutham Ghosh, 1st Indian print Pearson Education, 2005.
**2. "Auto CAD 2006, for engineers and designers".** Sham Tickoo. Dream Tech 2005
**3. Fundamentals of Geometric Dimensioning and Tolerancing** by Alex Krulikowski 2012

SELF STUDY CAN BE CONSIDERED FROM
**Threaded Fasteners**: Thread terminology, sectional views of threads. ISO Metric (Internal & External) BSW (Internal & External) square and Acme. Sellers thread, American Standard thread. Etc.
**Fasteners**: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly), Proportions for square and hexagonal headed bolts & nuts, simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.
**Assembly** of Pin or Knuckle joint, Universal coupling, Screw Jack and Swivel Bearing

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Choose appropriate views to give information about machine parts. |
| CO 2 | Sketch Sectional views to improve clarity and reveal interior features of Machine parts. |
| CO 3 | Identify relationships of each part to the others in Assemblies |
| CO 4 | Construct Assembly drawings showing all parts in their operational positions |
| CO 5 | Create Geometric Models of Mechanical Parts and assemblies employing CAD tools. |
| CO 6 | Apply principles of GD&T to communicate Design intent unambiguously |

**Scheme of Examination (SEE):**

Unit 1 → 20 Marks
Unit 2 → 15 Marks
Unit 3 → Assembly from Part 2 only → 65 Marks
**Total → 100 Marks**

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| Name | Dynamics of Machines | L | T | P | S | CIE | SEE |
| Code | 16ME5DCDOM | 3 | 0 | 0 | 0 | 50 | 50 |

**PRE-REQUISITES:**
Intended for students who are familiar with:
- Kinematics of machines
- Engineering Mechanics

**SYLLABUS:**

**UNIT – 1**

**STATIC FORCE ANALYSIS:** Introduction, Static equilibrium, Equilibrium of two and three force members. Member with two forces and torque, Free-body diagrams, Static force analysis of simple mechanisms. Principle of virtual work. **6 Hours**

**TURNING MOMENT DIAGRAM:** Turning moment diagram and flywheels, Fluctuation of Energy. Determination of size of a flywheel. **5 Hours**

**UNIT – 2**

**FRICTION AND BELT DRIVES**: Definitions; Types of friction, laws of friction, Friction in pivot and collar bearings. Flat belt drive, ratio of belt tensions, centrifugal tension, power transmitted. Belt thickness and width calculations. **5 Hours**

**GOVERNORS**: Types of governors; force analysis of Porter and Hartnell governors. Controlling force, stability, sensitiveness, isochronism, effort and power **5 Hours**

**UNIT – 3**

**BALANCING OF ROTATING MASSES**: Static and dynamic balancing, Balancing of single rotating and many rotating masses by another mass in one plane. Effect of transferring rotating mass from one plane to another. Balancing of several rotating masses by balancing masses in different plane. **6 Hours**

**UNIT – 4**

**BALANCING OF RECIPROCATING MASSES:** Inertia effect of crank and connecting rod, single cylinder engine, balancing in multi cylinder-inline engine (primary & Secondary forces), V-type engine; Radial engine – Direct and reverse crank method. **6 Hours**

**UNIT – 5**

**GYROSCOPE**: Vectorial representation of angular motion, gyroscopic couple. Effect of gyroscopic couple on the movement of a Naval ship, plane disc, aeroplane, stability of a two wheeler and four wheeler taking a turn **6 Hours**

**TEXT BOOKS:**

1. **Theory of Machines and mechanisms**: Dr. Jagdish Lal, Metropolitan Book Co. Pvt. Ltd., New Delhi, 2nd Edition, 1999.

2. **Theory of Machines**: Rattan S.S. Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2009.

**REFERENCE BOOKS:**

1. **Theory of Machines** by Thomas Bevan, CBS Publication 1984.
2. **Kinematics & Dynamics of Machinery** by Robert L. Norton, McGraw Hill, 2009.
3. **Theory of Machines** by P. L. Ballaney, Khanna Publishers, New Delhi, 16th Edition, 1988.

**MOOCs:**

1. Dynamics* (https://www.edx.org/course/dynamics-mitx-2-03x )
2. NPTEL Course: "Dynamics of Machines"( http://nptel.ac.in/courses/112104114)

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Determine the forces in mechanisms for static equilibrium. |
| CO 2 | Design a flywheel based on energy fluctuation. |
| CO 3 | Estimate the power in bearings and belt drives and the power of engine using turning moment diagram |
| CO 4 | Analyze the effect of gyroscopic couple on rotors, ships, aero planes and automobiles and Governors for speed control. |
| CO 5 | Solve problems concerning static and dynamic balancing of systems involving rotating masses and partial balancing of reciprocating engines |
| CO 6 | Evaluate primary and secondary unbalanced forces in reciprocating engines. |

**Scheme of Examination (SEE):**

Answer Five full questions selecting one from each unit.
To set One question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2.

| Course | | Credits : 06 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| Name | Fundamentals of Heat Transfer | L | T | P | S | CIE | SEE |
| Code | 16ME5DCFHT | 3 | 0 | 1 | 2 | 50 | 50 |

**PRE-REQUISITES:**
1. Mathematics
2. Thermodynamics
3. Fluid Mechanics

**SYLLABUS:**

**UNIT -1**

**INTRODUCTION:** Modes of heat transfer-conduction, convection and radiation, Material properties of importance in heat transfer, Thermal conductivity, Specific heat capacity, Derivation of general three dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems (No derivation). **3 Hours**

**CONDUCTION:** One dimensional conduction equations for plane wall, cylinder and sphere, Thermal contact resistance, Critical thickness of insulation. **3 Hours**

**HEAT TRANSFER IN EXTENDED SURFACES**: Heat transfer through rectangular fin: Long fin, short fin with insulated tip and convective tip. Fin efficiency and effectiveness. **3 Hours**

**TRANSIENT CONDUCTION:** Lumped parameter analysis, Use of Transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere. **3 Hours**

**UNIT -2**

**CONVECTIVE HEAT TRANSFER:** Principle of heat flow in fluids, heat transfer coefficient, overall heat transfer coefficient, Velocity boundary layer, Thermal Boundary layer, drag co-efficient, Significance of Reynold number, Prandtl number, Grashof Number, Stanton Number, Nusselt number, for internal and external flow (discussion only), Momentum and Energy equations for hydrodynamic and thermal boundary layer over a flat plate, Dimensional analysis for forced and natural convection **5 Hours**

**NATURAL CONVECTION:** Empirical correlations for flow around flat vertical plate, horizontal flat surface, horizontal cylinder, sphere, enclosure. **4 Hours**

**UNIT-3**

**FORCED CONVECTION**

**INTERNAL FLOW:** Laminar flow, Turbulent flow, thermal entrance region, full developed flow, Empirical correlations for flow through pipe. **3 Hours**

**EXTERNAL FLOW:** Empirical correlations for flow over a flat plate, cylinders, flow across a cylinder and sphere. **3 Hours**

**UNIT -4**

**RADIATION HEAT TRANSFER:** Basic definitions-Thermal radiation, Emissive power, radiosity, irradation, absorptivity, reflectivity, transmissivity, black body and grey body, Basic laws: Planck's law, Wein's law, Stefan-Boltzman law, Kirchoff's law and Lambert's cosine law, Radiation heat exchange between two parallel infinite black surfaces, two parallel infinite gray surfaces and View factor algebra; Infinite long concentric cylinders,

small body in a large enclosure. **7 Hours**

**UNIT – 5**

**HEAT EXCHANGERS:** Thermal design of heat exchangers, overall heat transfer coefficient, fouling and fouling factor, Temperature profile of heat exchangers, Log Mean Temperature Difference(LMTD): parallel & counter flow, LMTD correction factor, heat transfer effectiveness-NTU methods of analysis of heat exchangers. **5 Hours**

**TEXT BOOKS:**

1. **Fundamentals of heat and mass transfer,** Frank P. Incropera and David P. Dewitt, John Wiley and Son's.
2. **Heat Transfer, Holman,** Mc Graw Hill
3. **A Textbook on Heat Transfer**, Sukhatme S P,

**REFERENCE BOOKS:**

1. **Heat transfer, a practical approach,** Yunus A- Cengel, 5th Edition, Tata Mc Graw Hill
2. **Principles of heat transfer,** Kreith Thomas Learning 2001
3. **Heat transfer-A basic approach,** Ozisik, Tata Mc Graw Hill 2002
4. **Heat transfer,** P.K. Nag, Tata Mc Graw Hill 2007.
5. **Heat Transfer,** Suchdev. R.C**,** New Age International Pub, 2010.

**E-Books/Web references:**

1. **A Text book of Heat Transfer, John H Lienhard, 4th Edition,**
2. **NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/**
3. **Heat Transfer, Chris Long & Naser Sayma, Bookboon.com**

**MOOCs:**

1. **Fluid flow, Heat and Mass Transfer- http://ocw.tudelft.nl/courses/applied-earth-sciences/fluid-flow-heat-mass-transfer/course**
2. **Heat transfer course- https://legacy.saylor.org/me204/Intro/**

**HEAT TRANSFER LABORATORY**

**PART - A**

1. Determination of Thermal Conductivity of a Metal Rod.
2. Determination of Overall Heat Transfer Coefficient of a Composite wall.
3. Determination of Effectiveness on a Metallic fin.
4. Determination of Heat Transfer Coefficient in a free Convection on a vertical/horizontal tube.
5. Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe.

**PART - B**

6. Determination of Emissivity of a Surface.
7. Determination of Stefan Boltzman Constant.
8. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers
9. Performance Test on a Vapour Compression Refrigeration.

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Identify the mode of heat transfer |
| CO 2 | Apply principles of heat transfer to thermal systems |

| | |
|---|---|
| CO 3 | Analyze conduction heat transfer phenomenon for transient processes |
| CO 4 | Determine convective heat transfer for free and forced convection. |
| CO 5 | Formulate the heat transfer process in heat exchangers for parallel and counter flow arrangement |
| CO 6 | Evaluate the parameters of radiative heat exchange process between surfaces. |

**Scheme of Examination (SEE):**

Answer Five full questions selecting one from each unit.

