| Course code | Course Name | L-T-P - Credits | Year of Introduction |
|---|---|---|---|
| ME301 | MECHANICS OF MACHINERY | 3-1-0-4 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

To provide knowledge on kinematics of selected mechanisms, design of cams, theory and analysis of gears, gear trains and synthesis of mechanisms.

**Syllabus**

Introduction to kinematics and mechanisms - different mechanisms, displacement, velocity, and acceleration analysis. Cam and followers - displacement, velocity, and acceleration analysis, cam profile synthesis. Gears – law of gearing, interference, gear trains, applications. Kinematic synthesis - dimensional synthesis, graphical synthesis, position synthesis, analytical synthesis, case study.

**Expected outcome** .

The students will be able to solve practical problems related to kinematics of mechanisms

**Text Books:**

1. Ballaney P. L., Theory of Machines and Mechanisms, Khanna Publishers,2005
2. S. S. Rattan, Theory of Machines, Tata Mc Graw Hill,2009

**References:**

1. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education,2005
2. D. H. Myszka, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education,2013
3. G. Erdman, G. N. Sandor, Mechanism Design: Analysis and synthesis Vol I & II, Prentice Hall of India,1984.
4. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press,1988
5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,2010

**Course Plan**

| Module | Contents | Hours | Sem. Exam Marks |
|---|---|---|---|
| I | Introduction to kinematics and mechanisms - various mechanisms, kinematic diagrams, degree of freedom- Grashof's criterion, inversions, coupler curves | 3 | 15% |
| | straight line mechanisms exact, approximate – Ackerman Steering Mechanism - Hooke's joint - Geneva mechanism - mechanical advantage, transmission angle | 4 | |
| | Displacement, velocity and acceleration analysis - relative motion - relative velocity - instant centre -Kennedy's theorem | 4 | |
| II | Relative acceleration - Coriolis acceleration - graphical and analytical methods – complex number methods - computer oriented methods. | 4 | 15% |
| | Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration, cycloidal motion | 4 | |
| **FIRST INTERNAL EXAMINATION** | | | |
| III | Graphical cam profile synthesis, pressure angle | 2 | 15% |

| | | | |
|---|---|---|---|
| | Analysis of tangent cam with roller follower and circular cam with flat follower | 6 | |
| | Introduction to polynomial cams. | 2 | |
| **IV** | Gears – terminology of spur gears – law of Gearing - involute spur gears involutometry - contact ratio - interference - backlash - gear standardization - interchangability | 4 | 15% |
| | Non-standard gears, centre distance modification, long and short addendum system. - internal gears - theory and details of bevel, helical and worm gearing | 4 | |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Gear trains - simple and compound gear trains - planetary gear trains – differential -solution of planetary gear train problems - applications | 5 | 20% |
| | Kinematic synthesis ( planar mechanisms) - tasks of kinematic synthesis – type, number and dimensional synthesis – precision points | 4 | |
| **VI** | Graphical synthesis for motion - path and prescribed timing - function generator . | 3 | 20% |
| | 2 position and 3 position synthesis – overlay Method | 3 | |
| | Analytical synthesis techniques, Freudenstein's equation – complex number methods - one case study in synthesis of mechanism. | 4 | |
| **END SEMESTER EXAM** | | | |

## QUESTION PAPER PATTERN:

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**

There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**

There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**

There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

**Note**: in all parts each question can have a maximum of four sub questions

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME302 | Heat and Mass Transfer | 3-1-0-4 | 2016 |

**Prerequisites : ME203 Mechanics of fluid**

**Course Objectives:**

- To introduce the various modes of heat transfer and to develop methodologies for solving a wide variety of practical heat transfer problems
- To provide useful information concerning the performance and design of simple heat transfer systems
- To introduce mass transfer

**Syllabus:**

Modes of Heat Transfer: Conduction: Most general heat conduction equation, One dimensional steady state conduction with and without heat generation, Critical radius of insulation, Elementary ideas of hydrodynamics and thermal boundary layers, Convection heat transfer: Newton's law of cooling, Dimensionless numbers, Dimensional analysis, Problems. Fins: Types of fins : Fin efficiency and effectiveness. Boiling and condensation heat transfer, Introduction to heat pipe. Transient heat conduction. Heat exchangers, LMTD and NTU methods. Radiation: laws of radiation, Electrical analogy, Radiation shields. Mass Transfer :Mass transfer by molecular diffusion, Convective mass transfer.

**Expected outcome:**

The students will be able to

1. Apply principles of heat and mass transfer to engineering problems
2. Analyse and obtain solutions to problems involving various modes of heat transfer
3. Design heat transfer systems such as heat exchangers, fins, radiation shields etc..

**Text Books**:


1. Sachdeva R C, Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited, 2009
2. R.K.Rajput. Heat and mass transfer, S.Chand& Co.,2015
3. Nag P K., Heat and Mass Transfer, McGraw Hill,2011
4. Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi, 2006


**Data Book:**

- Heat and Mass Transfer data book: C.P. Kothandaraman, S. Subramanya, New age International publishers,2014

**References Books:**


1. Yunus A Cengel, Heat Transfer: A Practical Approach, McGraw Hill,2015
2. Holman J P, Heat Transfer, McGraw Hill, 2011
3. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons, 2011

| Course Plan | | | |
|---|---|---|---|
| **Module** | **Contents** | **Hours** | **End Sem. Exam Marks** |
| **I** | Modes of Heat Transfer: Conduction: Fourier law of heat conduction-Thermal conductivity of solids, liquids and gases-Factors affecting thermal conductivity- Most general heat conduction equation in Cartesian, cylindrical and spherical coordinates One dimensional steady state conduction with and without heat generation conduction through plane walls, cylinders and spheres-variable thermal conductivity conduction shape factor- heat transfer through corners and edges. Critical radius of insulation. | 12 | 15% |
| **II** | Elementary ideas of hydrodynamics and thermal boundary layers-Thickness of Boundary layer-Displacement, Momentum and Energy thickness (description only).<br>Convection heat transfer: Newton's law of cooling- Laminar and Turbulent flow, Reynolds Number, Critical Reynolds Number, Prandtl Number, Nusselt Number, Grashoff Number and Rayleigh's Number. Dimensional analysis Buckingham's Pi theorem- Application of dimensional analysis to free and forced convection- empirical relations- problems using empirical relations | 10 | 15% |
| **FIRST INTERNAL EXAMINATIONEXAM** | | | |
| **III** | Transient heat conduction-lumped heat capacity method. Fins: Types of fins - Heat transfer from fins of uniform cross sectional area- Fin efficiency and effectiveness. Boiling and condensation heat transfer(elementary ideas only),Introduction to heat pipe. | 8 | 15% |
| **IV** | Combined conduction and convection heat transfer-Overall heat transfer coefficient - Heat exchangers: Types of heat exchangers, AMTD, Fouling factor, Analysis of Heat exchangers- LMTD method, Correction factor, Effectiveness-NTU method, Special type of heat exchangers (condenser and evaporator, simple problems only) | 8 | 15% |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Radiation- Nature of thermal radiation-definitions and concepts- monochromatic and total emissive power-Intensity of radiation- solid angle- absorptivity, reflectivity and transmissivity-Concept of black body- Planck' law- Kirchoff's law- Wein's displacement law-Stefan Boltzmann's law- black, gray and real surfaces-Configuration factor (derivation for simple geometries only)- Electrical analogy- Heat exchange between black/gray surfaces- infinite parallel plates, equal and parallel opposite plates-perpendicular rectangles having common edge- parallel discs (simple problems using charts and tables). Radiation shields(no derivation). | 10 | 20% |

| | | | |
|---|---|---|---|
| **VI** | Mass Transfer :Mass transfer by molecular diffusion- Fick's law of diffusion- diffusion coefficient Steady state diffusion of gases and liquids through solid- equimolar diffusion, Isothermal evaporation of water through air- simple problems.<br>Convective mass transfer- Evaluation of mass transfer coefficient- empirical relations- simple problems- analogy between heat and mass transfer. | 8 | 20% |
| **END SEMESTER EXAM** | | | |



**Question Paper Pattern**

*Use of approved data book permitted*

Total marks: 100, Time: 3 hrs

The question paper should consist of three parts

**Part A**

There should be 2 questions each from module I and II

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**

There should be 2 questions each from module III and IV

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**

There should be 3 questions each from module V and VI

Each question carries 10 marks

Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME303 | MACHINE TOOLS AND DIGITAL MANUFACTURING | 3-0-0-3 | 2016 |

**Prerequisite: Nil**

**Course Objectives:** The main objectives of this course are

1. To introduce students to the scientific principles underlying material behavior during manufacturing processes so as to enable them to undertake calculations of forces, tool stresses and material removal rates.
2. To understand various machine tools such as lathe, drilling machine, reciprocating machines etc. and their operations.
3. To impart knowledge of appropriate parameters to be used for various machining operations.
4. To develop knowledge on the importance of milling grinding and super finishing in metal cutting process.
5. To introduce the fundamentals of digital manufacturing.

**Syllabus**

Introduction to metal cutting, Mechanism of metal removal, Merchants theory, Frictional forces in metal cutting, Thermal aspects of machining, General purpose machine tools, Principle and operation of lathe, Drilling machines, Reciprocating machines, Milling machines, Grinding machines, Super finishing operations, Semi-automatic machine tools, Single and multi-spindle machines, Introduction to digital manufacturing and digital manufacturing science.

**Expected outcomes:**

The students will be able to

1. Analyze various machining process and calculate relevant quantities such us velocities, forces and powers.
2. Identify and explain the function of the basic components of a machine tool.
3. Understand the limitations of various machining process with regard to shape formation and surface texture.
4. Apply cutting mechanics to metal machining based on cutting force and power consumption.
5. Understand the use of various machine tools and their fields of application.
6. Understand the principle and applications of grinding and super finishing operations.
7. Get a basic knowledge on the importance of digital manufacturing.

**Text books**


1. Chapman W. A. J., Workshop Technology, Viva books (P) Ltd,1988
2. HMT, Production Technology, Tata McGraw-Hill,2001
3. Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited,2012

**Reference books**


1. Acharkan. N., Machine Tool Design Vol. 1 to 4, MIR Publication,2000
2. Chernov, Machine Tools, MIR Publication,1984
3. Ghosh A. And Malic A. K., Manufacturing Science, East West Press, 2010
4. Hajra Choudary, Elements of workshop technology, Vol I & II, Media Publishers, 2010
5. Lihui Wang and Andrew Yeh Ching Nee, Collaborative Design and Planning for Digital Manufacturing, Springer-Verlag London Limited, 2009
6. Malkin Stephen, Grinding Technology: Theory and Applications of Machining with Abrasives, Industrial press, 2008
7. Poul De Garmo, J.T.Black, R.A.Kosher, Materials and Processes in Manufacturing, Prentice Hall of India Pvt. Ltd.,1997.


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Introduction to metal cutting: Tool nomenclature – Attributes of each tool nomenclature – Attributes of feed and tool nomenclature on surface roughness obtainable | 1 | 15% |
| | Orthogonal and oblique cutting - Mechanism of metal removal – Primary and secondary deformation shear zones | 1 | |
| | Mechanism of chip formation – Types of chips, need and types of chip breakers – Merchant's theory | 1 | |
| | Analysis of cutting forces in orthogonal cutting– Work done, power required (simple problems) | 1 | |
| | Friction forces in metal cutting – development of cutting tool materials | 1 | |
| | Thermal aspects of machining -Tool wear and wear mechanisms | 1 | |
| | Factors affecting tool life– Economics of machining (simple problems)<br>Cutting fluids | 1<br>1 | |
| II | General purpose machine tools – Principle and operation of lathe – Types of lathes and size specification | 1 | 15% |
| | Work holding parts of lathes and their functions – Main operations | 1 | |
| | Taper turning and thread cutting – Attachments | 1 | |
| | Feeding mechanisms, Apron mechanisms | 1 | |
| | Drilling Machines – Types – Work holding devices | 1 | |
| | Tool holding devices – Drill machine operations | 1 | |
| | Drilling machine tools – Twist drill nomenclature- cutting forces in drilling. | 1 | |
| **FIRST INTERNAL EXAMINATION** | | | |
| III | Reciprocating machines: Shaping machines – Types – Size – Principal parts – Mechanism | 1 | 15% |
| | Work holding devices – Operations performed – Tools | 1 | |

| | | | |
|---|---|---|---|
| | Cutting speed, feed and depth of cut – Machining time. | 1 | |
| | Slotting machines – Types – Size – Principal parts – Mechanism – Work holding devices | 1 | |
| | Operations performed – Tools – Cutting speed, feed and depth of cut | 1 | |
| | Planing machines – Types – Size – Principal parts – Mechanism – Work holding devices | 1 | |
| | Operations performed – Tools – Cutting speed, feed and depth of cut – Machining time- Surface roughness obtainable. | 1 | |
| **IV** | Milling machines – Types – Principal parts – Milling mechanism | 1 | 15% |
| | Work holding devices – Milling machine attachments | 1 | |
| | Types of milling cutters – Elements of plain milling cutters | 1 | |
| | Nomenclature - Cutting forces in milling – Milling cutter materials | 1 | |
| | Up milling, down milling and face milling operations | 1 | |
| | Calculation of machining time | 1 | |
| | Indexing – Simple indexing – Differential indexing | 1 | |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Grinding machines – Classification – Operations – Surface, cylindrical and centreless grinding | 1 | 20% |
| | Grinding mechanisms – Grinding wheels: Specification – types of abrasives, grain size | 1 | |
| | Types of bond, grade, structure – Marking system of grinding wheels – Selection of grinding wheels | 1 | |
| | Glazing and loading of wheels – Dressing and Truing of grinding wheels, surface roughness obtainable | 1 | |
| | Superfinishing operations: Lapping operation– Types of hand lapping – Lapping machines – Types of honing –Methods of honing | 1 | |
| | Types of honing stones – Honing conditions – Cutting fluids – Types of broaches – Force required for broaching – Surface roughness obtainable in lapping, honing and broaching operations. | 1 | |
| | Semi-automatic machine tools – Turret and capstan lathes. Automatic machine tools – Single and multi-spindle machines. | 1 | |
| **V1** | Introduction to Digital Manufacturing: Concepts and research and development status of digital manufacturing | 1 | 20% |
| | Definition of digital manufacturing – Features and development of digital manufacturing. | 1 | |
| | Theory system of digital manufacturing science: Operation Mode and Architecture of Digital Manufacturing System | 1 | |
| | Operation reference mode of digital manufacturing system – Architecture of digital manufacturing system | 1 | |
| | Modeling theory and method of digital manufacturing science | 1 | |
| | Critical modeling theories and technologies of digital manufacturing science | 1 | |
| | Theory system of digital manufacturing science – Basic | 1 | |

| | | | |
|---|---|---|---|
| | architecture model of digital manufacturing system. | | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: in all parts each question can have a maximum of four sub questions

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME304 | DYNAMICS OF MACHINERY | 2-1-0-3 | 2016 |

**Prerequisite: ME301 Mechanics of Machinery**

**Course Objectives:**

- To impart knowledge on force analysis of machinery, balancing of rotating and reciprocating masses, Gyroscopes, Energy fluctuation in Machines.
- To introduce the fundamentals in vibration, vibration analysis of single degree of freedom systems.
- To understand the physical significance and design of vibration systems with desired conditions

**Syllabus**

Force analysis of machinery - static and dynamic force analysis of plane motion mechanisms. Flywheel analysis - static and dynamic balancing - balancing of rotating masses, gyroscopic couples. Vibrations – free vibrations of single degree freedom systems, damping, forced vibration, torsional vibration.

**Expected outcome:**

The students will be able to

1. Develop the design and practical problem solving skills in the area of mechanisms
2. Understand the basics of vibration and apply the concepts in design problems of mechanisms.

**Text Books**:


1. Ballaney P.L. Theory of Machines, Khanna Publishers,1994
2. S. S. Rattan, Theory of Machines, Tata McGraw Hill, 2009
3. V. P. Singh, Theory of Machines, Dhanpat Rai,2013


**References :**


1. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education, 2003
2. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press, 2003
3. H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education, 4e, 2012
4. Holowenko, Dynamics of Machinery, John Wiley, 1995
5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,1995
6. W.T.Thompson, Theory of vibration, Prentice Hall,1997

| Course Plan | | | |
|---|---|---|---|
| **Module** | **Contents** | **Hours** | **End Sem. Exam Marks** |
| **I** | Introduction to force analysis in mechanisms - static force analysis (four bar linkages only) - graphical methods | 4 | 15% |
| | Matrix methods - method of virtual work - analysis with sliding and pin friction | 3 | |
| **II** | Dynamic force analysis: Inertia force and inertia torque. D'Alemberts principle, analysis of mechanisms (four bar linkages only), equivalent dynamical systems | 4 | 15% |
| | Force Analysis of spur- helical - bevel and worm gearing | 3 | |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Flywheel analysis - balancing - static and dynamic balancing - balancing of masses rotating in several planes | 4 | 15% |
| | Balancing of reciprocating masses - balancing of multi-cylinder in line engines - V engines - balancing of machines | 3 | |
| **IV** | Gyroscope – gyroscopic couples | 3 | 15% |
| | Gyroscopic action on vehicles-two wheelers, four wheelers, air planes and ships. Stability of an automobile – stability of a two wheel vehicle –Stabilization of ship. | 4 | |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Introduction to vibrations – free vibrations of single degree freedom systems – energy Method | 2 | 20% |
| | Undamped and damped free vibrations – viscous damping – critical damping - logarithmic decrement - Coulomb damping – harmonically excited vibrations | 3 | |
| | Response of an undamped and damped system – beat phenomenon - transmissibility | 2 | |
| **VI** | Whirling of shafts – critical speed - free torsional vibrations – self excitation and stability analysis - vibration control - vibration isolation – vibration absorbers | 4 | 20% |
| | Introduction to multi-degree freedom systems - vibration measurement - accelerometer – seismometer – vibration exciters | 3 | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME305 | COMPUTER PROGRAMMING & NUMERICAL METHODS | 2-0-1-3 | 2016 |

**Prerequisite: Nil**

**Course Objectives:**

- To equip students with fundamentals of computer programming
- To provide fundamental idea about the use of computer programming and numerical methods for analyzing the basic engineering problems.

**Syllabus**

Introduction to computer programming concept, control statements, basics pointers, Introduction to Class and Object, Errors and approximations, curve fitting, Solution of Partial differential equations, Numerical problems and preparation of computer programs.

**Expected outcomes:**

- The students will be able to write computer programs for numerical solutions for engineering problems like system of equations and heat equations..

**Text Books**


1. Balagurusamy, Computer Programming 1e McGraw Hill Education , 2013
2. Balagurusamy, Numerical Methods 1e McGraw Hill Education, 1999
3. Jose S., Computer Programming and Numerical Methods, Pentagon, 2015.
4. Ravichandran D., Programming with C++, Tata McGraw Hill, 2007.


**Reference Books**


1. Balaguruswamy E., Object Oriented Programming with C++, Tata McGraw Hill, 1992.
2. Barkakati N., Object Oriented Programming in C++, SAMS, 1991.
3. Gerald C. F. and P. O. Wheatley, Applied Numerical Analysis, Pearson,2004.
4. Kamthane A. M., Object Oriented Programming with ANSI & Turbo C++,
5. Lippman S. B. and J. Lajoie, C++ Primer, Pearson Education, 2005.
   Pearson Education, 2009.


**Course Plan**

| Module | Contents | Hours | Sem. Exam Marks |
|---|---|---|---|
| I | Introduction to Computer programming concept –internal representation of data - Algorithm and flow chart, Basics of procedure oriented and object oriented programming. Introduction to C++: Structure of C++ program; Keywords; Identifiers; Data types – integer, real, character, string, boolean, enumeration, Constant and Variables; Operators – assignment, arithmetic, relational, logical, increment, decrement and conditional operators; Statements – simple & compound, declaration statements. Input and output streams. | 5 | 15% |
| II | Control statements: **`if`**, **`if-else`**, **`switch`**, **`for`**, **`while`**, **`do-while`**, **`break`** and **`continue`** statements, Arrays – one dimensional & two dimensional; Functions: inline functions, function over loading, Functions with default arguments, recursion. | 7 | 15% |
| **FIRST INTERNAL EXAM** | | | |

| | | | |
|---|---|---|---|
| **III** | Basics of Pointers. Function call by value, call by reference. Preparation of programs for evaluation of Factorial of a number, infinite series, Sorting, Searching and Matrix multiplication. | 8 | 15% |
| **IV** | Introduction to Class and Object- definition, data members, member function. private & public member functions, member access, friend declaration, class objects, predefined classes, initialization. Inheritance- base class and derived class. Simple programs using the above features. (No programming questions for University examination and internals) | 7 | 15% |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Errors and approximations, sources of errors. Solution of linear system of equations: Gauss elimination, Gauss-Jordan and Gauss–Seidel methods. Interpolation: Lagrange and Aitken techniques. | 7 | 20% |
| **VI** | Curve fitting: method of least squares, non-linear relationships, Linear correlation, measures of correlation. Solution of Partial differential equations: classification, Laplace equation, Finite difference method. Numerical problems and preparation of computer programs for the above methods | 8 | 20% |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME306 | ADVANCED MANUFACTURING TECHNOLOGY | 3-0-0-3 | 2016 |

**Pre requisite: ME 220 Manufacturing Technology, ME303 Machine Tools and Digital Manufacturing**

**Course Objectives**

1. To introduce machining principles and processes in the manufacturing of precision components and products that use conventional and nonconventional technologies.
2. To give basic understanding of the machining capabilities, limitations, and productivity of advanced manufacturing processes.
3. To describe how PLC's operate and how they control automated equipment and systems
4. To demonstrate tool path simulations with CNC powered equipment
5. To introduce CNC programming

**Syllabus:-**

Powder Metallurgy- Programmable Logic Controllers- CNC- non-traditional and micro machining process - high velocity forming of metals-material additional process.

**Expected outcome:**

The students will be able to

i. Become conversant with the non- traditional machining process and to appreciate the effect of process parameters on the surface integrity aspects during the non- traditional machining process.
ii. Appreciate the use of an EDM as a non traditional method of machining complex and hard materials.
iii. Prescribe a laser materials processing technique suitable for a given product with material, size, precision, and surface quality requirements.
iv. Program and operate a CNC mill and lathe.
v. Select the tool material and machining process parameters.

**Text books/References**


1. ASTME, High velocity forming of metals, PHI, 1968.
2. Davies K and Austin E.R, Developments in high speed metal forming, the machinery publishing Co, 1970.
3. Ibrahim Zeid, R Sivasubrahmanian CAD/CAM: Theory & Practice, McGraw Hill Education, 2009
4. Jain V.K., Introduction to Micromachining, Narosa publishers,2014
5. M.P. Groover, E.M. Zimmers, Jr. CAD/CAM; Computer Aided Design and Manufacturing, Prentice Hall of India, 1987
6. Petruzella Frank.D., Programmable logic controllers,McGraw Hill,2016
7. Yoram Koren, Computer control of manufacturing systems, TMH,2006

| Course Plan | | | |
|---|---|---|---|
| **Module** | **Contents** | **Hours** | **End Sem. Exam. Marks** |
| **I** | Introduction: Need and comparison between traditional, non-traditional and micro & nano machining process. | 1 | **15%** |
| | Powder Metallurgy: Need of P/M - Powder Production methods:- Atomization, electrolysıs, Reduction of oxides, Carbonyls (Process parameters, characteristics of powder produced in each method). | 1 | |
| | Powder characteristics: properties of fine powder, size, size distribution, shape, compressibility, purity etc. | 1 | |
| | Mixing – Compaction:- techniques, pressure distribution, HIP & CIP. | 1 | |
| | Mechanism of sintering, driving force for pore shirking, solid and liquid phase sintering - Impregnation and Infiltration Advantages, disadvantages and specific applications of P/M. | 1 | |
| | Programmable Logic Controllers (PLC): need – relays - logic ladder program –timers, simple problems only. | 1 | |
| | Point to point, straight cut and contouring positioning - incremental and absolute systems – open loop and closed loop systems - control loops in contouring systems: principle of operation. | 1 | |
| **II** | DDA integrator:-Principle of operation, exponential deceleration –liner, circular and complete interpolator. | 1 | **15%** |
| | NC part programming: part programming fundamentals - manual programming – | 1 | |
| | NC coordinate systems and axes — sequence number, preparatory functions, dimension words, speed word, feed world, tool world, miscellaneous functions – | 1 | |
| | Computer aided part programming:– CNC languages – APT language structure: geometry commands, motion | 1 | |
| | commands, postprocessor commands, compilation control commands | 1 | |
| | Programming exercises: simple problems on turning and drilling etc - machining centers- 5 axis machining **(*At least one programming exercise must be included in the end semester University examination).*** | 2 | |
| | **FIRST INTERNAL EXAMINATION** | | |

| | | | |
|---|---|---|---|
| **III** | Electric Discharge Machining (EDM):- Mechanism of metal removal, dielectric fluid, spark generation, recast layer and attributes of process characteristics on MRR, accuracy, HAZ etc, Wire EDM, applications and accessories. | 3 | **15%** |
| | **Ultrasonic Machining (USM):-**mechanics of cutting, effects of parameters on amplitude, frequency of vibration, grain diameter, slurry, tool material attributes and hardness of work material, applications. | 2 | |
| | Electro chemical machining (ECM):- Mechanism of metal removal attributes of process characteristics on MRR, accuracy, surface roughness etc, application and limitations. | 1 | |
| **IV** | Laser Beam Machining (LBM), Electron Beam Machining (EBM), Plasma arc Machining (PAM), Ion beam Machining(IBM) - Mechanism of metal removal, attributes of process characteristics on MRR, accuracy etc and structure of HAZ compared with conventional process; application, comparative study of advantages and limitations of each process. | 3 | **15%** |
| | Abrasive Jet Machining (AJM), Abrasive Water Jet Machining **(AWJM)** - Working principle, Mechanism of metal removal, Influence of process parameters, Applications, Advantages & disadvantages. | 3 | |
| | **SECOND INTERNAL EXAMINATION** | | |
| **V** | High velocity forming of metals:-effects of high speeds on the stress strain relationship steel, aluminum, Copper – comparison of conventional and high velocity forming methods- deformation velocity, material behavior, stain distribution. | 3 | **20%** |
| | Stress waves and deformation in solids – types of elastic body waves- relation at free boundaries- relative particle velocity. | 2 | |
| | Sheet metal forming: - explosive forming:-process variable, properties of explosively formed parts, etc. | 2 | |
| | Electro hydraulic forming: - theory, process variables, etc, comparison with explosive forming. | 1 | |
| **V1** | Micromachining: Diamond turn mechanism, material removal mechanism, applications. | 1 | **20%** |
| | Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing. | 2 | |
| | Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining. | 3 | |
| | Material addition process:- stereo-lithography, selective laser sintering, 3D Printing, fused deposition modeling, laminated object manufacturing, , laser engineered net-shaping, laser welding, LIGA process. | 2 | |

## Question Paper Pattern

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P – Credits | Year of Introduction |
|---|---|---|---|
| ME307 | MACHINE DESIGN - I | 3-1-0-4 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

- To understand the basic components and layout of linkages in the assembly of a system/machine.

**Syllabus**

Introduction to design of riveted, threaded, and welded joints – springs and design –Design laws – stresses in components and machines.

**Expected outcome**.

- The students will become aware of the machine components, forces, stresses affecting them and the aspects of designing them.

**Text Books:**

1. R L Norton, Kinematics and Dynamics of Machinery, 1st ed., Tata McGraw Hill Education Private Limited, Delhi, 2004
2. S .S Rattan Theory of Machines, 3rd ed., Tata McGraw Hill Education Private Limited, Delhi, 2009

**References:**

1. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, Oxford University Press, 2016
2. A. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press, 3e, 2006
3. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, 3rd edition, Pearson Education, 2003
4. Holowenko, Dynamics of Machinery, John Wiley & Sons, 1995

**Course Plan**

| Module | Contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, Mobility – Kutzbach criterion, Gruebler's criterion – Grashof's Law –Kinematic inversions of four-bar chain, slider crank chains and double slider crank chains – Limit positions –Mechanical advantage – Transmission Angle -Coupler curves – Description of some common Mechanisms – Quick return mechanisms, Straight line generators | 10 | 15% |
| II | Displacement, velocity and acceleration analysis of simple mechanisms – Graphical method – Velocity and acceleration polygons **Force analysis of machinery** - static and dynamic force analysis of plane motion mechanisms - graphical method - principle of superposition –matrix methods - method of virtual work. | 10 | 15% |
| | **FIRST INTERNAL EXAMINATION** | | |
| III | Governors: - terminology and classification ; Watt, Porter, Proel, Hartnell, Hartung, quality of governors,inertia governors- governor speed control<br>Gyroscope: - Principle-Angular acceleration-Effect of gyroscopic | 8 | 15% |

| | | | |
|---|---|---|---|
| | couple airplanes, and ships, stability of automobile and two wheel vehicles, Rigid disc at an angle fixed to a rotating shaft | | |
| **IV** | Turning moment diagram and Flywheel: - coefficient of fluctuation of energy and speed- energy saved in a flywheel- force analysis, piston effort-crankpin effort- crank effort-turning moment diagrams for I.C. engines. | 8 | 15% |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Cams and Followers: - types-follower motion-SHM-uniform velocity and acceleration- Cycloidal - displacement, velocity and acceleration curves-Cam profile-Reciprocating and oscillating followers-Tangent cams-Convex and concave cams with footed followers. Introduction to Polynomial cams. (Numerical problems) | 10 | 20% |
| **VI** | Law of toothed gearing – Involutes and cycloidal tooth profiles –Spur Gear terminology and definitions –Gear tooth action – contact ratio – Interference and undercutting<br>Gear trains – Speed ratio, train value – Parallel axis gear trains– Epicyclic Gear Trains (Numerical problems) | 10 | 20% |
| **END SEMESTER EXAM** | | | |

## QUESTION PAPER PATTERN

Maximum Marks :100 Exam Duration: 3 Hours

**PART A**

4 Questions uniformly covering modules 1 and 2. Each question carries 10 marks. Students will have to answer any three questions out of four. (3X10=30 marks)

**PART B**

4 Questions uniformly covering modules 3 and 4. Each question carries 10 marks. Students will have to answer any three questions out of four. (3X10=30 marks)

**PART C**

6 Questions uniformly covering modules 5 and 6. Each question carries 10 marks. Students will have to answer any four questions out of six. (4X10=40 marks)

**Note:** Each question can have maximum of 4 sub questions ( a, b, c, d)

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME308 | COMPUTER AIDED DESIGN AND ANALYSIS | 3-0-0-3 | 2016 |

**Prerequisite: ME201 Mechanics of solids**

**Course Objectives:**

1. To impart basic knowledge on Computer Aided Design methods and procedures
2. To introduce the fundamentals of solid modelling
3. To introduce the concepts of finite element analysis procedures.

**Syllabus**

Introduction to CAD/CAM, Basics of geometric and solid modeling, transformation, representation points, lines, surfaces and solid models. Introduction to finite element analysis, solution procedures, interpolation, isoparametric formulation, applications.

**Expected outcome:**

The students will be able to

1. Gain a basic knowledge on Computer Aided Design methods and procedures
2. Understand the fundamentals of solid modelling
3. Have a basic knowledge in finite element analysis procedures.