To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2

**Electives – Group 1**

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Theory of Elasticity** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME5DETOE** | **3** | **0** | **0** | **0** | **50** | **50** |

**SYLLABUS:**

**UNIT - 1**

**Introduction :** Stress, Stress at a Point, Equilibrium Equations, Principal Stresses, Mohr's Diagram, Maximum Shear Stress, Boundary Conditions. **6 Hours**

**UNIT - 2**

**Strain at a point:** Compatibility Equations, Principal Strains, Generalized Hooke's law, Methods of Solution of Elasticity Problems –Plane Stress & Plane Strain Problems. **8 Hours**

Uniqueness theorem**,** Principle of super position, reciprocal theorem, Saint Venant principle. **1 Hour**

**UNIT - 3**

**TWO DIMENSIONAL PROBLEMS**: Cartesian co-ordinates – Airy's stress functions – Investigation of Airy's Stress function for simple beam problems – Bending of a narrow cantilever beam of rectangular cross section under edge load. **7 Hours**

**UNIT - 4**

**GENERAL EQUATIONS IN CYLINDRICAL CO-ORDINATES:** Thick cylinder under uniform internal and / or external pressure, shrink fit. **6 Hours**

Stresses in an infinite plate with a circular hole subjected to uniaxial and biaxial loads, stress concentration, stresses in rotating discs and cylinders. **6 Hours**

**UNIT – 5**

**TORSION OF CIRCULAR, ELLIPTICAL AND TRIANGULAR BARS:** membrane analogy, torsion of thin open sections and thin tubes. **5 Hours**

**TEXT BOOKS:**

1. **Advanced Mechanics of solids**, L. S. Srinath, Tata Mc. Graw Hill, 2003
2. **Theory of Elasticity:** S. P. Timoshenko and J. N Gordier, Mc.Graw Hill International, 3rd edition, 1972

**REFERENCES BOOKS:**

1. **Theory of Elasticity:** Dr. Sadhu Singh, Khanna Publications, 1988
2. **Elasticity, Theory, Applications & Numericals:** Martin H Sadd, Elsevier. 2005
3. **Applied Elasticity,** Seetharamu & Govindaraju, Interline Publishing
4. **Applied Elasticity,** C.T. WANG Sc. D. Mc. Graw Hill Book Co.1953

**E-Books:**

**1. Theory of Elasticity** by L.D. Landau and E. M. Lifshitz
http://www.me.ust.hk/~meqpsun/Notes/Theory%20Of%20Elasticity(Landau-1959)
**2. Elasticity - theory, applications and applications** by Martin H. Sadd
http://iate.oac.uncor.edu/~manuel/libros/Mechanics/Elasticity/Elasticity%20%20Theory,%20applications,%20and%20numerics%20-%20M.Sadd.pdf

**MOOCs:**

1. Mechanical Behavior of Materials, Part 1: Linear Elastic Behavior
https://www.edx.org/course/mechanical-behavior-materials-part-1-mitx-3-032-1x
2. Mechanical Behavior of Materials, Part 2: Stress Transformations, Beams, Columns, and Cellular Solids
https://www.edx.org/course/mechanical-behavior-materials-part-2-mitx-3-032-2x

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Apply basic concepts of continuum mechanics to elasticity problems |
| CO 2 | Choose suitable solution strategies for boundary value problems |
| CO 3 | Determine stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole |
| CO 4 | Examine behavior of non-circular shafts and thin tubes under torsion. |
| CO 5 | Utilize MATLAB or equivalent software to simulate boundary value problems |
| CO 6 | Develop analytical Solutions For Problems of Limited Complexity |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.
To set one question each from Unit 1 3 & 5 and two questions each from Units 2 & 4.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| Name | Non-Traditional Machining | L | T | P | S | CIE | SEE |
| Code | 16ME5DENTM | 3 | 0 | 0 | 0 | 50 | 50 |

**SYLLABUS:**

**UNIT-1**

**INTRODUCTION-** History, need, classification, comparison between conventional and non-conventional machining process and selection.

**ULTRASONIC MACHINING (USM) -** Introduction, equipment details, cutting tool system design, mechanism of metal removal, effect of parameters, USM process characteristics, applications, advantages & disadvantages of USM. **5 Hours**

**UNIT-2**

**ABRASIVE JET MACHINING (AJM) -** Introduction, equipment details, variables in AJM, nozzle design, shape of cut, mechanism of metal removal, process characteristics, applications, advantages & disadvantages of AJM.

**ABRASIVE WATER JET MACHINING (AWJM) -**Principal, equipment, operation, mechanism of metal removal, application, advantages and limitations. **5 Hours**

**UNIT-3**

**ELECTROCHEMICAL MACHINING (ECM) -** Introduction, study of ECM machine, elements of ECM process, mechanism of metal removal, process characteristics,
Applications such as Electrochemical Grinding, Electrochemical Honing, Electrochemical deburring, advantages, limitations and applications. **6 Hours**

**CHEMICAL MACHINING (CHM)-**Introduction, elements of process, mechanism of metal removal, chemical blanking process : Preparation of work piece, preparation of masters, masking with photo resists, etching for blanking, accuracy of chemical blanking, applications of chemical blanking, chemical milling (contour machining), Process steps – masking, Etching, process characteristics of CHM, , advantages, limitations & application of CHM. **6 Hours**

**UNIT-4**

**ELECTRICAL DISCHARGE MACHINING (EDM) -**Introduction, mechanism of metal removal, dielectric fluid, spark generator, process parameter advantages, limitations & application of EDM. **6 Hours**

**PLASMA ARC MACHINING AND LASER BEAM MACHINING:** Introduction, equipment, mechanism of metal removal, process parameters, process characteristics, advantages, limitations & applications**.** Laser cutting (LC) – Laser drilling (LD) - Laser marking and engraving (LM) - Laser micromachining (LMM) - Laser engineered net shaping (LENS) - Applications - Limitations. **5 Hours**

**UNIT-5**

**ELECTRON BEAM MACHINING AND ION BEAM MACHINING:** Introduction, equipment, mechanism of metal removal, process parameters, process characteristics, advantages, limitations & applications

**SPECIAL PROCESSING TECHNOLOGY** - Rapid Prototyping - Methods - Fused Deposition

Modeling (FDM) - Laminated Object Manufacturing (LOM) - Selective laser sintering (SLA) - Solid Ground curing (SGC) - 3D printing (3DP) - Processing of integrated circuits - Micro and nano fabrication technologies. **6 Hours**

**TEXT BOOKS:**

1. **Modern machining process,** Pandey and Shan, Tata McGraw Hill 2000
2. **New Technology,** Bhattacharya 2000
3. Abdel, H. and El-Hofy, G. "**Advanced Machining Processes**", McGraw-Hill, USA, 2005.
4. Wellar, E.J. "**Non-Traditional Machining Processes**", Society of Manufacturing Engineers Publications, 2nd Edition, Michigan, 1984.
5. **Non Traditional Manufacturing Processes**, by Gary F Benedict, Taylor & Francis

**REFERENCE BOOKS:**

1. **Production Technology,** HMT Tata McGraw Hill. 2001
2. **Nontraditional manufacturing Processes, Geoffrey Boothroyd, Marcel Dekker,** 1987
3. **Advanced methods of Machining, J.A McGeough, Chapman and Hall,** 1988

**MOOC:**

1. http://nptel.ac.in/courses/112105127/

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Classify the various Non-Traditional Machining process to machine new novel materials. |
| CO 2 | Choose an appropriate Non Traditional Machining technique to machine the given material |
| CO 3 | Compare material removal rate for abrasive jet machining and abrasive water jet machining |
| CO 4 | Identify the Process parameters affecting the functioning of various Non-Traditional Machines. |
| CO 5 | List the advantages, limitations & applications of different Non-Traditional Machines. |
| CO 6 | Inspect 3 D printing, laser engraving and water jet machining to experience a few Non Traditional process. |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit. To set one question each from Unit 1, 2 & 5 and two questions each from Units 3 & 4

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Advanced Materials Technology** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME5DEAMT** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**

1. Material Science and Metallurgy

**SYLLABUS:**

**UNIT - 1**

**Modern Metallic Materials:** Dual phase steels, High strength low alloy (HSLA) steels, Transformation induced plasticity (TRIP) Steels, Maraging steel, Hadfield steel, Ni and Ti aluminides – smart materials, shape memory alloys. **6 Hours**

**UNIT - 2**

**Non Metallic Materials:** Polymeric materials – Formation of polymer structure – Production techniques of fibers, foams, structure, properties and applications of engineering polymers **6 Hours**

Advanced structural ceramics, WC, TiC, TaC, $Al_2O_3$, SiC, $Si_3N_4$, CBN and diamond. Properties processing and applications **5 Hours**

**UNIT - 3**

**High temperature alloys:** Classification of Titanium alloys, properties, microstructure and applications, heat treatment and machining of Ti alloys and Ti super alloys. **5 Hours**

**UNIT - 4**

**Surface technology:** Coatings for specific applications, coating materials and their selection, coating technologies and their merits and demerits, coating characterization, Use of LASER for coating life enhancement, hard facing. **6 Hours**

**UNIT - 5**

**Nanotechnology:** Definition, Types of nanomaterial, Nano powders and nanomaterial, methods of preparation – ball milling, atomization, chemical method, combustion method comparative studies of the advantages and disadvantages of Nano powder production technologies. **6 Hours**

Carbon nanotubes, types of nanotubes, formation of nanotubes, advantages of nanotubes over nano powders nanofabrication technologies, characterization of nanomaterial and nanostructured materials, AFM, STEM, XRD, FTIR for nano characterization. **5 Hours**

**Text Books:**

1. Materials Science & Engineering- An Introduction William D. Callister Jr. Wiley India Pvt. Ltd.
2. Engineering Metallurgy - Raymond and Higgens - ELBS/EA
3. Titanium and Titanium Alloys: Fundamentals and Applications- Editor(s): Christoph Leyens, Manfred Peters .Published Online: 28 JAN 2005
4. Nanotechnology – Basic Science and Emerging Technologies, -Mick Wilson Kamali Kannangara, Overseas Press India Private Limited, First Indian Edition 2005.

**REFERENCES:**

1. Manufacturing Engineering and Technology (7th edition) by Serope Kalpak Jain and Steven Schmid
2. Engg. Materials & their applications - R. A. Flinn & P. K. Trojan, 4th edition, Jaico Publishing House.
3. Titanium a technical guide, second addition, Mathew j Donnachie, Jr ASM International
4. Nanotechnology by Gregory Timp (ed.) Published by Springer-Verlag, New York, 1999

**E-Books / Web References**

1. Material Science, R.D. Rawlings, CRC Press, 2004
(http://link.springer.com/book/10.1007%2F978-1-4899-6826-5)
2. Material Science and Engineering, V. Raghavan, PHI, 2004.
(http://phindia.com/bookdetails/materials-science-and-engineering-raghavan-v--ISBN-978-81-203-5092-2)
3. http://textofvideo.nptel.iitm.ac.in/video.php?courseId=113105057
4. http://www.intechopen.com/books/materials-science-advanced-topics
5. Material Science, S. L Kakani, Amit Kakani, New Age International Publishers
(https://iimtstudies.files.wordpress.com/2014/03/material-sciencekakani-2004.pdf)

**MOOCs:**

https://www.coursera.org/course/nanotech

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Classify based on the applications various types, properties of modern metallic materials |
| CO 2 | Choose the different processing ,properties, applications of polymers and ceramics |
| CO 3 | Estimate machinability of Ti alloys and its Physical metallurgy. |
| CO 4 | Select various surface coating technologies, characterization based on their application in industry |
| CO 5 | Build knowledge of nanotechnology principles, characterization and formation of carbon nanotubes. |
| CO 6 | Examine materials using AFM, STEM, XRD, FTIR (nano characterization) |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 3 & 4 and two questions each from Units 2 & 5.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| Name | Incompressible Fluid Dynamics | L | T | P | S | CIE | SEE |
| Code | 16ME5DEIFD | 3 | 0 | 0 | 0 | 50 | 50 |

**PRE-REQUISITES:**
1. Basic course in Fluid Mechanics.
2. Basic calculus and ODE

**SYLLABUS:**

**Unit 1**

**Fundamentals of Fluid Mechanics:** Continuity equation, conservation of linear momentum and energy Some useful vector identities, differential and integral forms of conservation equations. Example problems. **5 Hours**

**Unit 2**

**Two-dimensional incompressible and irrotational flow:** General motion of a fluid element: rotation and deformation, introduction to vorticity and circulation, Kelvin's circulation theorem, starting vortex, concept of velocity potential and stream function, Flow singularities and their superposition, lifting and nonlifting flows, Kutta-Joukowski's theorem. Example problems. **5 Hours**

**Conformal transformations:** Analytic complex functions, complex potential and velocity functions for lifting and nonlifting flows, Blasius formula for complex load calculation on a body, Conformal maps, flow past symmetric Joukowski's airfoil. Example problems **5 Hours**

**Unit 3**

**Flow past airfoils:** Airfoil characteristics, standard airfoils and their nomenclature, Kutta condition, thin airfoil theory for symmetrical airfoils: lifting and nonlifting cases, Thin airfoil theory for cambered airfoils, numerical panel method. **5 Hours**

**Flow past finite wings:** Vorticity transport equations, vortex lines, filaments, horse-shoe vortex, Biot-Savart law, lifting line theory, Elliptic and non-elliptic wings, discussion on flow past low aspect ratio wings and delta wings. Example problems. **6 Hours**

**Unit 4**

**Viscous flow:** Viscosity and thermal conduction, Navier-Stokes equation, boundary layer, boundary layer of a flat plate, similarity in boundary layer flows, Momentum integral, flow separation. **6 Hours**

**Unit 5**

**Aerodynamic Design Considerations:**

a) High lift configurations - increasing the area and lift coefficient, flap systems, multi-element airfoils, power segmented lift.
b) Drag reduction – Variable twist, variable camber wings, laminar flow control and winglets
c) Circulation control wing d) Development of an Airframe Modification

**7 Hours**

**Text Book:**

1. Anderson J.D. Jr., (2007), Fundamentals of Aerodynamics, Tata McGraw- Hill, New

Delhi.
2. Karamcheti K., (1966), Principles of Ideal-Fluid Aerodynamics, John Wiley& Sons Inc.

**References:**

1. Bertin J.J., (2002), Aerodynamics for Engineers, 4th Ed. Prentice-Hall Inc.
2. Kuethe A. M. and Chow C.-Y., (1986), Foundations of Aerodynamics, John Wiley & Sons Inc.
3. Kundu P.K. & Cohen I.M., (2008), Fluid Mechanics, Elsevier Inc.
4. Katz J. & Plotkin A., (2001), Low- Speed Aerodynamics, Cambridge University Press.
5. Cebeci T., (1999), An Engineering Approach to the Calculation of Aerodynamic Flows, Horizons publishing Inc.

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Distinguish between the inviscid and viscous flow characteristics in the background of aerodynamics |
| CO 2 | Explain the concepts of two dimensional incompressible and irrotational flow with the help of mathematical concepts |
| CO 3 | Analyze the theoretical and practical design aspects involved in the aerodynamic systems |
| CO 4 | Apply momentum principles for viscous flows |
| CO 5 | Evaluate the low speed and high speed flow effect on aerodynamic systems |
| CO 6 | Examine the design aspects during the flow over airfoils and finite span wing |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 4 & 5 and two questions each from Units 2 & 3.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Energy Engineering** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME5DEENE** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**

1. Elementary calculus and Vector Calculus
2. Basic and Applied Thermodynamics
3. Fluid Mechanics

**SYLLABUS:**

**UNIT - 1**

**STEAM POWER PLANT:** Different Types of Fuels used for steam generation, Equipment for burning coal in lump form, strokers, different types, Oil burners, Advantages and Disadvantages of using pulverized fuel, Equipment for preparation and burning of pulverized coal, unit system and bin system. Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures.

**CHIMNEYS**: Natural, forced, induced and balanced draft, Chimney design for a given draft, Cooling towers and Ponds. Accessories for the Steam generators such as Super-heaters, De-super heater, control of super-heaters, Economizers, Air pre-heaters and re-heaters. Co-generation concept. **10 Hours**

**UNIT - 2**

**HYDRO-ELECTRIC PLANTS**: Hydrographs, flow duration and mass curves, unit hydrograph. Storage and Pondage, pumped storage plants, low, medium and high head plants, Penstock, water hammer, surge tanks, gates and valves. General layout of hydel power plants. **6 Hours**

**UNIT - 3**

**NUCLEAR POWER PLANT**: Principles of release of nuclear energy; Fusion and fission reactions. Nuclear fuels used in the reactors. Multiplication and thermal utilization factors. Elements of the nuclear reactor; moderator, control rod, fuel rods, coolants. Brief description of reactors of the following types-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor, Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor, Radiation hazards, Shieldings, Radioactive waste disposal. **10 Hours**

**UNIT - 4**

**ENERGY CONSERVATION IN THERMAL SYSTEMS**: Potential for waste heat recovery, Direct utilization of waste heat boilers, Use of heat pumps, Improving boiler efficiency, Industrial boiler inventory, Use of fluidized beds, Potential for energy conservation, Power economics, General economic problems, Load curves, Selections of plants, Specific economic energy problems, Energy rates. **7 Hours**

**UNIT – 5**

**ENERGY AND ENVIRONMENT:** Air Pollution: Classification of air pollutants, sources of emission and air quality standards, Physical and chemical characteristics, Meteorological aspects of air pollutant dispersion, Temperature lapse rate and stability, Factors influencing dispersal of air pollutant, Air pollution dispersion models, Air pollution sampling and measurement, types, Ambient air sampling, Gaseous air pollutants,

Particulate air pollutants, Analysis of air pollutants. **6 Hours**

**TEXT BOOKS:**

1. **Power Plant Engineering**, P. K. Nag Tata McGraw Hill 2nd Edn 2001.
2. **Power Plant Engineering,** Domakundawar, Dhanpath Rai sons. 2003

**REFERENCE BOOKS:**

1. **Power Plant Engineering,** R. K. Rajput, Laxmi publication, New Delhi.
2. **Principles of Energy conversion**, A. W. Culp Jr., McGraw Hill. 1996
3. **Non-conventional Energy sources**, G D Rai Khanna Publishers.
4. **Non-conventional resources**: B H Khan TMH – 2007

**EBook:**

**MOOCs**:

**Introduction to Thermodynamics: Transferring Energy from Here to There**, coursera, https://www.coursera.org/course/introthermodynamics

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Analyze for air pollution using Meteorological aspects |
| CO 2 | List different type of nuclear fuels and reactor related accessories in nuclear power plant. |
| CO 3 | Apply the laws of thermodynamics to different power plant systems to maximise the performance of power plant. |
| CO 4 | Estimate the boiler and reactor accessory parameters for general operating conditions and Factors affecting different types of pollutions |
| CO 5 | Discuss clean and sustainable solutions for the environment. |
| CO 6 | Survey waste heat recovery systems to improve boiler efficiency, |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.

To set one question each from Unit 2, 4 & 5 and two questions each from Unit 1& 3.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| Name | Statistical Quality Control | L | T | P | S | CIE | SEE |
| Code | 16ME5DESQC | 3 | 0 | 0 | 0 | 50 | 50 |

**1. Use of Statistical quality control table is permitted in the examination**
**SYLLABUS:**

**UNIT - 1**

**INTRODUCTION:** The Meaning of Quality and Quality Improvement; Brief History of Quality Methodology; Statistical Methods for Quality Control and Improvement; Total Quality Management (quality philosophy, links between quality and productivity, quality costs, legal aspects of quality implementing, quality improvement). **4 Hours**

**UNIT - 2**

**MODELING PROCESS QUALITY:** Mean, Median, Mode, Standard deviation, Calculating area, The Deming funnel experiment, Normal distribution tables, Finding the Z score, Central limit theorem. **6 Hours**

**METHODS OF STATISTICAL PROCESS CONTROL:** Chance and assignable causes, Statistical Basis of the Control Charts (basic principles, choices of control limits, significance of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on control charts, warning limits, Average Run Length-ARL)

**4 Hours**

**UNIT - 3**

**CONTROL CHARTS FOR VARIABLES**: Control Charts for X-Bar and R- Charts, Statistical basis of the charts, Development and use of X bar and R charts, Interpretation of charts. Type I and Type II errors, the probability of Type II error. Numerical Problems. **6 Hours**

**UNIT - 4**

**PROCESS CAPABILITY:** The foundation of process capability, Natural Tolerance limits, $c_p$ – process capability index, $c_{pk}$, $p_p$ – process performance index, summary of process measures. Numerical problems **4 Hours**

**UNIT 5**

**Control Charts For Attributes:** Binomial distribution, Poisson distribution (from the point of view of Quality control) Control Chart for Fraction Nonconforming, Control Chart for number Nonconforming, Control Charts for Nonconformities or Defects, Control Chart for Number of non-conformities per unit. Numerical problems **7 Hours**

**LOT-BY-LOT ACCEPTANCE SAMPLING FOR ATTRIBUTES**: The acceptance sampling problem, single sampling plan for attributes, Double, Multiple, and Sequential sampling, AOQL, LTPD, OC curves, Military Standard 105E, the Dodge-Romig sampling plans. Numerical problems **8 Hours**

**TEXT BOOKS**:

1. **Statistical Quality Control,** E.L. Grant and R.S. Leavenworth, 7th edition, McGraw- Hill publisher.
2. **Statistical Quality Control,** R C Gupta, Khanna Publishers, New Delhi, 2005

**REFERENCE BOOKS:**

1. **Statistical Process Control and Quality Improvement,** Gerald M. Smith, Pearson Prentice Hall. ISBN 0 – 13-049036-9.
2. **Statistical Quality Control for Manufacturing Managers,** W S Messina, Wiley & Sons, Inc. New York, 1987
3. **Statistical Quality Control,** Montgomery, Douglas, 5th Edition, John Wiley & Sons, Inc. 2005, Hoboken, NJ (ISBN 0-471-65631-3).
4. **Principles of Quality Control,** Jerry Banks, Wiley & Sons, Inc. New York.

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Analyze different statistical methods for statistical process control. |
| CO 2 | Assess general advantages and disadvantages for alternative process control methods |
| CO 3 | compare alternative process control methods |
| CO 4 | Identify the different quality control techniques for varying sampling methods |
| CO 5 | Formulate an adequate statistical control problem for a production or similar process. |
| CO 6 | Estimate the quality measures in general by means of modern and relevant statistical tools. |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.

To set one question each from Unit 1, 3 & 4 and two questions each from Units 2& 5.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Applied Electronics and Microprocessors** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME5DEAEμ** | **3** | **0** | **0** | **0** | **50** | **50** |

**SYLLABUS:**

**UNIT - 1**

Digital logic families and comparison – MSI logic – multiplexers, decoders, encoders, adders, subtractors, JK flip flops and counters , D to A convertors, counter type and successive approximation type A to D convertors, Numerical. **11 Hours**

**UNIT - 2**

Power control – SCR and Triac. Chopper circuits, block diagrams of DC motor and induction motor control. Numerical **6 Hours**

**UNIT - 3**

Introduction, Organization of 8085 processor interrupts and addressing modes available. 8085 programming – Instruction set, assembler directives, assembly language programming examples. **11 Hours**

**UNIT - 4**

Interfacing – Modes of data transfer, introduction to interfacing, memory mapped I/O and I/O mapped I/O, serial I/O data communication. **6 Hours**

**UNIT - 5**

Introduction to Microcontrollers – Classification, Components of a typical full featured microcontroller, the PIC16F84 microcontroller, PIC16F84 pin out and required external components. **5 Hours**

**Text Books**:

1. Gaonkar, "Microprocessor Architecture programming and application," Wiley Eastern Ltd., New Delhi.
2. Thyristors and its applications, K.K. Sugandhi and R.K. Sugandhi
3. Digital Fundamentals, Floyd.

**Reference Books:**

1 An introduction to Mechatronics, David G. Alciatore and Michale B. Histand
2. Introduction to Microprocessors by A.P Mathur, Tata McGraw Hill Pub. Co., New Delhi.
3. Digital Fundamentals by Maris and Melvino.

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Apply the basic concepts of logic families, IC's and logic / digital devices along with timing diagrams involving selection of devices / performance characteristics including numericals |
| CO 2 | Discuss the regulation of power using SCR, triac and electrical actuators, principles and control along with numericals |
| CO 3 | Analyze 8085 architecture & to perform programming and the concepts involved in a processor internals like communication , data storage / memory and |

| | |
|---|---|
| | interpretations |
| CO 4 | Select & explain the different modes of data transfer, communication and interfacing aspects |
| CO 5 | Prioritize the function / operation of microcontroller and its applications |
| CO 6 | Develop alternate approaches for logic circuits and 8085 programming |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.