**Text Books**:


1. M.P. Groover, E.M. Zimmers, Jr.CAD/CAM; Computer Aided Design and Manufacturing, Prentice Hall of India, 1987
2. T. R. Chandrupatla and A. D. Belagundu, Introduction to Finite Elements in Engineering, Pearson Education, 2001


**References**:


1. Chris Mcmahon and Jimmie Browne - CAD/CAM – Principle Practice and Manufacturing Management, Addision Wesley England,1998
2. D. F. Rogers and J. A. Adams, Mathematical Elements in Computer Graphics, McGraw-Hill,1990
3. Daryl Logan, A First course in Finite Element Method, Thomson Learning,2007
4. David V Hutton, Fundamentals of Finite Element Analysis, THM,2003
5. Donald Hearn, M. Pauline Baker and Warren Carithers, Computer Graphics with open GL, Pearson Education,2001
6. Grigore Burdea, Philippe Coiffet, Virtual Reality Technology, John Wiley and sons,2003
7. Ibrahim Zeid, CAD/ CAM Theory and Practice, McGraw Hill,2007
8. P. Radhakrishnan and S. Subramanyan, CAD / CAM / CIM, New Age Int. Ltd.,2008

| Course Plan | | | |
|---|---|---|---|
| **Module** | **Contents** | **Hours** | **End Sem. Exam Marks** |
| **I** | Introduction to CAD , Historical developments, Industrial look at CAD, Comparison of CAD with traditional designing, Application of computers in Design | 2 | 15% |
| | Basics of geometric and solid modeling, Packages for CAD/CAM/CAE/CAPP | 1 | |
| | Hardware in CAD components, user interaction devices, design database, graphic Standards, data Exchange Formats, virtual Reality. | 4 | |
| **II** | Transformation of points and line, 2-D rotation, reflection, scaling and combined transformation, homogeneous coordinates, 3-D scaling. | 4 | 15% |
| | Shearing,rotation, reflection and translation, combined transformations, orthographic and perspective projections, reconstruction of 3-D objects. | 3 | |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Algebraic and geometric forms, tangents and normal, blending functions, reparametrization, straight lines, conics, cubic splines, Bezier curves and B-spline curves. | 4 | 15% |
| | Plane surface, ruled surface, surface of revolution, tabulated cylinder, bi-cubic surface, bezier surface, B-spline surfaces and their modeling techniques. | 3 | |
| **IV** | Solid models and representation scheme, boundary representation, constructive solid geometry. | 3 | 15% |
| | Sweep representation, cell decomposition, spatial occupancy enumeration, coordinate systems for solid modeling. | 4 | |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Introduction to finite element analysis - steps involved in FEM- Preprocessing phase – discretisation - types of elements | 2 | 20% |
| | Formulation of stiffness matrix (direct method, 1-D element) - formulation of load vector - assembly of global equations - implementation of boundary conditions - solution procedure - post processing phase | 3 | |
| | Simple problems with axial bar element (structural problems only) | 2 | |
| **VI** | Interpolation – selection of interpolation functions - CST element - isoparametric formulation (using minimum PE theorem) – Gauss-quadrature | 4 | 20% |

| | | | |
|---|---|---|---|
| | Solution of 2D plane stress solid mechanics problems (linear static analysis) | 3 | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME309 | METALLURGY AND MATERIALS SCIENCE | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives:**

- To provide physical concepts of atomic radius, atomic structure, chemical bonds, crystalline and non-crystalline materials and defects of crystal structures, grain size, strengthening mechanisms, heat treatment of metals with mechanical properties and changes in structure
- To makee aware of the behavior of materials in engineering applications and select the materials for various engineering applications.
- To understand the causes behind metal failure and deformation
- To determine properties of unknown materials and develop an awareness to apply this knowledge in material design

**Syllabus**

Chemical bonds – crystallography- imperfections- crystallization- diffusion- phase diagrams-heat treatment – strengthening mechanisms- hot and cold working – alloying- ferrous and non ferrous alloys- fatigue-creep- basics, need, properties and applications of modern engineering materials.

**Expected outcome:**

The students will be able to

i. Identify the crystal structures of metallic materials.
ii. Analyze the binary phase diagrams of alloys Fe-Fe3C, etc.
iii. Correlate the microstructure with properties, processing and performance of metals.
iv. Recognize the failure of metals with structural change.
v. Select materials for design and construction.
vi. Apply core concepts in materials science to solve engineering problems.

**Text Books**


1. Jose S and Mathew E V, Metallurgy and Materials Science, Pentagon, 2011
2. Raghavan V, Material Science and Engineering, Prentice Hall,2004


**References**


1. Anderson J.C. *et.al*., Material Science for Engineers,Chapman and Hall,1990
2. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill, 2009
3. Callister William. D., Material Science and Engineering, John Wiley, 2014
4. Clark and Varney, Physical metallurgy for Engineers, Van Nostrand,1964
5. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill,1976
6. Higgins R.A. - Engineering Metallurgy part - I – ELBS,1998
7. Myers Marc and Krishna Kumar Chawla, Mechanical behaviour of materials, Cambridge University press,2008
8. Reed Hill E. Robert, Physical metallurgy principles, 4th Edn. Cengage Learning, 2009
9. Van Vlack -Elements of Material Science - Addison Wesley,1989
10. http://nptel.ac.in/courses/113106032/1
11. http://www.myopencourses.com/subject/principles-of-physical-metallurgy-2
12. http://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-tosolid- State-chemistry-fall-2010/syllabus/
13. http://www.msm.cam.ac.uk/teaching/partIA.php

| COURSE PLAN | | | |
|---|---|---|---|
| **Module** | **Contents** | **Hours** | **End Sem. Exam Marks** |
| **I** | Earlier and present development of atomic structure; attributes of ionization energy and conductivity, electronegativity and alloying; correlation of atomic radius to strength; electron configurations; electronic repulsion Primary bonds: - characteristics of covalent, ionic and metallic bond: attributes of bond energy, cohesive force, density, directional and non-directional and ductility, properties based on atomic bonding:- attributes of deeper, energy well and shallow energy well to melting, temperature, coefficient of thermal expansion - attributes of modulus of elasticity in metal cutting process – Secondary bonds:- classification- hydrogen bond and anomalous behavior of ice float on water, application- atomic mass unit and specific heat, application. *(brief review only, no Universityquestions and internal assessment from these portions.)* | **2** | **15%** |
| | Crystallography:- Crystal, space lattice, unit cell- BCC, FCC, HCP structures - short and long range order – effects of crystalline and amorphous structure on mechanical properties. | 1 | |
| | Coordination number and radius ratio; theoretical density; simple problems - Polymorphism and allotropy. | 1 | |
| | Miller Indices: - crystal plane and direction (brief review) - Attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - Modes of plastic deformation: - Slip and twinning. | 1 | |
| | Schmid's law, equation, critical resolved shear stress,correlation of slip system with plastic deformation in metals and applications. | 1 | |
| **II** | Mechanism of crystallization:Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity. | 1 | 15% |
| | Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory, simple problems | 1 | |
| | Classification of crystal imperfections: - types of dislocation – effect of point defects on mechanical properties - forest of dislocation, role of surface defects on crack initiation. | 1 | |
| | Burgers vector –dislocation source, significance of Frank Read source in metals deformation - Correlation of dislocation density with strength and nano concept, applications. | 1 | |
| | Significance high and low angle grain boundaries on dislocation – driving force for grain growth and applications during heat treatment. | 1 | |
| | Polishing and etching to determine the microstructure and grain size. | 1 | |
| | Fundamentals and crystal structure determination by X – ray diffraction, simple problems –SEM and TEM. | 1 | |
| | Diffusion in solids, Fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems. | 1 | |
| **FIRST INTERNAL EXAMINATION** | | | |

| | | | |
|---|---|---|---|
| **III** | Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types. | 2 | 15% |
| | Coring - lever rule and Gibb`s phase rule - Reactions: monotectic, eutectic, eutectoid, peritectic, peritectoid. | 1 | |
| | Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties changes in austenite, ledeburite, ferrite, cementite, special features of martensite, transformation, bainite, spheroidite etc. | 1 | |
| | Heat treatment: - Definition and necessity – TTT for eutectoid iron–carbon alloy, CCT diagram, applications - annealing, normalizing, hardening, spheroidizing. | 1 | |
| | Tempering:- austermpering, martempering and ausforming- Comparative study on ductility and strength with structure of pearlite, bainite, spherodite, martensite, tempered martensite and ausforming. | 1 | |
| | Hardenability, Jominy end quench test, applications- Surface hardening methods:- no change in surface composition methods :- Flame, induction, laser and electron beam hardening processes- change in surface composition methods :carburizing and Nitriding; applications. | 2 | |
| **IV** | Types of Strengthening mechanisms: - work hardening, equation - precipitation strengthening and over ageing- Dispersion hardening. | 1 | 15% |
| | Cold working: Detailed discussion on strain hardening; recovery; re-crystallization, effect of stored energy; re-crystallization temperature - hot working, Bauschinger effect and attributes in metal forming. | 1 | |
| | Alloy steels:- Effects of alloying elements on steel: dislocation movement, polymorphic transformation temperature, alpha and beta stabilizers, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement in corrosion resistance, mechanical properties | 1 | |
| | Nickel steels, Chromium steels etc. - Enhancement of steel properties by adding alloying elements: Molybdenum, Nickel, Chromium, Vanadium, Tungsten, Cobalt, Silicon,Copper and Lead. | 1 | |
| | High speed steels:- Mo and W types, effect of different alloying elements in HSS | 1 | |
| | Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, Microstructure, properties and applications. | 1 | |
| | Principal Non ferrous Alloys: - Aluminum, Copper, Magnesium, Nickel, study of composition, properties, applications, reference shall be made to the phase diagrams whenever necessary. | 1 | |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Fatigue: - Stress cycles – Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve. | 1 | 20% |
| | Factors affecting fatigue strength: stress concentration, size effect, surface roughness, change in surface properties, surface residual stress. | 1 | |

| | | | |
|---|---|---|---|
| | Ways to improve fatigue life – effect of temperature on fatigue, thermal fatigue and its applications in metal cutting | 1 | |
| | Fracture: – Brittle and ductile fracture – Griffith theory of brittle fracture – Stress concentration, stress raiser – Effect of plastic deformation on crack propagation. | 1 | |
| | Transgranular, intergranular fracture - Effect of impact loading on ductile material and its application in forging, applications - Mechanism of fatigue failure. | 1 | |
| | Structural features of fatigue: - crack initiation, growth, propagation - Fracture toughness (definition only) – Ductile to brittle transition temperature (DBTT) in steels and structural changes during DBTT, applications. | 1 | |
| **VI** | Creep: - Creep curves – creep tests - Structural change: deformation by slip, sub-grain formation, grain boundary sliding | 1 | 20% |
| | Mechanism of creep deformation - threshold for creep,prevention against creep - Super plasticity: need and applications | 1 | |
| | Composites:- Need of development of composites - geometrical and spatial Characteristics of particles – classification - fiber phase: - characteristics, classifications -composites:- Need of development of composites - | 2 | |
| | Modern engineering materials: - only fundamentals, need, properties and applications of, intermetallics, maraging steel, super alloys, Titanium – introduction to nuclear materials, smart materials and bio materials. | 2 | |
| | Ceramics:-coordination number and radius ratios- AX, AmXp, AmBmXp type structures – applications. | 1 | |
| **END SEMESTER EXAMINATION** | | | |

## QUESTION PAPER PATTERN

Maximum Marks : 100 Exam Duration: 3 Hrs

**PART A**
4 Questions uniformly covering modules 1 and 2. Each question carries 10 marks. Students will have to answer any three questions out of four. (3X10=30 marks)

**PART B**
4 Questions uniformly covering modules 3 and 4. Each question carries 10 marks. Students will have to answer any three questions out of four. (3X10=30 marks)

**PART C**
6 Questions uniformly covering modules 5 and 6. Each question carries 10 marks. Students will have to answer any four questions out of six. (4X10=40 marks)

**Note:** In all parts, each question can have a maximum of 4 sub questions, if needed.

| Course code | Course Name | L-T-P – Credits | Year of Introduction |
|---|---|---|---|
| ME311 | MANUFACTURING PROCESSES | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

- To introduce the different types of manufacturing processes used to create different forms of metals/alloys/composites.

**Syllabus**

Introduction to material casting processes - welding process and the physics of welding - mathematical/ physical description of forming processes – rolling and types – forging processes – advanced manufacturing – non-traditional machining – design for manufacturing

**Expected outcome**.

- The students will become aware of the types of processes used for the manufacturing the parts of automobile.

**Text Books:**

1. Helmi A Youssef, Hassan A El-Hofy and Mahmoud H Ahmed, Manufacturing Technology (materials, processes and equipments) , CRC Press, 2017
2. Kalapakjian and Schmid , Manufacturing Engineering and Technology, Pearson, 7e, 2013

**References:**

1. Hine and Rosenthal, Principles of Metal Casting , Tata McGraw Hill India, 1995
2. P.R.Beeley, Foundry Technology, Butterworths Publication, 1972

**Course Plan**

| Module | Contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Casting of metallic materials – introduction – expendable mold casting processes – sand casting, shell, vacuum, slurry, plaster and ceramic molding, expandable pattern casting – permanent mold castings – die and centrifugal casting – melting furnaces – cupolas and crucible furnace –cleaning and finishing of castings – quality of castings – defects & method of inspection of defects | 7 | 15% |
| II | Bulk forming of metallic materials – Classification – Forging processes – open die, close die, special forging processes – forging equipment and defects<br>Rolling processes – flat, section, tube , and special rolling processes and rolling defects – Extrusion – classification – equipment & defects<br>Drawing – rod, wire and tube – classification and drawing die | 7 | 15% |
| FIRST INTERNAL EXAMINATION | | | |
| III | Sheet metal forming processes – Classification – Shearing processes and mechanism – Bending processes – parameters – springback and residual stresses – bending equipment – stretch forming – Deep drawing – blank holding pressure, ironing, deep drawing force, redrawing – hydroforming – spinning – | 8 | 15% |

| | | | |
|---|---|---|---|
| | conventional, flow tunneling and tube spinning. | | |
| **IV** | Joining processes – Fusion welding – gas, thermit, electric arc, resistance and high energy beam welding – Solid state welding – cold, diffusion, explosion, forge, friction, hot pressure, roll, and ultrasonic welding – Solid-liquid state welding – brazing, soldering and adhesive bonding – welding of plastics – metallurgy of welded joints – welding defects – quality control – destructive and non-destructive tests – mechanical joining. | 8 | 15% |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Non-traditional machining – Jet machining – abrasive, water jet, and abrasive water jet – ultrasonic machining – USM equipment and process capabilities – Chemical milling & photochemical machining - ECM – elements, equipment and process capabilities – electrochemical grinding – EDM – sinking, milling and wire cutting – EBM – LBM – plasma arc cutting | 8 | 20% |
| **VI** | Advanced manufacturing techniques – near net shape manufacturing – metal injection molding and rapid prototyping – microfabrication technology – microcutting, microfinishing, and nonconventional micromachining – application of nano technology – sustainable and green manufacturing.<br>Manufacturing process capabilities – process selection factors – process information maps – ranking strategy – design for manufacturing – casting, sheet metal forming, die forging, welding, and assembly. | 7 | 20% |
| **END SEMESTER EXAM** | | | |

## QUESTION PAPER PATTERN

Maximum Marks : 100 Exam Duration: 3 Hrs

**PART A**
4 Questions uniformly covering modules 1 and 2. Each question carries 10 marks. Students will have to answer any three questions out of four. (3X10=30 marks)

**PART B**
4 Questions uniformly covering modules 3 and 4. Each question carries 10 marks. Students will have to answer any three questions out of four. (3X10=30 marks)

**PART C**
6 Questions uniformly covering modules 5 and 6. Each question carries 10 marks. Students will have to answer any four questions out of six. (4X10=40 marks)

**Note:** In all parts, each question can have a maximum of 4 sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME312 | METROLOGY AND INSTRUMENTATION | 3-0-0-3 | 2016 |

**Prerequisite: Nil**

**Course Objectives:**

- To understand the working of linear and angular measuring instruments.
- To familiarize with the working of optical measuring instruments and fundamentals of limits and limit gauges.
- To give basic idea about various methods for measurement of screw thread and surface finish parameters.
- To give an exposure to advanced measuring devices and machine tool metrology.
- To provide students an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement.
- To provide basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.

**Syllabus**

Introduction to Metrology - Errors in Measurement- Basic standards of length - Linear Measurement, Comparators - Angular Measurement - Limits and Limit gauges - Optical Measuring Instruments - Screw thread measurement - Measurement of surface texture - Machine tool metrology - Coordinate Measuring Machine (CMM) and Machine Vision.
Introduction to Mechanical Measurement - Motion and Dimension measurement, Strain and Stress Measurement - Measurement of Force, Torque and Temperature Measurement.

**Expected outcome:**

The students will be able to

i. Understand the working of linear and angular measuring instruments.
ii. Know the fundamentals of limits and limit gauges, various methods for measurement of screw thread and surface roughness parameters and the working of optical measuring instruments.
iii. Get an exposure to advanced measuring devices and machine tool metrology.
iv. Acquire an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement.
v. Get basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.