To set one question each from Unit 2, 4, and 5 and two questions each from Units 1 & 3.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| Name | Biomechanics of Human Movement | L | T | P | S | CIE | SEE |
| Code | 16ME5DEBHM | 3 | 0 | 0 | 0 | 50 | 50 |

**PRE-REQUISITES:**
Engineering Mechanics

**SYLLABUS:**

**UNIT – 1**

**Introduction to Biomechanics**: - Basic terminology and concept of human musculoskeletal system, anatomy and overall function, structure and function of joints **8 Hours**

**UNIT – 2**

**Measurement of Human Movement**: Direct motion measurement systems, Imaging systems electro goniometers, accelerometers, gyroscopes, force platforms, measuring energy consumption, kinematic systems, combined kinematic/kinetic systems, calculation limb and joint angles, calculation of velocity and acceleration, anthropometry, calculation of moments from kinematic and kinetic data. **8 Hours**

**UNIT – 3**

**Work and Energy**: Introduction, efficiency, causes of inefficient movement, Calculation of internal and external work, power balance.
**Muscle Mechanics**: Introduction, Force length characteristics, force velocity characteristics, muscle modeling **8 Hours**

**UNIT – 4**

**Biomechanics of Walking**: kinematics, kinetics and energetics of human walking, muscle activity during walking. **8 Hours**

**UNIT – 5**

**Modeling and Simulation of Human Movement**: Need for models, Dynamic modeling of human movement, case studies. **7 Hours**

**Text Books:**
1. Winter D. A., Biomechanics and Motor Control of Human Movement, Wiley, 2009 Incorporated.
2. J Rose, J G Gamble, Human Walking, Lippincott Williams & Wilkins, 2006

**Reference Books**
1. Nordin, M., & Frankel, V. H. Basic biomechanics of the musculoskeletal system, Lippincott Williams & Wilkins
2. Whitle M, Gait Analysis: An Introduction, Butterworth Heienmann, 2006

**Course Outcomes**
Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Apply principles of classical mechanics to the study of human motion |
| CO 2 | Analyze human movement from experimental data |
| CO 3 | Identify the muscle actions that cause movement |
| CO 4 | Discuss the internal and external forces acting on the body during typical human activities |
| CO 5 | Elaborate the methods and limitations of different experimental and analytical |

| | |
|---|---|
| | techniques used |
| CO 6 | Model simple human movements |

**Scheme of Examination (SEE):**
Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 4 & 5 and two questions each from Unit 2 & 3.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| Name | INTERNAL COMBUSTION ENGINES | L | T | P | S | CIE | SEE |
| Code | 16ME5DEICE | 3 | 0 | 0 | 0 | 50 | 50 |

**SYLLABUS:**

**UNIT – 1**

**THERMODYNAMIC CYCLE ANALYSIS**: Deviation from ideal processes. Effect of chemical equilibrium and variable specific heats. Effect of air fuel ratio and exhaust gas dilution. Calculation of combustion temperatures. Use of combustion charts. Simple numerical problems. **5 Hours**

**UNIT – 2**

**CARBURATION AND COMBUSTION PROCESS IN S.I. ENGINES**: Mixture requirements in S.I engine. Simple Carburetor and its limitations. Knock free and knocking combustion-Theories of combustion process in S.I. engines. Effect of Knock on engine performance. Effect of operating variables on knocking. Knock rating of fuels-octane number. HUCR values. Anti knock agents – Pre-ignition - Post ignition.

**COMBUSTION IN C.I. ENGINES**: Ricardo's three stages of combustion process in C.I. engines. Delay period & factors affecting delay period. Diesel knock- Methods of controlling diesel knock. Knock rating of Diesel fuels. **12 Hours**

**UNIT – 3**

**COMBUSTION CHAMBERS**: Requirements of combustion chambers. Features of different types of combustion chambers system for S.I. engine.I-head, F-head combustion chambers. C.I. engine combustion chambers-Air swirl turbulence-M. type combustion chamber. Comparison of various types of combustion chambers. **5 Hours**

**UNIT – 4**

**FUELS**: Hydro carbons - chemical structure-influence of chemical structure on knock alternative fuels; Alcohols; vegetable oils; Biogas as Diesel engine fuels.

**FUEL INJECTION SYSTEMS**: Diesel injection systems jerk pump injectors, Nozzles of different types, Petrol injection systems for S.I. engines. Electronic fuel injection system. Cooling system- Water cooling, air cooling & liquid cooling-role of thermostats-radiator construction. **10 Hours**

**UNIT – 5**

**EMISSION REGULATION AND CONTROL SYSTEMS**: Mechanism of pollutant formation. Total emission control package thermal reactor package; catalytic converter package; control of NO X -Exhaust gas recirculation-Water injection.

**MODERN DEVELOPMENTS**: Turbo charging and super charging of I.C Engines, Stratified charge engines (Lean burned SI engine) Multi fuel engines, Rotary piston engine, Two injector engines Pilot ignition engine, all ceramic swirl chamber engines **7 Hours**

**Text Books:**

1. **A course in I.C. Engines**, M. L. Mathur and R. P. Sharma, DhanpatRai Pub, 2001.
2. **Internal Combustion Engines**, Colin R. Ferguson C. John Wiley & sons, 1986

**Reference Books**

1. I.C. Engines, Edward. F. Obert, Harper International edition, 1973.
2. Internal Combustion Engines,Ganeshan, Tata McGraw Hill, 2 nd Edition, 2003.
3. Engineering Fundamentals of the I.C. Engine, Willard W. Pulkrabek. 1998.
4. Combustion Engine Process, Lichty, Judge 2000

**Course Outcomes**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Compare ideal and real thermodynamic cycles and different types of fuels with respect to their advantages and limitations |
| CO 2 | Evaluate the engine parameters considering actual conditions |
| CO 3 | Analyze the current and future SI and CI engine designs, combustion processes, effect of operating variables on engine performance, effect of dissociation, variable specific heats, and exhaust dilution on thermodynamic cycles, chemical structure of fuels, fuel injection and cooling systems |
| CO 4 | Identify the requirements of combustion process for SI and CI engines |
| CO 5 | Discuss modern developments of engines |
| CO 6 | Survey methods to reduce knocking tendency and means to control pollution |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.

To set one question each from Unit 1, 3 & 5 and two questions each from Unit 2 & 4.

# VI Semester Syllabus

| Course | | Credits : 06 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Turbo Machines** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DCTUM** | **3** | **0** | **1** | **2** | **50** | **50** |

**PRE-REQUISITES:**

1. Fluid Mechanics
2. Thermodynamics
3. Vector Calculus

**SYLLABUS:**

**UNIT – 1**

**INTRODUCTION:**
Definition of a Turbomachine; Parts of a Turbomachine; Comparison with positive displacement machine; Classification; Application of First and Second Law to Turbomachines; Efficiencies, Dimensionless parameters (No Derivation only Discussion) and their physical significance; Specific speed, Stagnation and static properties and their relations. **3 Hours**

**THERMODYNAMIC ANALYSIS OF COMPRESSION AND EXPANSION PROCESSES:**
**Compression process –** Overall isentropic efficiency; Stage efficiency; Comparison and relation between overall efficiency and stage efficiency; Polytropic efficiency; Preheat factor.
**Expansion Process –** Overall isentropic efficiency; Stage efficiency; Comparison and relation between overall efficiency and stage efficiency, polytropic efficiency; Reheat factor. **4 Hours**

**UNIT – 2**

**GENERAL ANALYSIS AND ENERGY TRANSFER IN**
**TURBINES:** Euler Turbine equation and its alternate forms – components of energy transfer; Degree of Reaction; Velocity triangles for different values of degree of reaction; General analysis of axial and radial flow turbines – Utilization factor; Vane efficiency; Relation between utilization factor and degree of reaction; condition for maximum utilization factor – optimum blade speed ratio for different types of turbines. **4 Hours**
**PUMPS AND COMPRESSORS:** Euler Equation for power absorbing machine; General analysis of Axial flow Compressors, Radial flow compressors, Centrifugal pumps; Velocity triangles; Effect of blade discharge angle on Energy transfer, Theoretical head capacity relationship. **5 Hours**

**UNIT - 3**

**CENTRIFUGAL COMPRESSORS:** Classification; Expression for overall pressure ratio; Blade angles at impeller eye root and eye tip; Slip factor and power input factor; width of the impeller channel; Compressibility effect – need for pre-whirl vanes**;** Diffuser design: Flow in the vane-less space, determination of diffuser inlet vane angle, width and length of the diffuser passages; Surging of centrifugal compressors. **4 Hours**
**AXIAL FLOW COMPRESSORS:** Classification; Expression for Pressure ratio developed per stage – work done factor, radial equilibrium conditions. **4 Hours**

**UNIT - 4**

**CENTRIFUGAL PUMPS:** Definition of terms used in the design of centrifugal pumps like manometric head, suction head, delivery head, pressure rise, manometric efficiency,

hydraulic efficiency, volumetric efficiency, overall efficiency, multistage centrifugal pumps, minimum starting speed, slip, priming, cavitation, NPSH. **5 Hours**

**UNIT - 5**

**STEAM TURBINES:** Classification, Single stage impulse turbine; Condition for maximum blade efficiency, stage efficiency. Compounding – Need for compounding, method of compounding. Impulse Staging – Condition of maximum utilization factor for multi stage turbine with equiangular blades; effect of blades and nozzle losses. Reaction turbine; Parson's reaction turbine, condition for maximum blade efficiency, reaction staging. **5 Hours**

**HYDRAULIC TURBINES:** Classification: Pelton Turbine-velocity triangles, Design parameters, turbine efficiency, volumetric efficiency; Francis turbine–velocity triangles, runner shapes for different blade speeds, Design of Francis turbine; Function of a Draft tube, types of draft tubes; Kaplan and Propeller turbines – Velocity triangles and design parameters. **5 Hours**

**TEXT BOOKS:**

1. **An Introduction to energy conversion**, Volume III – Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers (P) Ltd.
2. **Turbines, Compressors & Fans,** S. M. Yahya, Tata-McGraw Hill Co., 4th Edition.

**REFERENCE BOOKS:**

1. **Principles of Turbo Machinery,** D. G. Shepherd, The Macmillan Company (1964)
2. **Fundamentals of Turbo machinery,** William W Peng, John Wiley & Sons, Inc. 2008.
3. **Principles of Turbomachinery**, R K Turton, Chapman & Hall, 2nd Edition (1995)
4. **Fluid Mechanics and Thermodynamics of Turbomachinery,** S L Dixon and C A Hall, Butterworth-Heinemann, 6th Edition.

**TURBOMACHINERY LABORATORY**

Performance testing of Turbomachines

1. Pelton wheel
2. Francis Turbine
3. Kaplan Turbines
4. Performance testing of Pumps
5. Multi stage centrifugal pumps
6. Performance test on an Air Blower

Performance testing of Positive Displacement Machines

7. Reciprocating pump
8. Performance test of a two stage Reciprocating Air Compressor

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Classify typical designs of turbo machines. |
| CO 2 | Compare homologous machines by using dimensional analysis. |
| CO 3 | Apply Euler's equation for turbomachinery to analyze energy transfer in turbines and compressors. |
| CO 4 | Evaluate the performance parameters of pumps, compressors, turbines on a 1-D basis with the use of velocity triangles |
| CO 5 | Make use of laboratory equipments for conducting experiments. |
| CO 6 | Estimate the data in design and development of Turbomachines. |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.