**Text books**

1. Anand K Bewoor, Vinay A Kulkarni, Metrology & Measurement, McGraw-Hill, 2009
2. Ernest O. Doebelin, Dhanesh N. Manik, Measurement Systems Application and Design, McGraw-Hill, 2004
3. Galyer J.F.W., Schotbolt C.R., Metrology for Engineers, ELBS,1990
4. Thomas G. Beckwith, John H. L., Roy D. M., Mechanical Measurements, 6/E , Pearson Prentice Hall, 2007

**Reference books**


1. ASME, Hand book of Industrial Metrology,1998
2. Hume K. J., Engineering Metrology, Macdonald &Co. Ltd.,1990
3. J.P.Holman, Experimental Methods for Engineers,Mcgraw-Hill, 2007
4. Sharp K.W.B., Practical Engineering Metrology, Sir Isaac Pitman & Sons Ltd.,1958


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Concept of measurement:-Introduction to Metrology; Need for high precision measurements; Terminologies in Measurement-Precision, accuracy, sensitivity, calibration. | 1 | 15% |
| | Errors in Measurement, types of errors, Abbe's Principle. | 1 | |
| | Basic standards of length- Line standard, End standards, Wavelength standard; Various Shop floor standards. | 1 | |
| | Linear Measurement – Slip gauges, wringing, grades; Surface plate; Dial indicators; Height gauges and Vernier calipers. | 1 | |
| | Comparators- mechanical, electrical, optical and pneumatic. | 1 | |
| | Angular Measurement – Bevel protractor; Sine Bar, principle and use of sine bar, sine centre; Angle gauges. | 1 | |
| | Sprit level; Angle Dekkor; Clinometers. | 1 | |
| II | Limits and Limit gauges – Making to suit, selective assembly, systems of limits and fits; Types of fits; Hole basis system and Shaft basis system. | 1 | 15% |
| | Standard systems of limits and fits; Shaft and Hole system; Tolerance, allowance and deviation (as per BIS). | 1 | |
| | Simple problems on tolerance and allowance, shaft and hole system. | 1 | |
| | Limit Gauges – GO and NO GO gauges; types of limit gauges. | 1 | |
| | Gauge design - Taylor's principle of gauging; Gauge tolerance, disposition of gauge tolerance, wear allowance. | 1 | |
| | Optical Measuring Instruments: - Benefits of using light waves as standards; Monochromatic light; Principle of Interference. | 1 | |
| | Interference band using optical flat, application in surface measurement. | 1 | |
| | Interferometers – NPL flatness interferometer, Pitter-NPL gauge interferometer. | 1 | |
| | **FIRST INTERNAL EXAMINATION** | | |
| | Screw thread measurement – Screw thread terminology; Measurement of major diameter; Measurement of minor or root diameter. | 1 | |
| | Measurement of pitch; Measurement of effective diameter with two wire method and three wire method. | 1 | |
| | Measurement of flank angle and form by profile projector and | 1 | |

| | | | |
|---|---|---|---|
| **III** | microscope. | | **15%** |
| | Measurement of surface texture – Meaning of surface texture, roughness and waviness; Analysis of surface traces, peak to valley height, R.M.S. value, Centre Line Average and $R_a$ value, Rt, Rz etc. | **1** | |
| | Methods of measuring surface roughness – Stylus probe, Tomlinson surface meter, Talysurf; Terms used in surface roughness measurement – assessment length, roughness width cut-off, sampling length and evaluation length. | **1** | |
| | Interference method for measuring surface roughness – using optical flat and interferometers. | **1** | |
| | Autocollimator, principle and use of autocollimator. | **1** | |
| **IV** | Machine tool metrology – Alignment testing of machine tools like lathe, milling machine, drilling machine. | **1** | **15%** |
| | Advanced measuring devices – Laser interferometers. | **1** | |
| | Coordinate Measuring Machine (CMM) – Introduction to CMM; Components and construction of CMM. | **1** | |
| | Types of CMM; Advantages and application of CMM | **1** | |
| | CMM probes, types of probes – contact probes and non contact probes | **1** | |
| | Machine Vision – Introduction to machine vision, functions, applications and advantages of machine vision. | **1** | |
| | Steps in machine vision | **1** | |
| | **SECOND INTERNAL EXAMINATION** | | |
| **V** | Introduction to Mechanical Measurement – significance of mechanical measurement; Fundamental methods of measurement; Classification of measuring instrument. | **1** | **20%** |
| | Stages in generalized measuring system – Sensor-Transducer stage, Signal-Conditioning stage, Readout-Recording stage; Types of input quantities; Active and Passive transducers. | **1** | |
| | Performance characteristic of measuring devices – Static characteristics – Accuracy, Precision, Repeatability, Sensitivity, Reproducibility, Drift, Resolution, Threshold, Hysteresis, Static calibration. | **1** | |
| | Dynamic characteristics- different order systems and their response-, Measuring lag, Fidelity, Dynamic error; Types of errors in measurement. | **1** | |
| | Transducers – Working, Classification of transducers. | **1** | |
| | Motion and Dimension measurement – LVDT – Principle, applications, advantages and limitations. | **1** | |
| **V1** | Strain and Stress Measurement - Electrical resistance strain gauge - Principle, operation. | **1** | |
| | Measurement of Force and Torque – Strain-Gauge Load Cells, Hydraulic and Pneumatic load cells – basic principle and three component force measurement using piezoelectric quartz crystal. | **1** | |
| | Torque Measurement – Dynamometers – Mechanical, Hydraulic and Electrical. | **1** | |
| | Vibration measurement – Vibrometers and Accelerometers – Basic principles and operation. | **1** | |

| | | | |
|---|---|---|---|
| | Temperature Measurement – Use of Thermal Expansion – Liquid-in-glass thermometers, Bimetallic strip thermometer, Pressure thermometers. | **1** | **20%** |
| | Thermocouples – Principle, application laws for Thermocouples, Thermocouple materials and construction, measurement of Thermocouple EMF. | **1** | |
| | Resistance Temperature Detectors (RTD); Thermistors; Pyrometers (Basic Principles). | **1** | |
| **END SEMESTER EXAMINATION** | | | |



**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P – Credits | Year of Introduction |
|---|---|---|---|
| ME314 | MACHINE DESIGN - II | 3-0-0-3 | 2016 |

**Prerequisite : ME307 Machine design - II**

**Course Objectives**

- To introduce the design considerations needed for different types of machine components and

**Syllabus**

Introduction to design of different types of bearings, clutches, brakes – IC engine parts design – Design recommendations

**Expected outcome**.

- The students will become aware of the machine components, forces, stresses affecting them and aspects of designing them.

**Text Books:**

1. C.S,Sarma, KamleshPurohit, Design of Machine Elements Prentice Hall of India Ltd NewDelhi
2. M. F. Spotts, T. E. Shoup, Design of Machine Elements, Pearson Education, 8e, 2003
3. T. Krishna Rao, Design of machine Elements volume 2 I K International Publishing House Pvt. Ltd New Delhi, 2011
4. V.B.Bhandari, Design of Machine Elements McGraw Hill Book Company, 4e, 2016

**Data book ( permitted for reference in the University examination)**

1. K. Lingaiah , Machine Design Data hand book, Suma Publishers, Bangalore/ Tata McGraw Hill

**References:**

1. Doughtie V.L., &Vallance A.V., Design of Machine Elements, McGraw Hill Book Company, 1964
2. J. E. Shigley, Mechanical Engineering Design, McGraw Hill Book Company, 5e, 1986
3. Juvinall R.C &Marshek K.M., Fundamentals of Machine Component Design, John Wiley, 5e, 2011
4. Siegel, Maleev& Hartman, Mechanical Design of Machines, International Book Company.

**Course Plan**

| Module | Contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Classification of design - Different phases in design process - design factors and considerations Engineering materials and their physical properties as applied to design - Selection of materials - Factors of safety in design – Endurance limit of materials- theories of failure - Guest's theory - Rankine's theory - St. Venant's theory - Haigh's theory - Von Mises&Hencky theory - shock and impact loads - fatigue loading - endurance limit stress- Factors affecting endurance limit - Factor of safety - creep and thermal stresses | 8 | 15% |
| II | Design of shafts on the basis of strength - Design of shaft on the basis of rigidity - Design of hollow shafts -design for static and fatigue loads- repeated loading- reversed bending<br>Design of welded joints- Representation of welds - stresses in fillet and butt welds- design for static loads - bending and torsion in welded | 7 | 15% |

| | | | |
|---|---|---|---|
| | joints- eccentrically loaded welds - design of welds for variable loads. | | |
| **FIRST INTERNAL EXAMINATION** | | | |
| **III** | Clutches - friction clutches- design considerations-multiple disc clutches-cone clutch- centrifugal clutch<br>Brakes- Classification, internal expanding shoe brake, disc brake<br>Spring- Design of leaf spring, coil spring , torsion bar | 6 | 15% |
| **IV** | Design of bearings - Types - Selection of a bearing type - bearing life - Rolling contact bearings – static and dynamic load capacity - axial and radial loads - selection of bearings - dynamic equivalent load - lubrication and lubricants – viscosity<br>Journal bearings - hydrodynamic theory - design considerations - heat balance - bearing characteristic number - hydrostatic bearings. | 6 | 15% |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Gears- classification- Gear nomenclature - Tooth profiles - Materials of gears - design of spur, helical, bevel gears and worm & worm wheel - Law of gearing - virtual or formative number of teeth- gear tooth failures- Beam strength - Lewis equation- Buckingham's equation for dynamic load | 8 | 20% |
| **VI** | Design of Internal Combustion Engine parts- Piston, Cylinder, Connecting rod, Crank shaft, Flywheel & valves | 7 | 20% |
| **END SEMESTER EXAM** | | | |

## QUESTION PAPER PATTERN

Maximum Marks : 100 Exam Duration: 3 Hrs

**PART A**
3 Questions uniformly covering modules 1 and 2. Each question carries 15 marks. Students will have to answer any two questions out of four. (2X15=30 marks)

**PART B**
3 Questions uniformly covering modules 3 and 4. Each question carries 15 marks. Students will have to answer any two questions out of four. (2X15=30 marks)

**PART C**
3 Questions uniformly covering modules 5 and 6. Each question carries 20 marks. Students will have to answer any two questions out of four. (2X20=40 marks)

**Note:** Each question can have maximum of 4 sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME322 | HEAT TRANSFER | 2-1-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

- To introduce the concepts of heat transfer to enable the students to design components subjected to thermal loading.

**Syllabus**

One dimensional steady state heat conduction - Extended Surfaces- Unsteady state heat Conduction - Free convection- Forced convection – Radiation heat transfer – Heat exchangers – condensers - evaporators – boiling heat transfer – heat transfer in gas turbine combustion chamber – ablative heat transfer – aerodynamic heating – moving boundary problems.

**Expected Outcome**

The students will

- Get idea about basic modes of Heat transfer.
- Be able to solve practical heat transfer problems.
- Be able to analyse heat exchangers.

**Text Books:**

1. S.C. Sachdeva, "Fundamentals of Engineering Heat & Mass Transfer", Wiley Eastern Ltd., New Delhi,1981.
2. Yunus A. Cengel, Heat Transfer – A Practical Approach, Tata McGraw Hill Edition, 2003.

**Data Book (Approved for use in the examination)**

- C P Kothandaraman and S Subramanyan, Heat and Mass Transfer Databook, New Age International, 2014

**References:**

1. C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.
2. J.P. Holman, "Heat Transfer", McGraw-Hill Book Co., Inc., New York, 6e, 1991.
3. John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New York, 1995.
4. John H. Lienhard, "A Heat Transfer Text Book", Prentice Hall Inc., 1981.
5. P. S. Ghoshdasidar , "Computer simulation of low and Heat transfer" McGraw-Hill Book Co, Inc, NewDelhi, 1998.
6. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002

**Course Plan**

| Module | Contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Basic Modes of Heat Transfer – One dimensional steady state heat conduction: Composite Medium – Critical thickness. | 2 | 15% |

| | | | |
|---|---|---|---|
| | Effect of variation of thermal Conductivity – Extended Surfaces – Unsteady state. | 2 | |
| | Heat Conduction: Lumped System Analysis, Heat Transfer in Semi-infinite and infinite solids, | 3 | |
| | Use of Transient, Temperature charts | 2 | |
| **II** | Introduction, Free convection in atmosphere free convection on a vertical flat plate – Empirical relation in free convection. | 2 | 15% |
| | Forced convection. | 2 | |
| | Laminar and turbulent convective heat transfer analysis in flows between parallel plates, over a flat plate and in a circular pipe. | 2 | |
| | Empirical relations, application of numerical techniques in problem solving. | 3 | |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Introduction to Physical mechanism of radiation heat transfer | 1 | 15% |
| | Radiation properties – Radiation shape factors. | 2 | |
| | Heat exchange between non – black bodies. | 2 | |
| | Radiation shields. | 1 | |
| **IV** | Heat exchangers-Classification. | 1 | 15% |
| | Temperature Distribution – Overall heat transfer coefficient. | 2 | |
| | Heat Exchange Analysis – LMTD Method.<br>Heat Exchange Analysis –E-NTU Method. | 3 | |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Special heat exchangers-condensers. | 1 | 20% |
| | Special heat exchangers- evaporators. | 1 | |
| | Condensation heat transfer. | 1 | |
| | Boiling heat transfer phenomenon,boiling co- relations. | 2 | |
| **VI** | Heat transfer in gas turbine combustion chamber (descriptive only) | 2 | 20% |
| | Ablative heat transfer. | 1 | |
| | Aerodynamic heating-Moving boundary problems. | 1 | |
| | Numerical treatment. | 2 | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

Maximum marks: 100 Exam duration: 3 hours

The question paper shall consist of three parts

**Part A**

4 questions uniformly covering modules I and II. Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**

4 questions uniformly covering modules III and IV. Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**

6 questions uniformly covering modules V and VI. Each question carries 10 marks

Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

**Note**: In all parts, each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P - Credits | Year of Introduction |
|---|---|---|---|
| ME331 | MANUFACTURING TECHNOLOGY LABORATORY – I | 0-0-3-1 | 2016 |

**Prerequisite: ME220 Manufacturing Technology**

**Course Objectives:**

1. To practice on machine tools and identify, manipulate and control various process parameters during machining processes in manufacturing industry.
2. To practice arc and gas welding technologies.
3. To gain knowledge on the structure, properties, treatment, testing and applications of Steel, Cast Iron and Brass.

**List of Exercises/Experiments :**

**Centre Lathe**

Study of lathe tools: - tool materials - selection of tool for different operations - tool nomenclature and attributes of each tool angles on cutting processes – effect of nose radius, side cutting edge angle, end cutting edge angle and feed on surface roughness obtainable – tool grinding.

- Study the different methods used to observe how the work-piece is precisely fixed on lathe.
- Study the **optimum aspect ratio** of work-piece to avoid vibration and wobbling during turning.
- Machine tool **alignment of test** on the lathe.
- **Re-sharpening** of turning tool to specific geometry

**1. Exercises on centre lathe**:- Facing, plain turning, step turning and parting – groove cutting, knurling and chamfering - form turning and taper turning – eccentric turning, multi-start thread, square thread and internal thread etc.

**2. Exercises on lathe:** - Measurement of cutting forces in turning process and correlation of the surface roughness obtainable by varying feed, speed and feed.

**3**. Measurement of **cutting temperature and tool life** in turning and machine tool **alignment test** on lathe machine.

**4. Exercises on Drilling machine**- drilling, boring, reaming, tapping and counter sinking etc.

**5. Exercises on drilling machine: -** Measurement of cutting forces in drilling process and correlate with varying input parameters.

**6. Exercises on Shaping machine**

Exercises on shaping machine: - flat surfaces, grooves and key ways.

**7. Exercises on Slotting machine**

Exercises on slotting machine: - flat surfaces, grooves and key ways.

**Exercises on Milling machine**

**8.** Exercises on milling machine: - face milling, end milling – spur and helical gear cutting – milling of keyways etc.

**9**. Exercises on milling machine: **-** Measurement of cutting forces in milling process and

correlate the surface roughness obtainable by varying input parameters.

**10** Machine tool **alignment test** on milling machine

**Planing and Broaching machine**

**11**. Study and demonstration of broaching machine.

**12.** Exercises on planing machine

**Exercises on Welding**

**13**. Exercises on arc and gas welding: - butt welding and lap welding of M.S. sheets.

**Exercises on Grinding machine**

**14**. Exercise on surface grinding, cylindrical grinding and tool grinding etc.

**15**. Measurement of cutting forces and roughness in grinding process and correlate with varying input parameters.

**Metallurgy**

**16. Specimen preparation**, etching & microscopic study of Steel, Cast iron and Brass and Grain size measurement.

**17. Heat treatment study**:–Effect on mechanical properties and microstructure of Steel, Cast Iron and Brass.

**18.** Studies of various quenching mediums, **Carryout heat treatments on steel** based on ASM handbook vol.4 and observe the hardness obtained.

**A minimum of 12 experiments are mandatory out of total 18 experiments but all the experiments mentioned in metallurgy are mandatory.**

Besides to the skill development in performing the work, oral examination should be conducted during end semester examination.

The student's assessment, continuous evaluation, awarding of sessional marks, oral examination etc. should be carried out by the assistant professor or above.

**Expected outcomes:**

The students will be able to

1. Identify various process parameters and their influence on surface properties of various metals.
2. Recommend appropriate speed, feed and depth of cut for various processes on lathe machine.
3. Position, hold and locate work material and cutting tools in various basic machine tools.
4. Choose suitable welding process for different metals.
5. Choose appropriate heat treatment process for different metals

**Text Books:**


1. Acharkan. N., Machine Tool Design Vol. 1 to 4, MIR Publication, 2000.
2. HMT, Production Technology, Tata McGraw Hill, 2001
3. W. A. J. Chapman, Workshop Technology Part I, ELBS & Edward Arnold Publishers, 1956

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME332 | COMPUTER AIDED DESIGN AND ANALYSIS LAB | 0-0-3-1 | 2016 |

**Prerequisite: ME308 Computer aided design and analysis**

**Course Objectives:**

- To provide working knowledge on Computer Aided Design methods and procedures
- To impart training on solid modelling software
- To impart training on finite element analysis software

**Syllabus**

Introduction to solid modeling and Finite Element Analysis software.