To set one question each from Unit 1, 3 & 4 and two questions each from Units 2 & 5.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Mechanical Vibrations** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DCMEV** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**
1. Engineering Mechanics
2. Engineering Physics
3. Engineering Mathematics (ODE and PDE)

**SYLLABUS:**

**UNIT – 1**

**Introduction**: Introduction to Vibrations **1 Hour**

**Undamped free vibrations**:
Single degree of freedom systems. Undamped free vibration-natural frequency of free vibration, stiffness of spring elements, effect of mass of spring. **5 Hours**

**UNIT – 2**

**Damped free vibrations**: Single degree freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement. **5 Hours**

**UNIT – 3**

**Forced Vibration**: Single degree freedom systems, steady state solution with viscous damping due to harmonic force. Solution by Complex algebra, Reciprocating and rotating unbalance, vibration isolation, transmissibility ratio -harmonic exitation and support motion. **7 Hours**

**Vibration measuring instruments & Whirling of Shafts**:
Vibrometer meter and accelerometer. Whirling of shafts with and without damping. Discussion of speeds above and below critical speeds. **5 Hours**

**UNIT – 4**

**Systems with two degrees of freedom**: Introduction, principle modes and Normal modes of vibration, co-ordinate coupling, generalized and principal co-ordinates, Free vibration in terms of initial conditions. Forced Oscillations-Harmonic excitation. Applications: a) Vehicle suspension. b) Dynamic vibration absorber. **6 Hours**

**UNIT 5**

**Numerical methods for Multi degree Freedom systems**: Introduction, Influence coefficients, Maxwell reciprocal theorem, Matrix Method, Matrix iteration-Method. Holzer and Stodola method, Introduction to Continuous systems, Vibrations of Strings. **10 Hours**

**TEXT BOOKS:**
1. **Mechanical Vibrations (English)** 8th Edition, G. K. Grover, Nem Chand and Brothers
2. **Mechanical Vibrations:** V.P. Singh, Dhanpat Rai & Company Pvt. Ltd., 3rd edition, 2006.

**REFERENCE BOOKS:**
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. **Theory of Vibration with Applications:** W.T. Thomson and Marie Dillon Dahleh, Pearson Education 5th edition, 2007.
5. **Elements of Vibrations Analysis:** Leonanrd Meirovitch, Tata McGraw Hill, Special Indian edition, 2007.

**MOOCs:**

1. Mechanical Vibrations - http://nptel.ac.in/courses/112103112/
2. Mechanical Vibration - http://ocw.mit.edu/courses/mechanical-engineering/2-003sc-engineering-dynamics-fall-2011/mechanical-vibration/

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Analyze the vibratory systems for natural frequency |
| CO 2 | Predict the mode shapes for un-damped vibratory systems. |
| CO 3 | Solve differential equations concerned to different vibratory systems |
| CO 4 | Identify vibration measuring techniques for varying parameters |
| CO 5 | Formulate mathematical equations for different types of vibrations for single and multi-degree freedom systems. |
| CO 6 | Apply the governing equations to automotive applications, shafts, shafts with disc. |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2, & 4 and two questions each from Units 3 & 5.

| Course | | Credits : 06 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Modelling and Finite Element Analysis** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DCMFE** | **3** | **0** | **1** | **2** | **50** | **50** |

**PRE-REQUISITES:**
1. Strength of Materials
2. Engineering Mathematics 1, 2 and 3

**SYLLABUS:**

**UNIT – 1**

**Fundamental concepts:** Principles of Elasticity: stresses-principal, maximum shear and von-Mises stresses, Equilibrium equations, strain displacement relationships in matrix form – Constitutive relationships for plane stress, plane strain, Axi-symmetric and 3D. Boundary conditions. **5 Hours**

Potential energy and equilibrium, Rayleigh-Ritz method and Galerkin method-applied to simple problems on axially loaded members, cantilever, simply supported beams, with point loads and distributed loads Gaussian quadrature-1pt, 2pt and 3pt formula. **5 Hours**

Introduction to FEM, basic concept, historical background, general applicability, engineering applications, general description ,comparison with other methods of analysis, commercial packages-preprocessor, solver and post processor. **1 Hour**

**UNIT – 2**

**One dimensional problems:** Introduction; Finite Element Modeling – Element Division; Numbering Scheme; Coordinate and Shape Functions; The Potential Energy Approach; Assembly of Global Stiffness Matrix and Load Vector; Treatment of Boundary Conditions; Temperature Effects; Numericals. Stiffness matrix of bar element by direct method, Properties of stiffness matrix. **7 Hours**

**UNIT – 3**

Local and Global co-ordinate systems, Trusses – assumptions, formulation of Truss element, Hermite functions, formulation of beam. Numericals on Trusses and beams. **6 Hours**

**UNIT – 4**

Formulation of triangular and quadrilateral elements. Introduction to axis symmetric–triangular elements. **7 Hours**

Convergence criteria-requirements of convergence of a displacement model, Displacement models and shape functions for i. tetrahedral and hexahedral elements (Pascal pyramid) and ii. Higher order elements in bar, triangular, quadrilateral elements (no formulations).Lagrangian and serendipity elements. Iso parametric, sub parametric and super parametric elements. **2 Hours**

**UNIT – 5**

**HEAT TRANSFER PROBLEMS:** Steady state heat transfer, 1D heat conduction governing equation, boundary conditions, One dimensional element, Galerkin approach for heat conduction, heat flux boundary condition, 1D heat transfer in thin fins. Numericals. **6 Hours**

**TEXT BOOKS:**

**1. Introduction to Finite Elements in Engineering**", T. R. Chandrupatla and A. D. Belegundu, 2nd Edition, Prentice Hall, India, 2003.
**2. The Finite Element Method in Engineering**, S.S. Rao, 4th Edition, Elsevier, 2006.

**REFERENCE BOOKS:**

**1. Finite Element Procedures**. Bathe, K. J., Cambridge, 2007. ISBN: 9780979004902.
**2. Concepts and Applications of Finite Element Analysis** by Robert D. Cook, David S. Malkus and Michael E. Plesha. John Wiley & Sons.2003
**3. Finite Element Method,** J.N.Reddy, McGraw –Hill International Edition.
**4. Finite Element Methods,** by Daryl. L. Logon, Thomson Learning 3rd edition, 2001.
**5. Finite Element Analysis,** C.S.Krishnamurthy,–Tata McGraw Hill Publishing Co. Ltd, New Delhi, 1995.
**6. Text book of Finite Element analysis,** P.Seshu–Prentice Hall of India.

**E-Books**

1. INTRODUCTION TO THE FINITE ELEMENT METHOD by Evgeny Barkanov http://icas.bf.rtu.lv/doc/Book.pdf
2. Finite Element Procedures for Solids and Structures Linear Analysis by Klaus-JOrgen Bathe http://www.adina.com/MITRES2_002S10_linear.pdf

**MOOCs**

1. Finite Element Method (FEM) Analysis and Applications - https://www.edx.org/course/finite-element-method-fem-analysis-tsinghuax-70120073x
2. A Hands-on Introduction to Engineering Simulations https://www.edx.org/course/hands-introduction-engineering-cornellx-engr2000x
3. http://nptel.ac.in/courses/112104115/
4. https://www.coursetalk.com/providers/mit/courses/finite-element-analysis-of-solids-and-fluids-i
5. https://online-learning.tudelft.nl/courses/linear-modeling-fem/

**MODELLING AND FINITE ELEMENT ANALYSIS Lab**

No. of Practical Hrs/ Week: 02

Study of a FEA package and modeling stress analysis of
a) Trusses
b) Bars of constant cross section area, tapered cross section area and stepped bar
c) Beams -Simply supported, cantilever, beams with UDL, and beams with varying load etc.

d) Stress analysis of a rectangular plate with a circular hole, axisymmetric problems
e) Dynamic Analysis
   1) Fixed -fixed beam for natural frequency determination
   2) Bar subjected to forcing function
   3) Fixed -fixed beam subjected to forcing function

SELF-STUDY

a) Thermal Analysis -2D problem with conduction and convection boundary conditions
b) Fluid flow Analysis -Potential distribution in the 2 -D bodies

REFERENCE BOOKS:

1. ANSYS Workbench Tutorial Release 14, Structural and Thermal Analysis Using Ansys Mechanical APDL Release 14 Environment, Kent Lawrence, Schroff Development Corporation, www.SDCpublications.com
2. Practical Finite Element Analysis, Nitin S. Gokhale, Sanjay S. Despande, Dr. Anand N. Thite, Finite To Infinite, ISBN 978-81-906195-0-9

Scheme for Evaluation:
One Question from Part A - 10Marks

| | |
|---|---|
| One Question from Part B - | 10Marks |
| Viva-Voce - | 05 Marks |
| Total | 25 Marks |

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Apply basics of Theory of Elasticity to continuum problems. |
| CO 2 | Formulate finite elements like bar, truss and beam elements for linear static structural analysis. |
| CO 3 | Develop models for 2D and axisymmetric finite elements and 1D heat transfer |
| CO 4 | Solve problems of limited complexity in structural and heat transfer domain |
| CO 5 | Utilize finite element software to simulate practical problems. |
| CO 6 | Identify the degree of freedom of elements to be modeled and boundary conditions to be incorporated. |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.

To set one question each from Unit 2, 3 & 5 and Two questions each from Units 1 & 4.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Metal Forming** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DCMTF** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**
Manufacturing Technology

**SYLLABUS:**

**UNIT – 1**

**INTRODUCTION AND CONCEPTS:** Classification of metal working processes, Hot, Cold and Warm working, characteristics of wrought products, advantages and limitations of metal working processes
**EFFECTS OF PARAMETERS:** Temperature, strain rate, friction and lubrication, hydrostatic pressure in metalworking, Deformation zone geometry, workability of materials, Metallurgical structure, Residual stresses in forming. **6 Hours**

**UNIT – 2**

**FORGING:** Classification of forging processes. Forging machines & equipment. Expressions for forging pressures & load for plate in open die forging, concepts of friction hill and factors affecting it. Die-design parameters. Material flow lines in forging. Forging defects, Residual stresses in forging. Simple problems. **6 Hours**

**UNIT – 3**

**ROLLING:** Classification of Rolling processes. Types of rolling mills, expression for Rolling load. Roll separating force. Frictional losses in bearing, power required in rolling, Effects of front & back tensions, friction, friction hill. Maximum possible reduction. Defects in rolled products. Rolling variables, simple problems. **6 Hours**

**UNIT – 4**

**DRAWING:** Drawing equipment & dies, Redundant work and its estimation, optimal cone angle & dead zone formation, drawing variables, Tube drawing, drawing defects. Simple problems. **5 Hours**

**EXTRUSION:** Types of extrusion processes, extrusion equipment & dies, deformation, lubrication & defects in extrusion. Extrusion of seamless tubes. Extrusion variables. Simple problems. **6 Hours**

**UNIT – 5**

**SHEET & METAL FORMING:** Forming methods, dies & punches, Types of presses & their working. Progressive die, compound die, combination die. Rubber forming. Different sheet metal work like punching, piercing, blanking, bending. Deep drawing, defects in drawn products, stretch forming.
**NON TRADITIONAL FORMING METHODS:** Principles, advantages and applications, explosive forming, electro hydraulic forming, Electromagnetic forming, Laser forming.
**10 Hours**

**TEXT BOOKS:**
1. **Mechanical metallurgy (SI units),** G.E. Dieter, McGraw Hill pub.2001
2. **Manufacturing Process-III,** Dr. K. Radhakrishna, Sapna Book House, Aug 2009.

**REFERENCE BOOKS:**
1. **Materials and Processes in Manufacturing** E. paul, Degramo, J.T. Black, Ronald, A.K. Prentice -hall of India 2002

2. **Principles of Industrial metal working process** - G.W. Rowe, CBSpub. 2002
3. **Manufacturing Science,** Amitabha Ghosh & A.K. Malik - East –Westpress 2001
4. **Theory of plasticity,** Dr. Sadhu Singh, Khanna Publishers.

**WEB REFERENCES:**

- http://nptel.ac.in/courses/112106153/

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Identify the various metal working processes, based on process parameters. |
| CO 2 | Discover the various process capabilities to establish the relation between them. |
| CO 3 | Solve relevant real world problems concerning Rolling , drawing and extrusion of metals. |
| CO 4 | Formulate mathematical equations for Rolling , drawing and extrusion of metals |
| CO 5 | Choose the appropriate die for the various functions of sheet metal working process |
| CO 6 | Categorize the different non-traditional forming processes. |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2, 3 & two questions each from Units 4 & 5.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Control Engineering** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DCCOE** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:** Ordinary Differential Equations, Linear Algebra

**SYLLABUS:**

**UNIT - 1**

**INTRODUCTION TO CONTROL SYSTEMS & SYSTEM MODELLING:** Introduction, Basic Terminologies, Advantages of Control Systems, Open loop & Closed loop control systems, Real time applications, Analysis and design objectives, Properties of Feedback.
Transfer Functions, models of mechanical systems (translational and rotational), Electrical Systems, Models of DC Motors, Block representation of control system elements, Modeling of mechanical & electrical systems in State Space. **9 Hours**

**UNIT - 2**

**TIME RESPONSE ANALYSIS OF CONTROL SYSTEMS:** Types of standard test signals (inputs), poles and zeros. Analysis of first & second order system response to step input, pole-placement. Higher order system response, system response with zeros. Concept of stability: Rout-Hurwitz Criterion. Steady state errors, system type, static error constant. **10 Hours**

**UNIT - 3**

**ANALYSIS AND DESIGN USING ROOT LOCUS:** Definition of root loci, general rules for constructing root loci, Analysis using root locus plots, Design of PI, PD and PID controllers using root locus **8 Hours**

**UNIT - 4**

**FREQUENCY RESPONSE ANALYSIS:** Nyquist criterion, Sketching Nyquist Diagram, Stability, Gain Margin & Phase Margin via Nyquist plots. Sketching of Polar Plots. **6 Hours**

**UNIT - 5**

**BODE PLOTS:** Introduction, Asymptotic Approximations: Bode Magnitude and Phase angle plots. Stability, Gain Margin & Phase Margin via Bode plot **6 Hours**

**Text Books**

1. **Control Systems Engineering**, 5th Edition, Norman S Nise, Wiley India - 2009

**Reference Books:**

1. **Modern Control Engineering,** Katsuhiko Ogata, Pearson Education, 2004.
2. **Automatic Control Systems,** B.C.Kuo, F.Golnaraghi, John Wiley & Sons, 2003.
3. **Modern Control Systems,** Richard C Dorf & Robert H Bishop, Prentice Hall, 2008

**E-Books:**

1. **Feedback Systems: An Introduction for Scientists & Engineers**, Karl J Astrom & Richard M Murray, Version v2.10b, Princeton University Press - http://www.cds.caltech.edu/~murray/books/AM05/pdf/am08-complete_22Feb09.pdf

**MOOCs:**

1. Dynamics and Control – **edX**: https://www.edx.org/course/dynamics-control-upvalenciax-dc201x-0

**Course Outcomes**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Identify the components of control systems given real life situation |
| CO 2 | Estimate the response characteristics and parameters related to stability of systems. |
| CO 3 | Develop transfer function models and state-space models of single input single output, linear time invariant systems |
| CO 4 | Analyse the time response of first and second order systems |
| CO 5 | Evaluate the stability of systems using various methods |
| CO 6 | Design PID controllers |

**Scheme of Examination (SEE):**

- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 3, 4 & 5 and two questions each from Units 1 & 2.

| Course | | Credits : 01 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **DESIGN LAB** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DLDES** | **0** | **0** | **1** | **0** | **50** | **50** |

**SYLLABUS:**

**PART - A**

1. Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional)
2. Determination of Frequencies and mode shapes of cantilever beam
3. Determination of Fringe constant of Photoelastic material using.
   a) Circular disc subjected to diametral compression.
   b) Pure bending specimen (four point bending )
4. Determination of stress concentration using Photoelasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook.

**PART - B**

5. Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proel /Hartnel Governor.
6. Determination of Pressure distribution in Journal bearing.
7. Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes.
8. Determination of stresses in Curved beam using strain gauge.
9. Experiments on Gyroscope.

**Course Outcomes**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Estimate the natural frequency for longitudinal, torsional and transverse systems. |
| CO 2 | Make use of Photo elasticity principles for stress analysis. |
| CO 3 | Determine Principal stresses and strains in members subjected to combined loading using Strain Rosettes and compare it with theoretical values |
| CO 4 | Examine the balancing of rotating masses |
| CO 5 | Experiment with different Governors and calculate equilibrium speed, sensitiveness, power and effort |
| CO 6 | Test for gyroscopic behavior under free and forced precession |

| **Scheme of Evaluation for SEE** | |
|---|---|
| One question from Part A | 20 Marks (05 Write-up +15) |
| One question from Part B | 20 Marks (05 Write-up +15) |
| Viva-voce | 10 marks |
| **Total** | **50 marks** |

**Electives – Group 2**

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Theory of Plasticity** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DETOP** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**

1. Engineering Mechanics
2. Strength of Materials
3. Theory of Elasticity

**SYLLABUS:**

**UNIT - 1**

**FUNDAMENTAL OF ELASTICITY:** Concept of stress, spherical and deviator stress tensors, octahedral stresses. Invariants, representative stress. Strain tensor, spherical and deviator strain, octahedral strain and representative strain, cubical dilation, true stress and strain, Generalized Hooke's law, elastic strain energy problems. **7 Hours**

**UNIT - 2**

**YIELD CRITERIA:** Introduction, yield or plasticity conditions, Von Mises and Tresca criteria, Geometrical representation, yield surface, yield locus (two dimensional stress space), experimental evidence for yield criteria, energy required to change the shape with basic principle, problems. **6 Hours**

**UNIT - 3**

**BENDING OF BEAMS:** Analysis for stresses, Non linear stress strain curve, Shear stress distribution, residual stresses in plastic bending, problems. **4 Hours**

**TORSION OF BARS:** Introduction, plastic torsion of a circular bar, elastic perfectly plastic material, elastic work hardening of material, residual stresses and problems. **4 Hours**

**UNIT - 4**

**STRESS STRAIN RELATIONS:** Introduction, types of materials, empirical equations, theories of plastic flow, experimental verification of St.Venant's theory of plastic flow, the concept of plastic potential. **6 Hours**

**UNIT - 5**

**PLASTIC DEFORMATION OF METALS:** Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth, flow figures or luder's cubes. **4 Hours**

**COMPUTATIONAL PLASTICITY**: 1-D Mathematical Model: Yield Criterion. Flow Rule. Loading/Unloading conditions. Isotropic and Kinematic, Hardening Models. 1-D Elasto-Plastic Boundary Value Problem. Computational Aspects of 1-D Elasto-Plasticity: Integration Algorithms for 1-D Elasto Plasticity. **8 Hours**

**Text Books**

1. Theory of Plasticity, Sadhu Singh, Khanna Publishers (2003)

2. Engineering Plasticity: Theory and Applications to metal forming, R.A.C. Slater, Macmillam, London, 1977.

**Reference Books:**

1. Basic Engineering Plasticity, DWA Rees, 1st Edition Elsevier.
2. Computational Methods for Plasticity: Theory and Applications, EA de Souza Neto, D Peric, DRJ Owen, John Wiley & Sons Ltd 2008 ISBN: 9780470694527.

**E-Books:**

1. http://www.vgu.edu.vn/fileadmin/pictures/studies/master/compeng/study_subjects/modules/tp/plastice.pdf
2. http://micro.stanford.edu/~caiwei/me342/
3. http://plas.yolasite.com/notes.php

**MOOCs:**

1. Mechanical Behavior of Materials, Part 3: Time Dependent Behavior and Failure https://www.edx.org/course

**Course Outcomes**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Analyze stresses and strains that exist within a body subjected to general type of loading |
| CO 2 | Predict the failure of components under multi axial loading based on yielding criteria. |
| CO 3 | Solve analytically the elastic-plastic problems of bending and torsion loads |
| CO 4 | Examine the theories of plastic flow, stress-strain relationships in plastic flow and the mechanism of plastic deformation |
| CO 5 | Formulate 1-D elastic-plastic boundary value problems with basic knowledge of computational aspects. |
| CO 6 | Utilize finite element simulation tools to solve plasticity problems with limited complexities (using Alternate Assessment Tool-AAT). |

**Scheme of Examination (SEE):**

- Students to answer five full questions selecting one from each unit.
- To set ONE question each from Units 1, 2 & 4 and TWO questions each from Units 3 & 5.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Fundamentals of Robotics** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DEROB** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**
Kinematics of Machines, Matrix Algebra

**SYLLABUS:**

**UNIT - 1**

**Introduction:** History of robotics, Applications, anatomy and classification **2 Hours**
**Spatial descriptions and Transformations:** Description of position and orientation: position vector, Rotation matrix; Mapping: translation and rotation, homogeneous transform; transformation arithmetic, transform equations, other forms of representation of orientation: Euler angles, 2 –vector representation, angle – axis representation, Euler parameters **6 Hours**
**Forward Kinematics:** Introduction, Link description, link connection description, Denavit-Hartenberg parameters, Derivation of link transformations, concatenating link transformations, actuator space, joint space and Cartesian space **4 Hours**

**UNIT 2**

**Inverse Kinematics**: Introduction, Solvability: existence of solution, multiple solutions and method of solution; algebraic vs. geometric approach, algebraic solution by reduction to polynomial, workspace, Repeatability and accuracy **4 Hours**
**Instantaneous Kinematics:** Jacobians, changing a Jacobian's frame of reference, resolved rate motion control, singularities **4 Hours**

**UNIT 3**

**Trajectory Generation:** Introduction, general considerations in path description and generation, Joint space schemes: cubic polynomial, cubic polynomial for a path with via points, linear function with parabolic blends, linear function with parabolic blends for a path with via points, Cartesian space schemes: Cartesian straight line motion, geometric problems with Cartesian paths, path generation at run time **6 Hours**

**UNIT 4**

**Linear Control:** Feedback control, second order linear systems, PD control, control law portioning, trajectory following control, disturbance rejection and steady state error, PID control, continuous vs. discrete time control, modeling and control of a single joint, architecture of PUMA 560 robot controller **7 Hours**

**UNIT 5**

**PCU and Actuators**: Power conversion unit, Types of actuators, Characteristics of actuating systems, Overview of hydraulic and pneumatic actuators, Electric actuators: PMDC servo motor, Brushless DC motor, stepper motor, modern actuators. **3 Hours**
**Sensors**: Introduction, Sensor characteristics, contact and noncontact type sensors **3 Hours**

**Text Book:**

1. Introduction to robotics: mechanics and control, Craig J J, 3/E,Pearson Education India,2008

**Reference Books:**

1. Robotics: Fundamental concepts & analysis, Ghosal A, Oxford University Press, 2006
2. Introduction to robotics: Analysis, systems, applications, Niku S B, Pearson Education, 2008

3. Robot Modeling and Control, M W Spong, S Hutchinson, M Vidyasagar, Wiley, 2005

**E-Books/Web References:**

Harry Asada, and John Leonard. *2.12 Introduction to Robotics, Fall 2005*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 8 Feb, 2016). License: Creative Commons BY-NC-SA

**MOOCs**

1. https://www.edx.org/course/robot-mechanics-control-part-i-snux-snu446-345-1x
2. https://www.edx.org/course/robot-mechanics-control-part-ii-snux-snu446-345-2x

**Course Outcomes**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Develop representation of robots in workspace. |
| CO 2 | Solve for kinematics of robot manipulators |
| CO 3 | Plan trajectory for robot motion |
| CO 4 | Select actuators, sensors and controllers for robotic applications |
| CO 5 | Design simple robots |
| CO 6 | Build simple robots |

**Scheme of Examination (SEE):**

- Students to answer five full questions selecting one from each unit.
- To set one question each from Unit 3, 4 & 5 and two questions each from Units 1 & 2.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Composite Material Technology** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DECMT** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**
Strength of Materials, Theory of Elasticity

**SYLLABUS**

**UNIT – 1**

**INTRODUCTION TO COMPOSITE MATERIALS:** Definition, classification and characteristics of composite Materials – fibrous composites, laminated composites, particulate composites. **Applications,** future potential of composites. **5 Hours**

**FIBER REINFORCED PLASTIC PROCESSING:** Lay up and curing, fabricating process, open and closed mould process, hand lay up techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermoforming, injection molding, blow molding. **6 Hours**

**UNIT – 2**

**Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli by Rule of mixture, Numerical problems.

**Macro Mechanics of a Lamina:** Hooke's law for different types of materials, Number of elastic constants, Two – dimensional relationship of compliance and stiffness matrix. **6 Hours**

**UNIT – 3**

**Macro Mechanics of a Lamina** Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **6 Hours**

**Biaxial Strength Theories:** Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai, Wu tensor theory. **4 Hours**

**UNIT – 4**

**Macro Mechanical Analysis of Laminate:** Introduction, code, Kirchoff hypothesis, CLT, A, B, and D matrices (Detailed derivation), Special cases of laminates. **6 Hours**

**UNIT – 5**

**METAL MATRIX COMPOSITES:** Reinforcement materials, types, characteristics and selection base metals selection. Need for production MMC's and its application.