Exercises on modeling and assembly.

a. Creation of higher end 3D solid models.(minimum 3 models)

b. Creation of assembled views of riveted joints, cotter joints and shaft couplings. (minimum 3 models)

Exercises on the application of Finite Element Method/Finite Volume Method to engineering systems:-

a. Structural analysis. (minimum 3 problems)

b. Thermal analysis. (minimum 2 problems)

c. Fluid flow analysis. (minimum 1 problem)

**Expected outcome:**

The students will be able to

i. Gain working knowledge in Computer Aided Design methods and procedures

ii. Solve simple structural, heat and fluid flow problems using standard software

**Points to note:**

- Any appropriate solid modeling software (like CATIA, Solids Works, ProE, IDEAS, Siemens Solid Edge and NX, free software, etc.) and package (like ANSYS, Comsol Multi Physics, NASTRAN, ABAQUS, ADINA, Siemens Femap Nastran,free software etc.) may be used.
- **Evaluation**

  Class exercises 60 marks
  Regular class viva 10 marks
  Final internal exam using software 30 marks
  All the above three evaluations are mandatory.

**References Books**:


1. Daryl Logan, A First course in Finite Element Method, Thomson Learning, 2007
2. David V Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill,2003
3. Ibrahim Zeid, CAD/ CAM Theory and Practice, McGraw Hill, 2007
4. Mikell P. Groover and Emory W. Zimmer, CAD/ CAM – Computer aided design and manufacturing, Pearson Education,1987
5. T. R. Chandrupatla and A. D. Belagundu, Introduction to Finite Elements in Engineering, Pearson Education, 2012

| Course code | Course Name | L-T-P - Credits | Year of Introduction |
|---|---|---|---|
| ME333 | HEAT ENGINES LAB | 0-0-3-1 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

- To give hands on experience in tesing different properties of fuels & lubricants
- To perform characteristic tests on petrol and diesel engines.

**List of Exercises/Experiments :**

1. Determination of viscosity using Saybolt Viscometer.
2. Determination of viscosity using Redwood Viscometer.
3. Determination of Flash point and Fire point using Pensky Marten's Apparatus.
4. Fuel Injection Pump Testing and Calibration of Fuel Injection pump.
4. Performance Test on Multi cylinder Four Stroke Diesel Engine.
5. Performance Test on Multi cylinder Four Stroke Petrol Engine.
6. Retardation Test on Twin cylinder Four Stroke Diesel Engine.
7. Morse Test on Multi cylinder Four Stroke Petrol engine.
8. Heat Balance Test on Multi cylinder Four Stroke Diesel Engine.
9. Volumetric Efficiency Test on Multi cylinder Four Stroke Diesel Engine.
10. Volumetric Efficiency Test on Multi cylinder Four Stroke Petrol Engine.
11. Cooling curve Test on Twin cylinder Four stroke Diesel Engine.
12. Valve Timing on Four stroke Diesel/ Petrol Engine
13. Determination of calorific value of liquid fuel using bomb calorimeter
14. Determination of calorific value of gaseous fuel using Junker's calorimeter

**Note: Minimum 12 experiments are mandatory**

**Expected outcome**:

The students will be able to

i. Test different Properties of fuels and lubricants.
ii. Test petrol and diesel engines to evaluate their performance

**List of Equipments**

- Saybolt viscometer
- Redwood viscometer
- Pensky Marten's flash & fire point apparatus
- Fuel pump testing and calibrating machine
- Single/multicylinder engine (petrol/diesel) for valve timing
- Single/Twin cylinder 4 stroke diesel engine with rope drum/electrical dynamometer
- Multi cylinder petrol engine with eddycurrent/hydraulic dynamometer
- Multi cylinder diesel engine with eddycurrent/hydraulic dynamometer
- Bomb Calorimeter
- Junker's gas calorimeter

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME334 | MANUFACTURING TECHNOLOGY LABORATORY – II | 0-0-3-1 | 2016 |

**Prerequisite: ME312 Metrology and Instrumentation**

**Course Objectives:**

- To provide programming practice on CNC machine tools
- To impart knowledge on the fundamental concepts and principles of metrology
- To explain the need of various modern measuring instruments and precision measurements

| List of Experiments/Exercises: | Sessions |
|---|---|
| Exercise on grinding machine | 1 |
| Study and preparation of program, simulation and exercise on CNC lathe:-turning, step turning, taper turning, thread cutting, ball and cup turning etc. | 2 |
| Study and preparation of program, simulation and exercise on CNC milling machine: - surface milling, pocket milling, contour milling etc. | 2 |
| **Basics for mechanical measurements**<br>Calibration of vernier caliper, micrometer and dial gauge etc.<br>Determination of dimensions of given specimen using vernier caliper, micrometer, height gauge, bore dial gauge etc.<br>Determination of dimensions of a rectangular, square, cylindrical specimens using slip gauges and comparing with height gauge/vernier caliper etc | 1 |
| **Experiments on Limits, Fits and Tolerance**<br>Determine the class of fits between given shaft and hole. etc. | |
| **Linear measurements**<br>Study of different linear measuring instruments.<br>Calibration of LVDT using slip gauges. | 1 |
| **Straightness error measurement**<br>Study of different straightness error measuring instruments – basic principle of auto collimator and spirit level.<br>Measurement of straightness error of a CI surface plate using auto collimator and comparing with sprit level.<br>laser interferometer used to determine straightness error<br>To check straightness error of a straight edge by the wedge method using slip gauges. | 1 |
| **Angle measurements**<br>Angular measurements using bevel protractor, combination sets, clinometers, angle dekkor etc.<br>Measurement of angle and width of a V-block and comparing with combination sets.<br>Measurement of angle using sine bar of different samples. | 1 |

| | |
|---|---|
| **Out of roundness measurement**<br>Study of different methods used for measurement out of roundness<br>Measurement of out of roundness using form measuring instrument<br>Measurement of out of roundness using V-block and dial gauge<br>Measurement of out of roundness using bench centre and dial gauge etc. | **1** |
| **Screw thread measurement**<br>Measurement of screw thread parameters using two wire and three wire method.<br>Measurement of screw thread parameters using tool maker's microscope etc.<br>Measurement of screw thread parameters using thread ring gage, thread plug gage, thread<br>snap gage, screw thread micrometer, optical comparator etc. | **1** |
| **Bore measurement**<br>Measurement of a bore by two ball method.<br>Measurement of a bore by four ball method.<br>Bore measurement using slip gauges and rollers.<br>Bore measurement using bore dial gauge etc. | **1** |
| **Calibration and determination of uncertainties**<br>Strain measurement using strain gauge load cells.<br>Calibration of a cantilever strain gauge load cell.<br>**Rotation measurement**<br>Determination of rpm using tachometer, optical tachometer and stroboscope, etc. | **1** |
| **Area determination**<br>Study of planimeter and Green's theorem<br>Determination of given irregular area using planimeter. | **1** |
| **Gear metrology**<br>Types of gears – gear terminology – gear errors - study of Profile Projector.<br>Measurement of profile error and gear parameters using profile projector etc.<br>**Use of Comparators**<br>Exercise on comparators: mechanical, optical, pneumatic and electronic comparators. | **1** |
| **Use of Tool makers microscope**<br>Study of tool maker's microscope – use at shop floor applications.<br>Measurement of gear tooth parameters using tool maker's microscope.<br>Measurement of different angles of single point cutting tool using tool maker's microscope. | **1** |
| **Surface roughness measurement**<br>Measurement of surface roughness using surface profilometer /roughness measuring machine of turned, milled, grounded, lapped and glass etc specimens. | **1** |
| **Squareness measurement**<br>Determination of squareness of a trisquare using angle plate and slip gauges. | **1** |
| **Flatness measurement**<br>Study of optical flat and variation of fringe patterns for different surfaces.<br>Determination of parallelism error between micrometer faces.<br>Compare given surface using optical flat with interpretation chart**.** | **1** |
| **Vibration measurement**<br>Measurement of displacement, velocity and acceleration of vibration. | **1** |

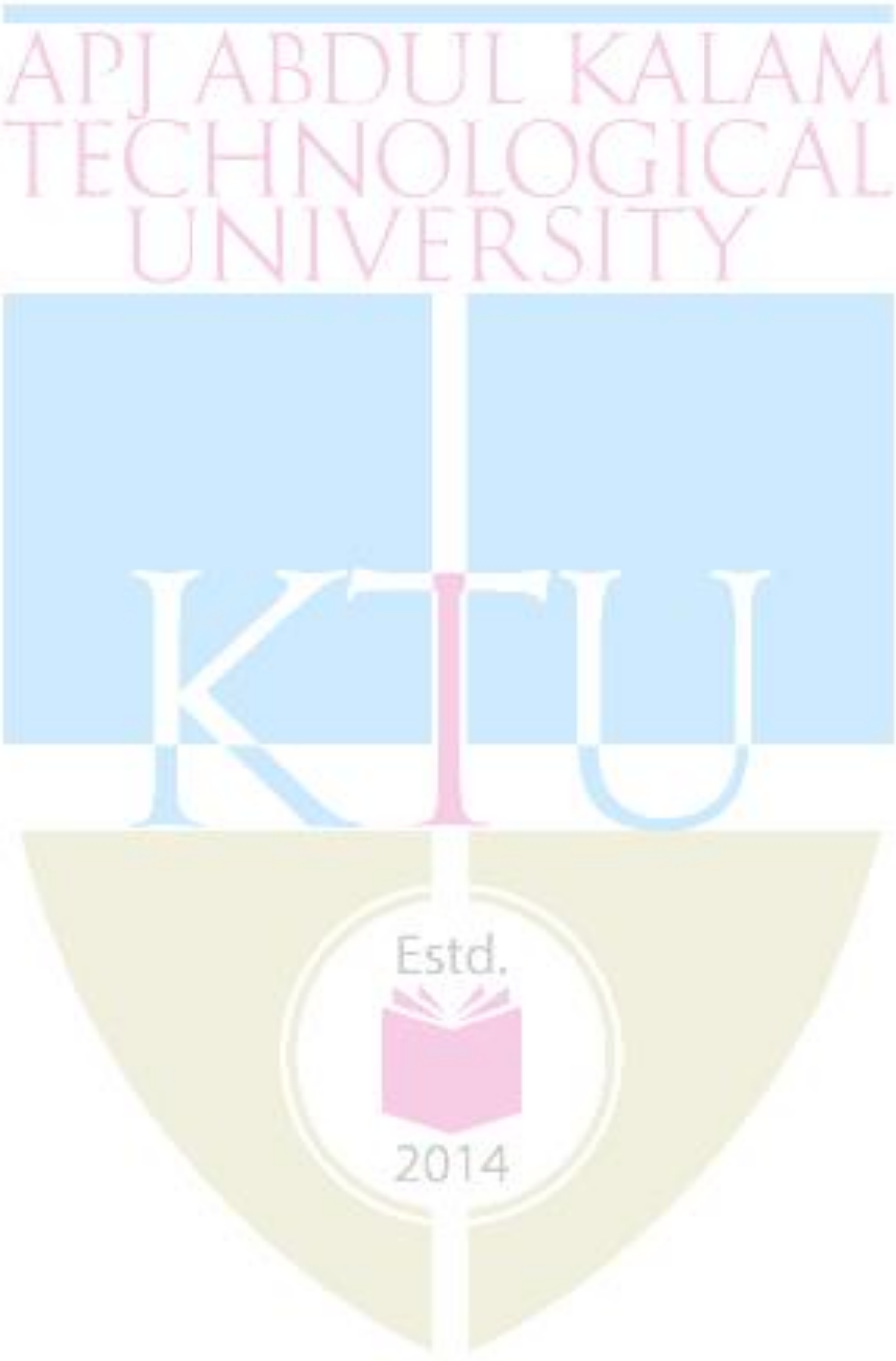
| | |
|---|---|
| **Use of Pneumatic comparator**<br>Checking the limits of dimensional tolerances using pneumatic comparator<br>Calibration using air plug gauge etc | **1** |

**Reference books**


1. Collett, C.V. and Hope, A.D, Engineering Measurements, Second edition, ELBS/Longman,1983
2. Sharp K.W.B. and Hume, Practical Engineering Metrology, Sir Isaac Pitman and sons Ltd, London,1958
3. Shotbolt C.R. and Gayler J.F.W, Metrology for Engineers, 5th edition, ELBS, London,1990
4. Yoram Koren, Numerical Control of Machine Tools, McGraw-Hill,1983


**A minimum of 12 experiments are mandatory but the experiments/exercises in CNC machines are mandatory.**

The academic evaluation shall be carried out by faculty.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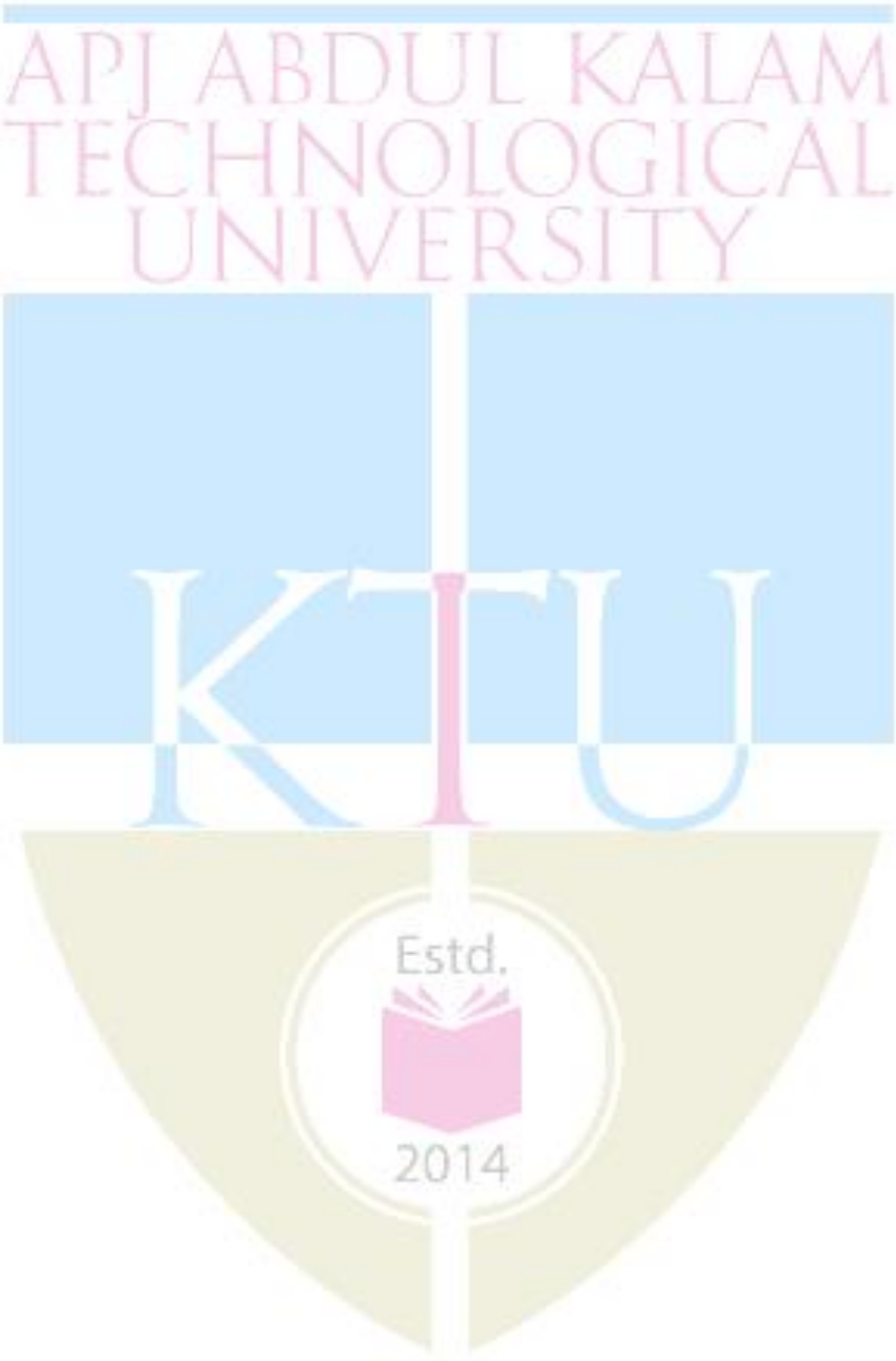
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| Course code | Course Name | L-T-P - Credits | Year of Introduction |
|---|---|---|---|
| ME335 | PRODUCTION ENGINEERING LAB | 0-0-3-1 | 2016 |

**Prerequisite: Nil**

**Course Objectives**

- To give an idea about different manufacturing processes and to perform different types of tests on various works.