**FABRICATION PROCESS FOR MMC'S:** Powder metallurgy technique, liquid metallurgy technique, diffusion bonding, squeeze technique and secondary processing. **6 Hours**

**TEXT BOOKS:**

1. **Mechanics of Composite Materials**, Robert M Jones, 2nd Edition, CRC Press, 1998.
2. **Fiber Reinforced Composites, Materials, Manufacturing, and Design,** P. K. Mallick, 3rd Edition, CRC Press, 2007.

**REFERENCE BOOKS:**

1. **Mechanics of composite materials**, Autar K. Kaw, 2nd Edition, 2005, CRC Press New

York.
2. **Composite Science and Engineering**, K. K. Chawla, 3rd Edition, Springer Verlag 2012.
3. **Composite materials hand book,** Mel M Schwartz, 2nd Edition, McGraw Hill Book Company, 1991
4. **Principles of composite Material mechanics,** Ronald F. Gibron. 3rd Edition, McGraw Hill international, 2011.
5. **Mechanics of Composite Materials and Structures**, Madhujit Mukhopadhya, University Press 2005.

**E-Books:**
1. http://www.ae.iitkgp.ernet.in/ebooks/

**Moocs:**
1. http://nptel.ac.in/downloads/101104010/

**COURSE OUTCOMES:**
Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Classify different composite materials based on the composition and structure of the composite material |
| CO 2 | Choose from different manufacturing techniques for making of composites based on type of application |
| CO 3 | Evaluate composite elastic properties based on micro-mechanical behaviour |
| CO 4 | Analyze the composites for their mechanical properties based on macro-mechanical behaviour |
| CO 5 | Examine the composite for their failure mechanisms |
| CO 6 | Formulate A, B and D matrices of Composite laminates based on Kirchoff's hypothesis and propose different laminate types |
| CO 7 | List different metal matrix reinforcements and base materials along with their applications |
| CO 8 | Decide the manufacturing technique in the making of metal matrix composites |

**Scheme of Examination (SEE):**
- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 2, 4 & 5 and two questions each from Units 1 & 3.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Surface Engineering** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DESUE** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**

- Engineering chemistry, Physics, Material science & Strength of materials

**SYLLABUS**

**Unit – 1**

**Fundamentals of surface engineering:** Surface engineering: classification, definition, scope and general principles, role and estimate of surface roughness. Surface engineering techniques: Cleaning, pickling, etching, grinding, polishing, buffing / puffing (principles only). **6 Hours**

**Unit – 2**

**Surface engineering by material addition**: Surface engineering by material addition: From liquid bath - hot dipping (principle and its application with examples), Electro deposition/ plating: theory and its scope of application.
**Surface modification of ferrous and non ferrous components**: Aluminizing, anodizing, calorizing, diffusional coatings (principle and scope of application).
**Surface modification using liquid/molten bath:** Cyaniding, liquid carburizing (principle, scope of application & diffusion from liquid state).
**Surface modification using gaseous medium:** Nitriding, carbo-nitriding (principle, scope of application). **10 Hours**

**Unit 03**

**Surface coating techniques**:
**Thin film coatings:** PVD: Evaporation, sputtering (DC, RF, and Magentron), CVD and PECVD, Plasma and ion beam deposition.
**Thick film coatings:** Plasma spray coating, HVOF & cold spray (principle, process parameters and scope of application).
**Functional and Nano-structured coatings:** applications in photovoltaics, bio- and chemical sensors, Silicon wafer deposition (Principle and its applications). **10 Hours**

**Unit – 4**

**Coating characterization**: Measurement of coatings thickness porosity & adhesion of surface coatings, measurement of residual stress & stability, surface microscopy & topography by scanning probe microscopy, spectroscopic analysis of modified surfaces, characterization of surface microstructure and properties (name of the techniques and brief operating principle). **7 Hours**

**Unit – 5**

**Surface engineering by energy beams**: General classification, scope and principles, types and intensity/energy deposition profile.
Surface engineering by energy beams: Laser assisted microstructural modification – surface melting, hardening, shocking, surface cladding and surface alloying of steel, non-ferrous metals and alloys. **6 Hours**

**Text Books**

- Surface Engineering for Corrosion and Wear Resistance. J. R. Davis.
- Deposition technologies for films and coatings: developments and applications by R. F. Bunshah, Noyes Publications; First Edition (June 1982), ISBN: 978-0815509066
- K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.

- M. Ohring, The Materials Science of Thin Films, Academic Press Inc., 2005
- Surface Finishing Systems. metal and non-metal finishing handbook-guide, George J. Rudzki - - Metals Park : ASM, 1983

**Reference Books**

- Surface Preparation and Finishes for Metal, James A. Murphy- McGraw-Hill, New York 1971
- Surface treatment and finishing of Aluminium and its alloy,Volume-2, P. G. Sheasby and R. Pinner - - ASM, Metals Park, 1987 - 5th ed.,
- Steel and its Heat Treatment Bofors Handbook, K. E. Thelning - London: Butterworths, 1975.
- Surface Engineering Hand Book, Keith Austin, - London : Kogan Page, 1998


**MOOC's/ WEB REFERENCES:**

- http://nptel.ac.in/courses/112105053/

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Identify the various surface engineering techniques based on relevance applications. |
| CO 2 | Categorize various surface addition methods based on mechanical & chemical properties and its applications. |
| CO 3 | Select appropriate coating technique for thin films based on relevant applications. |
| CO 4 | Choose appropriate coating technique for thick films based on relevance applications. |
| CO 5 | Evaluate material properties using various coating characterization techniques. |
| CO 6 | Analyze different energy beam methods of surface modification |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 4, 5& two questions each from Units 2 &3.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Computational Fluid Dynamics** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DECFD** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**
Fluid Dynamics, Vector Calculus, Calculus, Linear Algebra.

**SYLLABUS:**

**UNIT - 1**

**Introduction to CFD and Governing Equations**
Need of CFD as tool, role in R&D, continuum, material or substantial derivative or total derivative, gradient, divergence and curl operators, Linearity, Principle of Superposition. **2 Hours**
Derivation of Navier-Stokes equations in control volume (integral form) and partial differential form, Euler equations (governing inviscid equations). **3 Hours**
Mathematical classification of PDE (Hyperbolic, Parabolic, Elliptic). Method of characteristics**,** Introduction to Riemann Problem and Solution Techniques **4 Hours**

**Unit – 2**

**One-dimensional Euler's equation**
Conservative, Non conservative form and primitive variable forms of Governing equations. Flux Jacobian, Is there a systematic way to diagonalise '**A**'. Eigenvalues and Eigenvectors of Flux Jacobian. Decoupling of Governing equations, introduction of characteristic variables. Relation between the two non-conservative forms. Conditions for genuinely nonlinear characteristics of the flux Jacobian. **5 Hours**
**Introduction to Turbulence Modeling:** Derivation of RANS equations and k-epsilon model. **3 Hours**

**Unit – 3**

**Representation of Functions on Computer**
Need for representation of functions, Box Function, Hat Function, Representation of sinx using hat functions: Aliasing, high frequency, low frequency. Representation error as a global error. Derivatives of hat functions, Haar functions, Machine Epsilon. Using Taylor series for representation of Derivatives. **6 Hours**

**Unit – 4**

**Numerical methods applied to governing equations**
**Finite difference method** – Applied to Linear Convection equation, Laplace Equations, Convection Diffusion equations, Burgers equations, modified equations • Explicit methods and Implicit methods – as applied to applied to linear convection equation, Laplace equations, convection-diffusion equation◦ FTCS,FTFS,FTBS,CTCS ◦ Jacobi Method, Gauss-Siedel, Successive Over Relaxation Method, TDMA.• VonNaumann stability (linear stability) analysis. Upwind Method in Finite Difference method. **9 Hours**

**Unit – 5**

**Finite volume method**
Finite volume method. Finding the flux at interface.
**Central schemes** - Lax-Friedrichs Method, Lax-Wendroff Method, Two-Step Lax-Wendroff Method and MacCormack Method
**Upwind Method in Finite Volume methods** - Flux Splitting Method Steger and Warming, vanLeer, Roe's Method and finding Roe's Averages. **7 Hours**

**Text Books**

1. Computational Fluid Dynamics, T.j.chung, , Cambridge University Press
2. Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics – Vol 1 & Vol 2, Charles Hirsch, Butterworth-Heinemann, 2007
3. Computational Fluid Dynamics, Malalasekhara,

**Reference Books**:

1. Pletcher, r. H., Tannehill, j. C., Anderson, d., Computational fluid mechanics and heat transfer, 3rd ed., Crc press, 2011, ISBN 9781591690375.
2. Moin, p., Fundamentals of engineering numerical analysis, 2nd ed., Cambridge university press, 2010, ISBN 9780521805261 (e- book available).
3. Ferziger, j. H., Numerical methods for engineering application, 2nd ed., Wiley, 1998.
4. Ferziger, j. H., Peric, m., Computational methods for fluid dynamics, 3rd ed., Springer, 2002.
5. Leveque, r., Numerical methods for conservation laws, lectures in mathematics, eth Zurich, birkhauser,199
6. Riemann Solvers and Numerical methods for Fluid Dynamics – A
7. Practical Introduction- Eleuterio F Toro, Springer Publications.

**MOOCs:**

(1) Introduction to CFD by Prof M. Ramakrishna, Aerospace Engineering, IIT Madras.
(2) Computational fluid dynamics by Prof Suman Chakraborty, Mechanical Engineering, IIT Kharagpur

**E-Books:**

1) Hirsch, c., Numerical computation of internal and external flows, 2nd ed., Butterworth-Heinemann, 2007, ISBN 9780750665940 (e-book available).

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Understand mathematical characteristics of partial differential equations. |
| CO 2 | Learn how to classify and computationally solve Euler and Navier-Stokes equations. |
| CO 3 | Apply concepts like accuracy, stability, consistency of numerical methods for the governing equations. |
| CO 4 | Identify and implement numerical techniques for space and time integration of partial differential equations. |
| CO 5 | Conduct numerical experiments and carry out data analysis. |
| CO 6 | Acquire basic skills on programming of numerical methods used to solve the Governing equations. |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.
To set one question each from Unit 1, 2 & 3 and two questions each from Units 4 & 5.