**List of Exercises/Experiments :**

Experiment on arc/TIG/MIG welding: -

1. butt welding and
2. lap welding

Experiment on lathe:-

3. Facing,
4. plain turning,
5. step turning,
6. parting – groove cutting,
7. knurling and chamfering
8. form turning and taper turning –
9. Eccentric turning.
10. Measurement of flank wear in turning process using tool makers microscope.

Experiment on thread cutting: -

11. single and multi start external
12. single and multi start internal threads,
13. Square and V-threads.

Experiment on drilling machine: -

14. Drilling,
15. boring,
16. reaming
17. counter sinking and taping

**Expected outcome**:

- The students will be able to perform welding and machining operations in lathe and drilling machine

**List of Equipments**

- 3 or 4 jaw Lathe
- Arc / TIG / MIG welding machine
- Drilling machine
- Thread cutting tools.

| Course code | Course Name | L-T-P - Credits | Year of Introduction |
|---|---|---|---|
| ME339 | Mechanical Engineering Lab | 0-0-3-1 | 2016 |

**Prerequisite: MP303 Thermal Engineering**

**Course Objectives**

1. To study the basic concepts of Energy conversions and heat transfer.
2. To know conduct of the performance test on IC engines, Compressors and blowers.
3. To do tests on heat transfer equipment.

**List of Exercises/Experiments**

1. Study of IC engines – Types, Parts and systems.
2. Study of Dynamometers – Types, working and applications.
3. Performance test on Diesel engine.
4. Performance test on Petrol engine.
5. Morse test on Multicylinder Petrol engine.
6. Heat balance test on Diesel/Petrol engine.
7. Determination of best cooling water temperature and Economic Speed of an IC engines.
8. Retardation test on Diesel engines.
9. Determination of Volumetric efficiency, Air-fuel ratio of IC engines.
10. Determination of Flash and Fire point of Petroleum Products.
11. Determination of Viscosity of Lubricating oils.
12. Determination of Calorific value of fuels.
13. Valve timing and Port timing diagram of IC engines.
14. Performance test on Rotary Compressors.
15. Performance test on Reciprocating Compressors.
16. Determination of Thermal Conductivity of solids.
17. Determination of Heat transfer coefficient in convection heat transfer (Free and Forced).
18. Determination of LMTD, effectiveness and overall heat transfer co efficient of parallel flow, counter flow and cross flow heat exchanger.
19. Performance test on Centrifugal Blower.
20. Performance tests on Refrigeration and Air conditioning unit.

**Expected outcome**.

The students will be able to

i. Understand various types of engines, working of dynamometers and performance evaluation of engines.
ii. Determine various efficiencies and plot the characteristic curves of different types of Internal Combustion Engines, compressors and blowers.
iii. Conduct experiments for the determination of viscosity, calorific value, flash point, etc of petroleum products

**Text Book:**


1. John B. Heywood , Internal Combustion Engines Fundamentals-, McGraw Hill.
2. R K Rajput, A Text Book of Thermal Engineering, Laxmi Publications.
3. R K Rajput, A Text Book of Internal Combustion engines, Laxmi Publications,
4. V Ganesan , Internal Combustion Engines –, Tata McGraw-Hill.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME361 | Advanced Fluid Mechanics | 3-0-0-3 | 2016 |

**Prerequisite : ME203 Mechanics of fluids**

**Course Objectives:** The main objectives of this course are to

- To provide knowledge regarding fluid-flow phenomena observed in mechanical engineering systems, such as potential flow, vortex flow, boundary-layer flows, etc.
- To undertake sustained learning in fluid mechanics to advance their knowledge in this field.
- To enhance the understanding of fluid mechanics, including the equations of motion in differential form and turbulence.

**Syllabus**

Basic Concepts and Fundamentals, Stream function and Potential function, Lagrangian and Eulerian approaches, Potential flow, Incompressible viscous flow, Boundary layer theory, Turbulent Flow.

**Expected Outcome:**

The students will be able to

i. Recognize the particular flow regime present in typical engineering system.
ii. Demonstrate the concept of stream function, potential function and boundary layer.
iii. Calculate the vorticity of a given velocity field and analyze the vorticity in idealized vortices: forced vortex and free vortex.
iv. Choose the appropriate fluid mechanics principles needed to analyze the fluid-flow situations.
v. Recognize how fluid flow theory can be employed in a modern mechanical engineering design environment.

**Text books**


1. Bansal R. K., A Text Book of Fluid Mechanics and Machines, Laxmi Publications, 2010.
2. Douglas J. F., Fluid Mechanics, Pearson Education, 2005.
3. Kumar D. S., Fluid Mechanics and Fluid Power Engineering, S. K. Kataria & Sons, 1987.
4. Muralidhar K., G. Biswas, Advanced Engineering Fluid Mechanics, Alpha Science International limited, 2005.
5. Rama D. D., Fluid Mechanics and Machines, New Age International, 2009.


**Reference books**


1. Schlichting H., K. Gersten , Boundary Layer Theory, 8/e, Springer 2000.
2. Shames I. H., Mechanics of Fluids, 4/e, McGraw-Hill, 2002.
3. Streeter V. L. and E. B. Wylie, Fluid Mechanics, McGraw-Hill, 1979.


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **I** | Basic Concepts and Fundamentals: Fluid statics, Cartesian Tensors, Fluid Kinematics, and Description of fluid motion – Types of motion of fluid elements, Vorticity and circulation – Concept of rotational and irrotational flows. Equation of motion of forced and free vortex flow.<br>Stream function and Potential function. Stream function and its relation with velocity field. Relation between stream function and stream lines - Relation between stream function and velocity potential for a 2-D irrotational and incompressible flow. | **7** | **15%** |
| **II** | Relation between stream lines and lines of constant potential. Sketching of stream lines. Lagrangian and Eulerian approaches, acceleration, temporal acceleration, convective acceleration. Reynolds transport theorem, derivation of continuity and momentum equations using Reynolds transport theorem. Problems on the application of momentum equation | **6** | **15%** |
| **FIRST INTERNAL EXAMINATION** | | | |
| **III** | Potential flow: Uniform flow, source flow, sink flow, free vortex flow and super imposed flow-source and sink pair, doublet, plane source in a uniform flow(flow past a half body), source and sink pair in a uniform flow(flow past a Rankine oval body), doublet in a uniform flow(flow past a circular cylinder). Pressure distribution on the surface of the cylinder. Flow past a cylinder with circulation, Kutta-Juokowsky's law. Complex flow potential, complex flow potentials for source, sink, vortex and doublet. Potential flow between two parallel plates, potential flow in a sector. Introduction to conformal transformation, conformal mapping. | **7** | **15%** |
| **IV** | Incompressible viscous flow. Concepts of laminar and turbulent flows . Stokes viscosity law. Navier Stoke's equation and significance (Derivation not necessary).Simplification of Havier stock equation for steady incompressible flows with negligible body forces. Parallel flow through straight channel and couette flow. Hagen - Poiseuille flow. Derivation of Hagen Poissuille equations for velocity and discharge through a pipe, derivation of friction factor for laminar flow, Couette flow for negative, zero and positive pressure gradients, flow in a rotating annulus, Viscometer based on rotating annulus. | **7** | **15%** |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Boundary layer theory, Boundary layer thickness, Displacement thickness, momentum thickness, Energy thickness and their calculation. Laminar Boundary Layers, Boundary layer equations; Boundary layer on a flat plate, Prandtl boundary layer equations, Blasius solution for flow over a flat plate, Von- Karman momentum integral | **8** | **20%** |

| | | | |
|---|---|---|---|
| | equations, Pohlhausen approximation solution of boundary layer for non-zero pressure gradient flow, favorable and adverse pressure gradients, Entry flow into a duct, flow separation and vortex shedding. | | |
| **V1** | Turbulent Flow: Introduction to turbulent flow, Governing equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Fully developed Turbulent pipe flow for moderate Reynold's number, Prandtl mixing hypothesis, Turbulence modeling. Boundary layer control. | **7** | **20%** |
| **END SEMESTER EXAMINATION** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME362 | Control System Engineering | 3-0-0-3 | 2016 |

**Course Objectives: :**

1. To introduce the concepts of controls and modelling of physical systems.
2. To give idea on system response analysis and stability of systems.
3. To use different methods to analyse stability of control systems

**Syllabus:**

Control systems and components, Mathematical models, Block diagrams, Signal Flow graphs, Transient and Steady state response analysis, Stability , Routh's stability criterion, Root locus method. Frequency response analysis using polar plots ,Bode plots, Nyquist stability criterion

**Expected Outcomes:** At the end of the course students will be able

1. To model and analyse physical systems.
2. To analyse the stability of feedback control systems

**Text books:**

1. Kuo, B. C., Automatic Control Systems, Prentice Hall,2012
2. Thaler and Brown, Analysis and Design of Feedback Control Systems, McGraw Hill, 1960.
3. Nagrath I J and Gopal M, Control Systems Engineering, New Age India Pvt Limited, 2009

**References:**

1. Ogata, K., Modern Control Engineering, Pearson Education, 2004
2. NPTEL courses, http//nptel.iitm.ac.in/courses.php, web and video courses on Control Engineering

**COURSE PLAN**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Introduction to control systems. Elementary ideas on types of control systems- Open loop and closed loop systems, Servo systems, Automatic regulating systems, Process control systems, Adaptive control systems, Learning control systems, Discrete control systems, Multivariable control systems, Linear and Non-linear systems. Elementary ideas on types of controls- proportional, integral, proportional integral, proportional integral derivative controls. Direct and indirect controls. Mathematical models of physical systems – typical examples of mechanical, thermal, electrical, hydraulic and pneumatic systems. | 7 | 15% |
| II | Block diagram, transfer function, reduction of block diagrams, signal flow graphs :Manson's gain formula. Control system components – servomotors, stepper motor, synchros, hydraulic pumps and motors, hydraulic valves, pneumatic bellows, pneumatic valve, pneumatic relay, pneumatic actuator, gyroscopes ( elementary ideas only. No derivations) | 7 | 15% |

| | | | |
|---|---|---|---|
| | **FIRST INTERNAL EXAMINATION** | | |
| **III** | System response- Time response of first and second order systems, steady state errors and error constants, specifications in time domain. Effect of pole locations, Concept of stability, Routh's stability criterion | **7** | **15%** |
| **IV** | Root locus method of analysis and design. Lead and lag compensation | **7** | **15%** |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Frequency response analysis- relationship between time & frequency response, Bode's plot, stability in frequency domain, gain margin and Phase margin | **7** | **20%** |
| **V1** | Polar plots, Nyquist stability criterion, Stability analysis, Relative stability concepts, Gain margin and phase margin. | **7** | **20%** |
| **END SEMESTER EXAMINATION** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
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Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME363 | COMPOSITE MATERIALS AND MECHANICS | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives:**

1. To understand various matrices and reinforcements used in composites
2. To know about polymer matrix composites, metal matrix composites, ceramic matrix composites and its manufacturing and applications
3. To introduce post processing operations and micromechanics of composites

**Syllabus**

Composites – Reinforcements – Matrices – Polymer matrix composite – Metal matrix composite – Ceramic matrix composite – Post processing operations – Micromechanics of composites

**Expected outcome:**

- The students will be able to gain knowledge about composites, reinforcements, matrices, post

**Text Books**:


1. K. K. Chawla, Composite Materials : Science and Engineering, Springer, 3e, 2013.
2. Reddy J N (Ed.), Mechanics of Composite Materials; Selected Works of Nicholas J. Pagano, Springer, 1994
3. Robert M. Jones, Mechanics of Composite Materials, CRC Press, 1998


**References Books**:


1. F.L.Matthews & R.D.Rawlings, Composite Materials, Engineering and Sciences, Chapman & hall, London, 1994
2. Hand Book of Composites, George Lubin. Van Nostrand, Reinhold Co. 1982
3. Micael hyer, Stress Analysis of Fiber - Reinforced Composite Materials , Tata McGraw Hill, 1998.
4. P.K.Mallicak, Fiber-reinforced composites , Monal Deklar Inc., New York, 1988.
5. Ronald Gibson, Principles of Composite Material Mechanics , TMH, 1994.


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Composite : Introduction, definition, characteristics, functions | 1 | 15% |
| | classification of composites based on structure and matrix | 1 | |
| | smart composites, advantages and limitations | 1 | |
| | history, industrial scene and applications | 1 | |
| | Interfaces: wettability and bonding interface in composites | 1 | |

| | | | |
|---|---|---|---|
| | types of bonding at interface. | **1** | |
| **II** | Fibers : Introduction, types of fibers, natural fibers | **1** | **15%** |
| | glass fiber fabrication, structure, properties and applications | **2** | |
| | boron fiber fabrication, structure, properties and applications | **1** | |
| | carbon fiber, Ex-Pan carbon fiber | **1** | |
| | Ex cellulose carbon fiber, Ex-Pitch carbon | **1** | |
| | carbon fiber structure, properties and applications | **1** | |
| | aramid fiber fabrication, structure, properties and applications | **1** | |
| | whiskers: characteristics, properties and applications. | **1** | |
| | **FIRST INTERNAL EXAMINATION** | | |
| **III** | Polymer matrix composites (PMC) : thermoset, thermoplastic and elastomeric polymers | **1** | **15%** |
| | properties, characteristics and applications as matrix materials | **1** | |
| | processing of polymer matrix composites: hand methods, Lay up method, spray up method | **2** | |
| | moulding methods, pressure bagging and bag moulding methods, | **1** | |
| | pultrusion and filament winding process. | **1** | |
| **IV** | Metal matrix composites (MMC) : classification of metals, intermetallics, alloys and their potential role as matrices in composites | **1** | **15%** |
| | properties, characteristics and applications of metals as matrix materials | **1** | |
| | production techniques: powder metallurgy, diffusion bonding, melt stirring | **2** | |
| | squeeze casting, liquid infiltration under pressure, spray code position, insitu process. | **2** | |
| | **SECOND INTERNAL EXAMINATION** | | |
| **V** | Ceramic matrix composites (CMC) : classification of ceramics and their potential role as matrices, | **1** | **20%** |
| | properties, characteristics and applications of ceramics as matrix materials | **1** | |
| | conventional techniques : cold pressing and sintering, hot pressing, reaction bonding, | **1** | |
| | hot pressing and reaction bonding new techniques : liquid infiltration, pultrusion, | **1** | |
| | lanxide process, insitu chemical technique, sol-gel technique | **2** | |

| | | | |
|---|---|---|---|
| **V1** | Post processing operations : machining, cutting, polishing, | **1** | **20%** |
| | welding, rivetting and painting | **1** | |
| | Advanced post processing methods : ultrasonic welding, plasma coating, | **1** | |
| | Water jet cutting and laser machining | **1** | |
| | Micromechanics of composites: maximum stress and strain criterion (derivations) | **2** | |
| | Tsai-Hill and Tsai-Wu failure criterion (derivations) | **2** | |
| | mechanics of load transfer from matrix to fiber (description) | **1** | |
| **END SEMESTER EXAMINATION** | | | |

## Question Paper Pattern

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME364 | Turbomachinery | 3-0-0-3 | 2016 |

**Prerequisite : ME205 Thermodynamics**

**Course Objectives: :**

1. To know the principle of operation of turbomachines
2. To provide students thorough understanding of velocity triangles, turbomachinery
3. To introduce students to fans, turbines, pumps etc..

**Syllabus:**

Definition of turbomachine, Application of first and second laws of thermodynamics to turbomachines, Efficiencies, Centrifugal fans and blowers, Centrifugal Compressors, Axial flow compressors, Axial and radial flow turbines

**Expected Outcomes:**

The students will be able to

1. Understand the operation of turbomachines
2. Gain ideas on performance characteristics, governing and selection of turbomachinery.

**Text books**


1. Bruneck, Fans, Pergamom Press, 1973.
2. Dixon, S.I, Fluid Mechanics and Thermodynamics of Turbomachinery , Pergamom, Press, 1990.
3. Ganesan .V, Gas Turbines , Tata McGraw Hill Pub. Co., New Delhi, 1999.
4. Stepanff, A.J, Blowers and Pumps , John Wiley and Sons Inc., 1965.
5. Yahya, S.H, Turbines, Compressor and Fans , Tata Mc Graw Hill, 1996.