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Renewable Energy and Sustainability** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DERES** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**
1. THERMODYNAMICS
2. FLUID MECHANICS
3. HEAT AND MASS TRANSFER

**SYLLABUS:**

**UNIT – 1**

**Introduction**: Sun as source of energy, sustainability, availability of Solar Energy. Solar radiation geometry: Sun earth angles- latitude, declination, hour angle, zenith, solar altitude angle, surface azimuth angle, solar azimuth angle, Local apparent time, solar time, apparent motion of sun, day length, numerical examples. Nature of Solar Radiation: global, beam and diffuse Radiation, Hourly, Daily and Seasonal variation of solar Radiation, Estimation of solar Radiation. **6 Hours**

**UNIT – 2**

**Measurement of Solar Radiation:** Pyronometer, Pyrheliometer, Sunshine recorder - schematic diagram and working principles of the devices.
**Solar thermal systems:** Flat Plate Collector: Hot Air Collector, Evacuated Tube Collector, Solar Water Heating Systems (Active & Passive), Solar Space Heating & Cooling Systems, Solar Industrial Process Heating Systems.
**Concentrator:** Parabolic, Compound Parabolic, cylindrical, evacuated tubular collectors and Fresnel Solar Concentrators, Central Receiver System, Ray tracing in a reflecting and refracting surfaces, Thermal Analysis of Solar Collectors, Performance of Solar Collectors, Solar Dryers & Desalination Systems, Solar Thermal Power Systems. **12 Hours**

**UNIT – 3**

**Solar cells and panels**: performance of solar cell, estimation of power obtained from solar power, solar panels PV systems, components of PV systems, performance of PV systems, design of PV systems, application of PV systems, concentrating PV systems, PV power plants, Solar cell array system analysis and performance prediction; Shadow analysis: Solar cell array design concepts; Storage autonomy; Voltage regulation; Maximum tracking. Transmission. **5 Hours**

**UNIT – 4**

**Wind energy:** Principles of wind energy conversion, Site selection considerations, Wind power plant design, Types of wind power conversion systems - Horizontal Axis Wind Turbine (HAWT), Blade Element Theory, wake analysis, Vertical Axis Wind Turbine (VAWT) aerodynamics. HAWT rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, yaw system, tower. Wind turbine loads, aerodynamic loads in steady operation, wind turbulence, yawed operation and tower shadow, WECS control system, requirements and strategies. Operation, maintenance and economics. **6 Hours**

**UNIT – 5**

**ENERGY FROM BIO MASS**: Photosynthesis, photosynthetic oxygen production, energy plantation. Bio Chemical route: Biogas production from organic wastes by anaerobic fermentation, classification of bio gas plants, factors affecting bio gas generation. Thermo Chemical route: Thermo chemical conversion on bio mass, types of gasifiers.
**BIO-DIESEL**: Production, Properties, environmental effects, esterification, trans-esterification and characterization of bio-diesel. **10 Hours**

**TEXT BOOKS:**

1. **Solar Energy- Principles of thermal collection and storage,** S.P Sukhatme, Tata McGraw- Hill publishing company limited, New Delhi, ISBN 0-07-462453-9.
2. **Solar Energy Utilization** – G. D. Rai, Khanna Publications

**REFERENCE BOOKS:**

1. **Solar Engineering of thermal processes**, Duffie, J.A. and Beckman, W.A., John Wiley and Sons, Netwark (1991)
2. **Non Conventional Energy Resources,** B.H. Khan- TMH
3. **Renewable Energy, Sorensen;** Elsevier publications.

**MOOCs:**

**1. NPTEL Course:** http://nptel.ac.in/courses/112105051/#

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Select the appropriate solar concentrators and tracking methods for harnessing solar energy |
| CO 2 | Estimate solar flux received from sun on flat and tilted surfaces, efficiency of flat plate and parabolic collectors |
| CO 3 | Flat plate and parabolic collectors for temperature distribution, Solar geometry and methods of measuring solar radiation and wind turbine designs |
| CO 4 | Experiment with flat plate and parabolic collectors and P-V panel set up |
| CO 5 | Alternate sources of energy and systems to generate power using them, methods of storing solar energy and methods of generating power using Bio Mass |
| CO 6 | Examine the domestic and industrial applications of Solar energy. |

**Scheme of Examination (SEE):**

Answer five full questions selecting one from each unit.
To set one question each from Units 1, 3 and 5. Two questions each from Units 2 and 5.
**Solar Energy Data Handbook permitted**

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **Production and Operation Management** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DEPOM** | **3** | **0** | **0** | **0** | **50** | **50** |

**SYLLABUS:**

**UNIT - 1**

**Operations Management and strategy**: Historical evolution, systems view of operations, managing the operations subsystem, framework for managing operations, problems of operation manager, strategic role of operations, contemporary operations management topics, operations/manufacturing strategy, strategic planning: for production and operations, framework, productivity and quality, simple numericals, technology and mechanization. **6 Hours**

**UNIT - 2**

**Operations capacity**: Introduction, capacity planning environment, strategies for modifying, capacity planning modeling, and linear programming applied to product mix and capacity, computer simulation to evaluate capacity, decision tree analysis, tree diagramming, Numericals on the above topics **4 Hours**

**UNIT - 3**

**Forecasting**: Introduction, forecasting in operations, forecasting and operation subsystem, characteristics of demand over time, elements of forecasting, useful forecasting models for operations, qualitative( Delphi, naïve), exponential smoothing, regression, behavioral dimensions of forecasting. Numericals on above topics **6 Hours**

**Designing products, processes and operations scheduling**: New product design, manufacturing process technology, flexible manufacturing system, characteristics, goal, examples, design of services and service processes. Operations scheduling: intermittent systems, scheduling concepts and processes, operation planning and scheduling system, loading, priority sequencing, detailed scheduling, behavioral elements in intermittent systems, shop loading methods(index and assignment), sequencing or prioritization: Johnson's rule, minimum critical ratio rule, nelsons study, LOB technique. Numericals on above topics **6 Hours**

**UNIT - 4**

**Purchasing and inventory control**: Introduction, Bayesian analysis, value engineering, purchasing research, vendor relations, negotiations, price forecasting, forward buying, make or buy, Inventory control: introduction, demand and control system characteristics, inventory concepts and systems, costs, modeling. Numericals on above topics **6 Hours**

Inventory control applications, deterministic, stochastic and single period model inventory models, inventory control applications, procedures, behavioral pitfalls, optimal order quantity, assumptions of EOQ formula, batch size and quantity, joint cycle for multiple products, inventory model with purchase discounts, approaches to determine buffer stock. Numericals on above topics **6 Hours**

**UNIT - 5**

**Job design, production operation standards & work measurement**: Introduction, job design, behavioral dimensions, effective job design, production and operation standards, work measurement, techniques, compensation. Numericals on above topics **5 Hours**

**Text Books:**

1. Production and Operations Management, Models & Behavior, 5th edition, Everete Adam, Jr. Ronald J Ebert, Prentice Hall India Publications.
2. Production and Operations Management, Chary, 3rd Edition Mc Graw Hill Publications

**Reference Books:**

1. Production and Operations Management by K. Aswathappa, K Shridhara Bhat, Himalaya Publishing House
2. Operations Management Along Supply Chain, 6th Edition, Russell and Taylor, John Wiley Publications

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Plan to use Operations Management And Strategies for managing operations |
| CO 2 | Identify suitable evaluation methods for capacity planning |
| CO 3 | Choose appropriate scheduling system for operations |
| CO 4 | Compare various types of inventory control |
| CO 5 | Develop various concepts for designing a product |
| CO 6 | Distinguish between several behavioral dimensions |

**Scheme of Examination (SEE):**

- Students to answer five full questions selecting one from each unit.
- To set one question each from Units 1, 2 & 5 and two questions each from Units 3 & 4

| Course | | Credits : 03 | | | | Marks | |
|---|---|---|---|---|---|---|---|
| **Name** | **CAD/CAM** | **L** | **T** | **P** | **S** | **CIE** | **SEE** |
| **Code** | **16ME6DECAM** | **3** | **0** | **0** | **0** | **50** | **50** |

**PRE-REQUISITES:**
Manufacturing Process, Engineering Mathematics

**SYLLABUS:**

**Unit – 1**

**Introduction to CAD/CAM**: Introduction to CAD/CAM, CAD/CAM input devices, CAD/CAM output devices, CAD/CAM Software. Transformations of geometry: Translation, Scaling, Reflection, Rotation, Homogeneous representation of transformation, Concatenation of transformations. **6 Hours**

**Unit – 2**

**Geometric Modelling of Curves**: 3-D Wire frame modelling, Bezier and B-spline curves. Geometric Modelling of Surfaces: Basic surfaces entities, Surface of revolution, blends, intersections, Modelling of analytical & sculptured surfaces. Geometric Modelling of Solids: Solid entities, Boolean operations, B-rep of Solid Modelling, CSG approach of solid modelling. Data Exchange Formats and Applications: Data exchange formats, Finite element analysis, Rapid prototyping. **12 Hours**

**Unit – 3**

**Computer Aided Manufacturing (CAM)**: Introduction to Computer Numerical Control (CNC), Structure of NC machine tools, Designation of axes, Drives & actuation systems, Feedback devices, CNC tooling, Automatic tool changers & Work holding devices.
**6 Hours**

**Unit – 4**

**CNC Programming**: Part programming fundamentals, Manual Part Programming, APT Programming, Geometric & motion commands, Post processor commands. Robotics: Anatomy & configuration of robot, characteristics of robots, Grippers, Application of robots in manufacturing, Robot programming. **6 Hours**

**Unit – 5**

**Group Technology**: Introduction to Group technology, Part classification & coding systems: OPITZ, MICLASS. Computer Aided Process Planning (CAPP): Introduction to CAPP, Variant & Generative methods of CAPP, advantages of CAPP. Flexible Manufacturing System (FMS): Components of FMS, FMS equipment & control, FMS
Case studies. **9 Hours**

**Text Books:**

1. CAD/CAM-Theory and Practice, Ibraham Zeid & R. Shivasubramanian, 2nd Edition, Tata McGraw Hill, 2009.
2. CAD / CAM Principles and Applications, Rao, P.N., McGraw Hill Publishers, New Delhi, 2010
3. Computer Control of Manufacturing, Yoram Koren, , McGraw Hill Publications, 2005.

**Reference Books:**

1. Robotics for Engineering- Koren. Y - Mc-Graw Hill - 1985.
2. CAD/CAM/CIM- P. Radhakrishna, New Age International-2nd edition.

**Moocs**:

1. http://www.nptel.ac.in/courses/Webcourse-contents/IIT-Delhi/Computer%20Aided%20Design%20&%20ManufacturingI/index.htm

**COURSE OUTCOMES:**

Upon completion of this course, student will be able to:

| | |
|---|---|
| CO 1 | Make use of CAD /CAM devices and transformation principles for geometry of parts |
| CO 2 | Choose from various methods of modeling of geometries in space during CAD applications |
| CO 3 | Evaluate the models using Finite element Analysis and rapid prototyping |
| CO 4 | Select appropriate tools, machines for Computer Aided Manufacturing of designed parts |
| CO 5 | Compile CNC/NC programs for generating toolpaths for machining the designed parts |
| CO 6 | Plan manufacturing processes and equipment with the help of computers in industries |

**Scheme of Examination (SEE):**

Students to answer five full questions selecting one from each unit.
To set one question each from Units 1, 3 & 5 and two questions each from Units 2 & 4.