**Reference books**


1. Earl Logan, Jr, Hand book of Turbomachinery, Marcel Dekker Inc, 1992.
2. Shepherd, D.G, Principles of Turbomachinery , Macmillan, 1969.


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Definition of turbomachine, parts of turbomachines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynolds number, Unit and specific quantities, model studies. | 7 | 15% |
| II | Application of first and second laws of thermodynamics to turbomachines, Efficiencies of turbomachines. Stage velocity triangles, work and efficiency for compressors and turbines | 7 | 15% |
| **FIRST INTERNAL EXAMINATION** | | | |

| | | | |
|---|---|---|---|
| **III** | Centrifugal fans and blowers : Types, stage and design parameters, flow analysis in impeller blades, volute and diffusers, losses, characteristics curves and selection, fan drives and fan noise. | **7** | **15%** |
| **IV** | Centrifugal Compressors: Construction details, types, impeller flow losses, slip factor, diffuser analysis, losses and performance curves. | **7** | **15%** |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Axial flow compressors : Stage velocity triangles, enthalpy-entropy diagrams, stage losses and efficiency, work done factor, simple stage design problems and performance characteristics. | **7** | **20%** |
| **V1** | Axial and radial flow turbines : Stage velocity diagrams, reaction stages, losses and coefficients blade design principles, testing and performance characteristics. | **7** | **20%** |
| **END SEMESTER EXAMINATION** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
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**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME365 | Advanced Metal Casting | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

- To gain theoretical and practical knowledge in material casting processes
- To develops an understanding of the dependent and independent variables which control materials casting in a production processes.
- To impart knowledge on design of gating system for castings
- To know foundry practice of ferrous and non ferrous alloys

**Syllabus**

Functional requirements of molding materials, gating - type of gating- gating design- factor involved in gating design, risers – primary function of a riser-theoretical consideration-riser design and placement, solidification, heat transfer during solidification, heat flow in solidification, ferrous and non-ferrous foundry practice, steel casting, aluminum and its alloys, magnesium and its alloys, casting design, defects and testing.

**Expected outcome:**

- The students will have exposed to the different areas of foundry practices, gained idea about metal casting, scope and its applications.

**Text Books/References**


1. A.K.Chakrabarti, Casting Technology and Cast Alloys, Prentice –Hall Of India Ltd, 2005
2. Beely, Foundry Technology, Newnes-Butterworths, 1979
3. Gruzleski, The Treatment of Liquid Aluminum-Silicon Alloys, the American Foundrymen's Society Inc, USA, 1992
4. Heine, Loper and Rosenthal, Principle of Metal Casting, 2nd Edition, Tata Mc-Graw-Hill Publishing Company Limited, New Delhi, 1978
5. John Cambell, Casting, Butterworth-Heineman Ltd, Jordon Hill, Oxford, 1991
6. T.V.Rama Rao, Metal casting Principles and Practice, New Age International,2010
7. Gruzleski, The Treatment of Liquid Aluminum-Silicon Alloys, the American Foundrymen's Society Inc, USA, 1992.


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | **Design of molds**<br>Functional requirements of molding materials, type of sands<br>Properties of molding sand, sand testing techniques<br>Effect of molding on sand properties, | 2 | 15% |

| | | | |
|---|---|---|---|
| | Bonding material | **1** | |
| | Mould surface coating | **1** | |
| | Sand design and control | **1** | |
| | Thermal aspect of molding sand, mould wall movement | **1** | |
| **II** | **Pouring and feeding**<br>**Gating -** type of gating- gating design | **1** | **15%** |
| | Factor involved in gating design-illustrative problems in determination of filling time and discharge rate | **1** | |
| | Aspiration effect- effects of friction and velocity distribution | **1** | |
| | **Risers** – primary function of a riser<br>Theoretical consideration<br>Riser design and placement<br>Determination of dimensions of rise- blind risers | **2** | |
| | Internal risers-use of chills<br>Use of insulators and exothermic compounds | **1** | |
| **FIRST INTERNAL EXAMINATION** | | | |
| **III** | **Solidification** | | **15%** |
| | Freezing of pure metal<br>Skin effects- nucleation and growth | **1** | |
| | Shrinkage- freezing of alloys | **1** | |
| | Effect of mould materials and alloy composition on casting | **1** | |
| | Fluidity- factor affecting fluidity- fluidity measurement and application of fluidity | **1** | |
| | Gases in metals- degassing | **1** | |
| | Grain refinement | **1** | |
| | Illustrative problems related to determination of solidification time | **1** | |
| **IV** | **Heat transfer during solidification** | | **15%** |
| | Methods of manipulating heat transfer | **1** | |
| | Experimental methods for the study of heat transfer during solidification | | |
| | Crystal growth methods | **1** | |
| | Heat flow in solidification | **1** | |
| | Heat transfer with in the solid/liquid metal system | **1** | |
| | Heat transfer at the metal-mould interface | **1** | |
| | Heat flow in one dimensional solidification geometries | **1** | |
| | Freezing at mould wall | **1** | |
| | Rapid freezing in contact with a cold substrate with initial melt super cooling | **1** | |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | **Ferrous and non ferrous castings**<br>**Steel Casting** – The family of cast iron | **1** | **20%** |
| | Melting of steels and cast irons–Grey iron<br>Foundry practice – ductile iron – Malleable Iron casting | **1** | |

| | | | |
|---|---|---|---|
| | design | | |
| | **Aluminum and its alloys:** Different Aluminum alloy systems<br>Advantage and limitation of Aluminum alloy castings | **1** | |
| | Molding for aluminum castings - melting of Aluminum- degassing- grain refinement | **1** | |
| | Modification- effect of various melt treatment on the mechanical properties of Aluminum castings. | **1** | |
| | **Magnesium and its alloys**: different alloy systems- advantage and limitation of Magnesium alloy castings<br>Molding for magnesium casting- melting of Magnesium- flux and flux less melting | **1** | |
| | Type and functions of fluxes used- degassing and grain refinement- pouring technique | **1** | |
| | **Copper alloys:** advantage of Copper alloys- melting- drossing-oxygen and hydrogen in Copper melting- control of gases- de oxidation | **1** | |
| **V1** | **Casting defects and testing** | | **20%** |
| | Functional design- metallurgical design | **1** | |
| | simplification of foundry practice- economic considerations | **1** | |
| | design of junction- specification of castings | **1** | |
| | inspection of castings- analysis of casting defects | **1** | |
| | nondestructive testing of casting- dye penetrant testing | **1** | |
| | magnetic flaw detection, radiography, ultrasonic testing, etc. | **1** | |
| | quality control and quality assurance | **1** | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**

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Each question carries 10 marks

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**Part B**

There should be 2 questions each from module III and IV

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

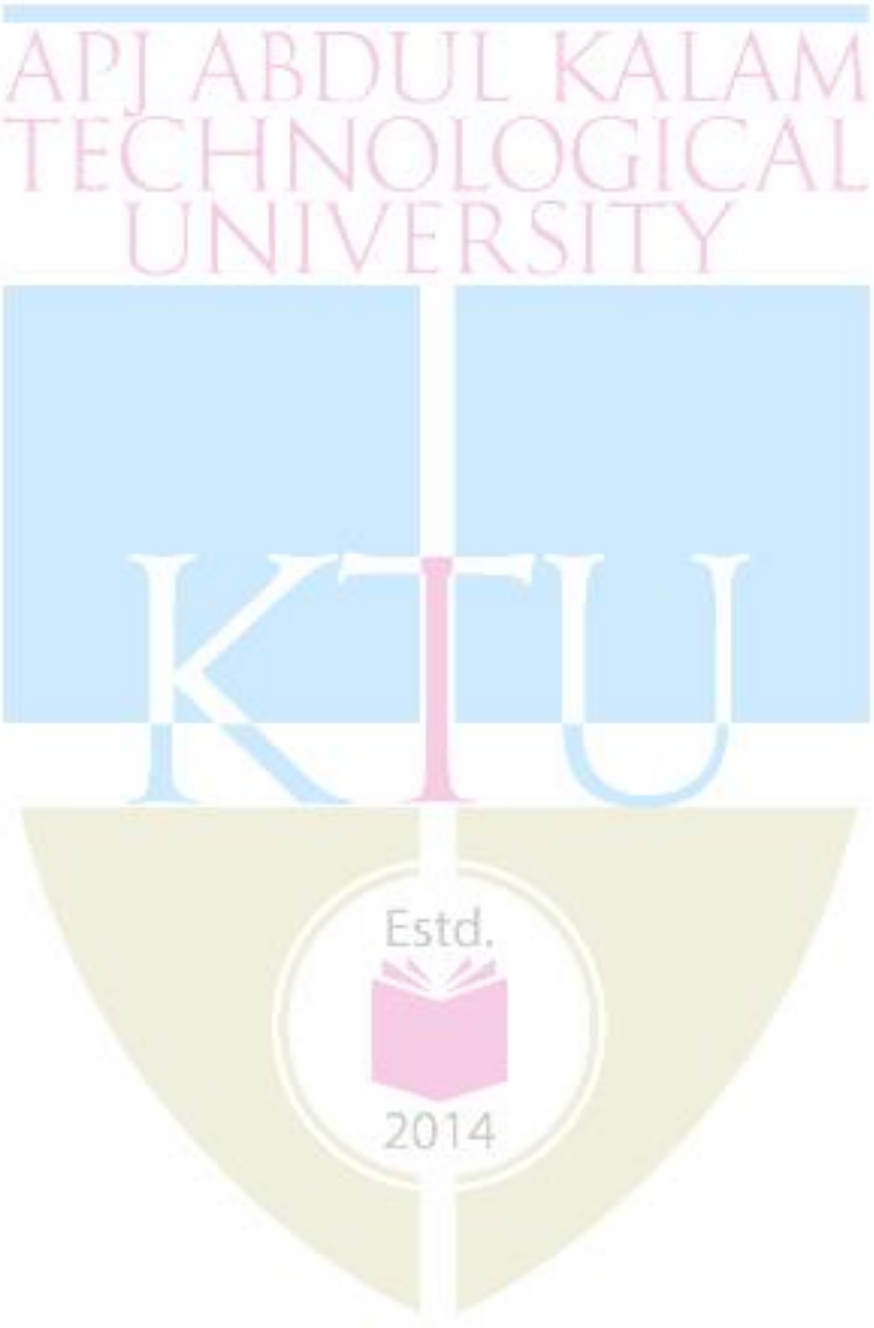
**Part C**

There should be 3 questions each from module V and VI

Each question carries 10 marks

Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.


APJ ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY
KTU
Estd.
2014

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME366 | ADVANCED METAL JOINING TECHNOLOGY | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

- To expose the students to the fundamental concepts of advanced welding technologies and their relevance

**Syllabus**

Radiant energy welding, Electron beam and Laser beam welding, Plasma arc welding, Micro plasma welding, Magnetically impelled arc butt welding, Underwater welding, Explosive welding, Adhesive bonding, Friction welding, Friction stir welding, Friction stir processing, Diffusion welding, Cold Pressure welding, Ultrasonic welding, Vacuum brazing.

**Expected outcome**

- The students will be able to understand the advancements in welding technologies and processes, their significance, application areas etc. leading to the development of products and processes.

**References Books**:


1. ASM Metals Hand Book "Welding and Brazing", Vol. 6, ASM, Ohio, 1988.
2. Parmar R.S., "Welding Processes and Technology", Khanna Publishers, Delhi, 1998.
3. Parmer R. S., Welding Engineering and Technology", Khanna Publishers, 1997
4. Rossi, Welding Engineering, McGraw Hill, 1954.
5. Schwartz M.M., "Metals Joining Manual", McGraw-Hill Inc., 1979.
6. Udin et al., Welding for Engineers, John Wiley & Sons, New York, 1967.
7. Welding Engineers Hand Book- ASHE Vol . I, II, III and IV.


## Course Plan

| Module | Contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Radiant energy welding: Electron Beam Welding- Background of the Process, Guns, Weld Environment, Welding in Different Degrees of Vacuum, Equipment and Safety, Joint Design, Applications, Laser Beam Welding, Physics of Lasers, Types of Lasers, Process Parameters, Applications and Limitations. | 7 | 15% |

| | | | |
|---|---|---|---|
| **II** | Diffusion Welding- theory and Principle of Process, Key Variables, Intermediate Materials, Deformation Welding, Equipment and Tooling, Joint Design, Economics, Advantages and Limitations, Materials and Applications, Cold Pressure Welding- Process, Equipment and Setup, Applications | 6 | 15% |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Explosive Welding- theory and Key Variables, Parameters, Weld Quality, Equipment and Tooling, Advantages and Limitations, Joint Design, Materials and Applications, Adhesive Bonding- theory and Key Parameters, Physical Characteristics, Metal Adhesive, Equipment, Design, Economics of Process, Materials and Applications. | 7 | 15% |
| **IV** | Ultrasonic welding-Principles of operation, Process Characteristics and Applications, Vacuum brazing- Theory, Mechanisms and Key Variables, Equipment and Tooling, Stop-Off and Parting Agents, Advantages, Limitations, Economics Materials and Applications. | 6 | 15% |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Plasma arc welding: Plasma Arc Welding- theory and Principles, Transferred arc and Non-Transferred arc Techniques, Equipment and Tooling, Joint Design Advantages, Disadvantages, Economics, Materials and Applications, Needle Arc Micro Plasma Welding - Characteristics of Process, Operating Characteristics, Fixturing and Joint Design, Shielding, Weld Penetration and Shape, Applications, Magnetically impelled arc butt (MIAB) welding, Under Water Welding- Wet and Dry Under Water Welding | 8 | 20% |
| **VI** | Friction Welding- Basic Principles, Process Variants, Different Stages of Friction Welding, Mechanism of Bonding, Influence of Process Parameters, Weld Quality and Process Control, Joining of Dissimilar Materials, Advantages, Limitations and Applications, Friction Stir Welding-Metal flow phenomena, tools, process variables and applications, Friction Stir Processing- Process, Application | 8 | 20% |
| **END SEMESTER EXAM** | | | |

## Question Paper Pattern

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3x10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3x10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4x10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME367 | Non-Destructive Testing | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

- To introduce the basic principles, techniques, equipment, applications and limitations of NDT methods such as Visual, Penetrant Testing, Magnetic Particle Testing, Ultrasonic Testing, Radiography, Eddy Current.
- To enable selection of appropriate NDT methods.
- To identify advantages and limitations of nondestructive testing methods
- To make aware the developments and future trends in NDT.

**Syllabus**

Introduction to NDT- Visual Inspection- Liquid Penetrant Inspection- Magnetic Particle Inspection- Ultrasonic Testing- Radiography Testing- Eddy Current Testing.

**Expected outcome**

- The students will be able to differentiate various defect types and select the appropriate NDT methods for the specimen.

**Text book**

- Baldev Raj, Practical Non – Destructive Testing, Narosa Publishing House ,1997

**Reference books**

1. Hull B. and V.John, Non-Destructive Testing, Macmillan,1988
2. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, Springer-Verlag, 1990

## Course Plan

| Module | Contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Introduction to NDT, Comparison between destructive and NDT, Importance of NDT, Scope of NDT, difficulties of NDT, future progress in NDT, economics aspects of NDT. | 1<br>1 | 15% |
| | **Visual Inspection** - tools, applications and limitations - Fundamentals of visual testing: vision, lighting, material attributes, environmental factors. | 1<br>1 | |
| | visual perception, direct and indirect methods mirrors, magnifiers, boroscopes, fibroscopes, closed circuit television, light sources | 1<br>1 | |
| | special lighting, a systems, computer enhanced system | 1 | |
| II | **Liquid Penetrant Inspection**: principles, properties required for a good penetrants and developers - Types of penetrants and developers | 1<br>1 | 15% |
| | and advantages and limitations of various methods of LPI - LPI technique/ test procedure | 1<br>1 | |
| | interpretation and evaluation of penetrant test indications, false indication | 1<br>1 | |

| | | | |
|---|---|---|---|
| | and safety precaution required in LPI, applications, advantages and limitations | **1** | |
| **FIRST INTERNAL EXAMINATION** | | | |
| **III** | **Magnetic Particle Inspection (MPI)-** Principles of MPI, basic physics of magnetism, permeability, flux density, cohesive force, magnetizing force, rentivity, residual magnetism | **1**<br>**1** | **15%** |
| | Methods of magnetization, magnetization techniques such as head shot technique, cold shot technique, central conductor testing, magnetization using products using yokes | **1**<br>**1** | |
| | direct and indirect method of magnetization, continuous testing of MPI, residual technique of MPI, system sensitivity, checking devices in MPI | **1**<br>**1** | |
| | Interpretation of MPI, indications, advantage and limitation of MPI. | **1** | |
| **IV** | **Ultrasonic Testing (UT):** principle, types of waves, frequency, velocity, wavelength, reflection, divergence, attenuation, mode conversion in ultrasonic UT testing methods | **1**<br>**1** | **15%** |
| | contact testing and immersion testing, normal beam and straight beam testing, angle beam testing, dual crystal probe, ultrasonic testing techniques | **1**<br>**1** | |
| | resonance testing, through transmission technique, pulse echo testing technique, instruments used UT, accessories such as transducers, types, frequencies, and sizes commonly used | **1**<br>**1** | |
| | Reference blocks with artificially created defects, calibration of equipment, Applications, advantages, limitations, A, B and C scan - Time of Flight Diffraction (TOFD). | **1** | |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | **Radiography Testing (RT):** Principle, electromagnetic radiation sources: X-ray source, production of X-rays, high energy X-ray source, gamma ray source - Properties of X-rays and gamma rays | **1**<br>**1** | **20%** |
| | Inspection techniques like SWSI, DWSI, DWDI, panoramic exposure, real time radiography, films used in industrial radiography, types of film, speed of films, qualities of film | **1**<br>**1** | |
| | screens used in radiography, quality of a good radiograph, film processing, interpretation, evaluation of test results, safety aspects required in radiography | **1**<br>**1** | |
| | applications, advantages and limitations of RT | **1** | |
| **V1** | **Eddy Current Testing (ECT)** - Principle, physics aspects of ECT like conductivity, permeability, resistivity, inductance, inductive reactance, impedance | **1**<br>**1** | **20%** |
| | Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT, relation between frequency and depth of penetration in ECT | **1**<br>**1** | |
| | equipments and accessories, various application of ECT such as | **1** | |

| | | | |
|---|---|---|---|
| | conductivity measurement, hardness measurement, defect detection | **1** | |
| | coating thickness measurement, advantages and limitations of eddy current testing | **1** | |
| **END SEMESTER UNIVERSITY EXAMINATION** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**

There should be 2 questions each from module I and II

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**

There should be 2 questions each from module III and IV

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**

There should be 3 questions each from module V and VI

Each question carries 10 marks

Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME368 | Marketing Management | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives: :**

- To introduce the concept of market and marketing
- To give idea about launching a new product
- To introduce the various marketing strategies

**Syllabus:**

Introduction to marketing, Social and Marketing planning, Consumer behavior, Marketing communication, Designing the message, New trends in marketing

**Expected Outcomes:**

The students will be able to

i. state the role and functions of marketing within a range of organizations.
ii. describe key marketing concepts, theories and techniques for analyzing a variety of marketing situations.
iii. identify and demonstrate the dynamic nature of the environment in which marketing decisions are taken
iv. synthesize ideas into a marketing plan

**Text books:**

1. Majumdar R., Marketing Research, Text, Applications and Case Studies, New Age International (P), 1991
2. Ramaswamy V.S. & Namkumari S, Marketing Management: Planning, Implementation and Control, Macmillan India Limited, 2002
3. Robert, Marketing Research, Prentice Hall of India,1999
4. T N Chabra and S K Grover : Marketing management, Dhanpat Rai, 2007

**Reference books:**

1. Kotler P, Marketing Management: Analysis, Planning, Implementation and Control, Prentice Hall of India,1993
2. Stanton W.J., Etzel M.J. & Walker B.J, Fundamentals of Marketing, McGraw Hill International Edition, 1994

**COURSE PLAN**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Introduction to marketing - concept of market and marketing – marketing environment - controllable factors - factors directed by top management - factors directed by marketing - uncontrollable factors - demography, economic conditions, competition. | 7 | 15% |
| II | Social and Marketing planning - marketing planning process - Boston consultancy group model - marketing mix - marketing mix variables. Developing, testing and launching of new products . | 7 | 15% |

| | | | |
|---|---|---|---|
| | **FIRST INTERNAL EXAMINATION** | | |
| **III** | Market segmentation and market targeting - introduction to segmentation - targeting and product positioning. Marketing research - need and scope - marketing research process – research objectives, developing research plan, collecting information, analysis, and findings. | **7** | **15%** |
| **IV** | Consumer behaviour - factors influencing consumer behaviour - perceived risks Product life cycle - marketing strategies for different stages of product life cycle | **6** | **15%** |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Marketing communication - marketing mix variables - steps in developing effective communication - identification of target audience - determination of communication objectives | **7** | **20%** |
| **V1** | Designing the message - selecting the communication channels - promotion mix evaluation - advertising and sales promotion - factors in advertising - sales promotion tools. New trends in marketing- Brand management - significance of branding to consumers and firms | **8** | **20%** |
| **END SEMESTER EXAMINATION** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME369 | Tribology | 3-0-0-3 | 2016 |
| Prerequisite : Nil | | | |

**Course Objectives**

- To provide broad based understanding of the subject 'Tribology' and its technological significance
- To understand the genesis of friction, the theories/laws of sliding and rolling friction and the effect of viscosity
- To learn about consequences of wear, wear mechanisms, wear theories and analysis of wear problems
- To learn about the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques and the application of lubrications in metal working.
- To understand the importance of adhesion property in different applications and to get knowledge about different bearing materials.
- To understand the nature of engineering surfaces, their topography and learn about surface characterization techniques

**Syllabus**

Introduction to Tribology- Tribology in Design, Tribology in Industry, Tribological Parameters Like Friction, Wear and Lubrication, different types of lubrication techniques and applications, measurement of friction and wear -The Topography of Engineering Surface, Contact Between Surfaces, surface modification techniques- Adhesion properties, Adhesion in Magnetic Recording Systems, Types of Bearings, Comparison of Sliding and Rolling Contact Bearings.

**Expected Outcome**

**The students will be able to**

i. Understand the subject 'tribology' and its technological significance.
ii. Understanding the theories/laws of sliding and rolling friction and the effect of viscosity.
iii. Get basic idea on consequences of wear, wear mechanisms, wear theories and analysis of wear problems
iv. Get an exposure to theories of hydrodynamic and the advanced lubrication techniques and the application of lubrications in metal working.
v. Gain overview of adhesion property in different applications and to get knowledge about different bearing materials
**vi.** Get basic idea about the nature of engineering surfaces, their topography and learn about surface characterization techniques.

**Text books**


1. Ernest Rabinowicz, Friction and Wear of Materials, John Wiley & sons,1995
2. I.M. Hutchings, Tribology: Friction and Wear of Engineering Materials, Butterworth-Heinemann,1992
3. Prasanta Sahoo, Engineering Tribology, PHI Learning Private Ltd, New Delhi, 2011.

**Reference books**


1. B. Bhushan, Introduction to Tribology, John Wiley & Sons, Inc, New York, 2002
2. B.Bhushan, B.K. Gupta, Handbook of tribology: materials, coatings and surface treatments", McGraw-Hill,1997
3. Halling J ,"Principles of Tribology", McMillan Press Ltd.,1978


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Introduction to Tribology- Tribology in Design, Tribology in Industry, Economic Aspects of Tribology | 1 | 15% |
| | Tribological Parameters Like Friction, Wear and Lubrication | 1 | |
| | The Topography of Engineering Surface, Contact Between Surfaces. | 2 | |
| | Types of Bearings, Comparison of Sliding and Rolling Contact Bearings. | 2 | |
| II | Introduction, Empirical Laws of Friction, Kinds of Friction | 1 | 15% |
| | Causes of Friction, Theories of Friction | 1 | |
| | Measurement of Friction | 1 | |
| | Friction of Metals, Ceramic Materials, Polymers. | 2 | |
| | Rolling Friction- Laws of Rolling Friction, Relation Between Temperature and Friction | 1 | |
| | Stick-Slip, Prevention of Stick-Slip, Consequences of Friction. | 1 | |
| **FIRST INTERNAL EXAMINATION** | | | |
| III | Types of Wear, Various Factors Affecting Wear | 1 | 15% |
| | Theories of Wear, Wear Mechanisms | 2 | |
| | Measurement of Wear. | 1 | |
| | Wear Regime Maps, Alternative Form of Wear Equations | 1 | |
| | Lubricated and Unlubricated Wear of Metals, Materials Used in Different Wear Situations. | 2 | |
| IV | Fundamentals of Viscosity And Viscous Flow | 1 | 15% |
| | Principle and Application of; Hydrodynamic Lubrication, Elastrodynamic Lubrication, Boundary and Solid Lubrication | 2 | |
| | Types of Lubricants, Properties of Lubricants | 1 | |
| | Effect of Speed and Load on Lubrication, Frictional Polymers. | 1 | |
| | **Lubrication in Metal Working:** Rolling, Forging, Drawing and Extrusion. | 2 | |
| **SECOND INTERNAL EXAMINATION** | | | |
| V | **Adhesion:** Introduction, Adhesion Effect by Surface Tension, Purely Normal Contact and Compression Plus Shear | 2 | 20% |

| | | | |
|---|---|---|---|
| | Adhesion in Magnetic Recording Systems | **1** | |
| | Dependence of Adhesion on Material and Geometric Properties. | **1** | |
| | **Bearing Materials**: Introduction, Rolling Bearing, Fluid Film Lubricated Bearing, Dry Bearing, Bearing Constructions. | **3** | |
| **V1** | Introduction To Surface Engineering, Concept and Scope of Surface Engineering. | **1** | **20%** |
| | Surface Modification – Transformation Hardening, Surface Melting, Thermo chemical Processes | **3** | |
| | Surface Coating – Plating and Anoding Processes, Fusion Processes, Vapor Phase Processes. | **3** | |
| | Selection of Coating For Wear And Corrosion Resistance, Potential Properties and Parameters of Coating. | **1** | |
| **END SEMESTER EXAMINATION** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
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There should be 2 questions each from module III and IV
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**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME371 | Nuclear Engineering | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives:**

- To explore the engineering design of nuclear power plants using the basic principles of reactor physics, thermodynamics, fluid flow and heat transfer.
- To provide an overview on reactor principles, nuclear safety, and reactor dynamic behaviour.
- To understand the standards of radiation protection and need for nuclear waste disposal

**Syllabus**

Review of Elementary nuclear physics, Nuclear fission, Boiling water reactor, Structural materials, Nuclear fuels, Reactor heat removal, Safety and disposal

**Expected Outcome:**

The students will be able to

1. understand the theories and principles of nuclear power generation
2. understand the heat removal techniques applied to reactor heat transfer systems.
3. acquire knowledge about safe disposal of nuclear wastes

**Text books/ Reference books**


1. S. Glasstone and A. Sesonske, *Nuclear Reactor Engineering*, D. Van Nostrand Company, INC. 1967.
2. S Glasstone, Source book on atomic energy, Krieger Pub Co., 1979


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Review of Elementary nuclear physics: Atomic structure – nuclear energy and nuclear forces – Nuclear fission. Nuclear reactions and radiations – Principles of radioactive decay interactions of an ray with matter – Neutron cross sections and reactions –The fission process – Chain reactions | 7 | 15% |
| II | Basic principles of controlled fusion .Nuclear reactor principles – Reactor classification – Critical size. Basic diffusion theory - Slowing down of neutrons – Neutrons – Neutron flux and power – Four factor formula – Criticality condition – Basic features of reactor control . | 7 | 15% |
| | **FIRST INTERNAL EXAMINATION** | | |

| | | | |
|---|---|---|---|
| **III** | Boiling water reactor . Description of reactor system – Main components –Control and safety features .Materials of reactor construction – Fuel , moderator , coolant | **7** | **15%** |
| **IV** | Structural materials – Cladding –Radiation damage,<br>Nuclear fuels : Metallurgy of Uranium – General principles of solvent extraction – Reprocessing of irradiated fuel – Separation process fuel enrichment . | **7** | **15%** |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Reactor heat removal / equations of heat transfer as applied to reactor cooling– Reactor heat transfer systems – Heat removed in fast reactors. Radiation safety : Reactor shielding – Radiation dozes – Standards of radiation protection | **7** | **20%** |
| **V1** | Safety and disposal: Nuclear plant safety-safety systems-changes and consequences of accident-criteria for safety-nuclear waste-types of waste and its disposal-radiation hazards and their prevention-weapons proliferation | **7** | **20%** |
| **END SEMESTER EXAMINATION** | | | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

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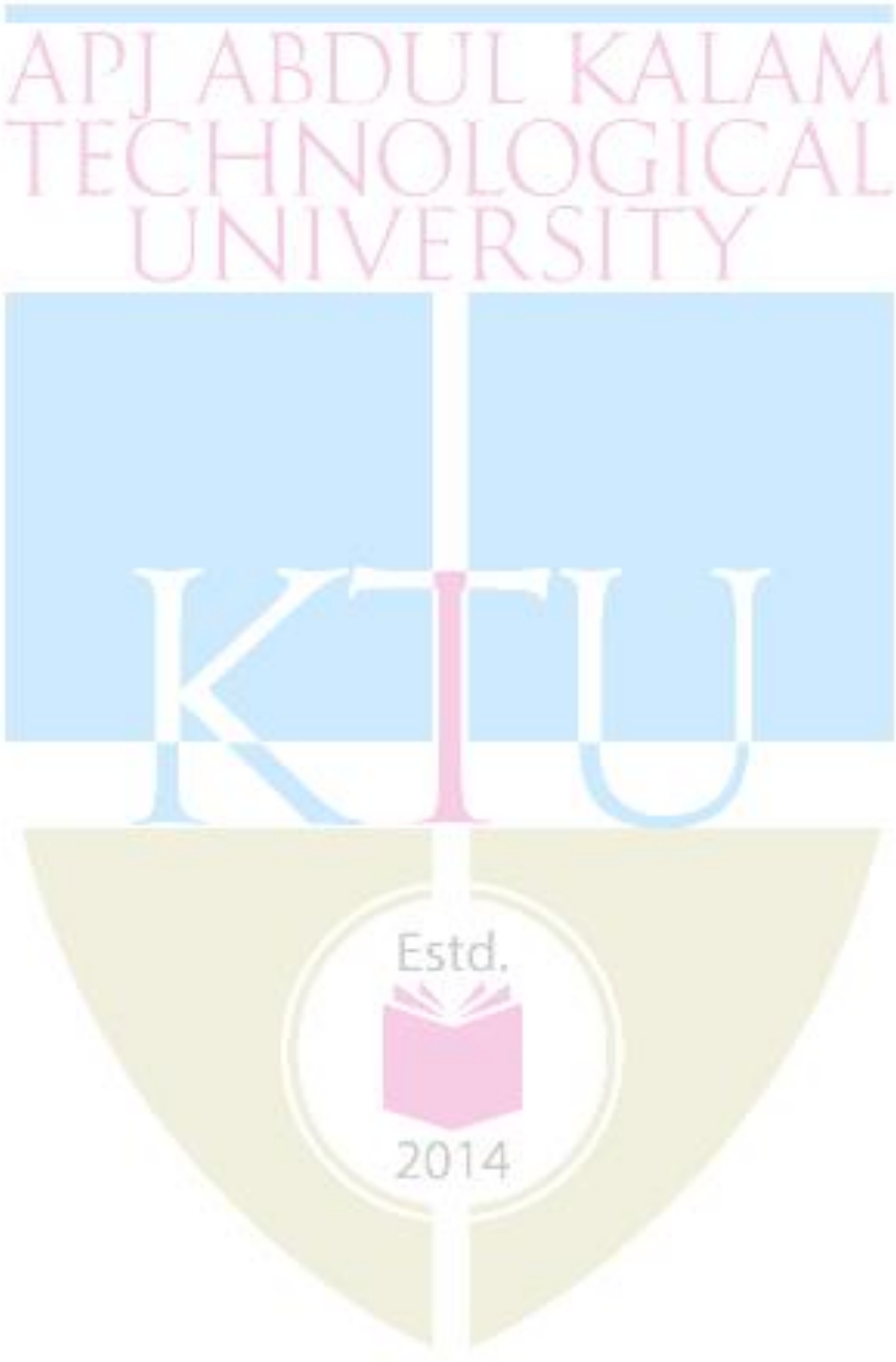
**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.


APJ ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY
KTU
Estd.
2014

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME372 | Operations Research | 3-0-0-3 | 2016 |

**Prerequisite -Nil**

**Course Objectives:**

- To understand the role of operation research in decision making
- To impart the various operation research techniques for effective problem solving.

**Syllabus:**

Operations research models, linear programming, transportation problem, assignment problem, sequencing problem, network analysis, queuing theory, inventory control, decision theory, game theory – simulation.

**Expected Outcome:**

- The students will be able to understand operations research techniques and apply them in solving practical problems in industry.

**Text Books:**


1. Miller, D. M. and Schmidt, J. W., Industrial Engineering and Operations Research, John Wiley & Sons, Signapore, 1990.
2. Paneerselvam, R., Operations Research, Prentice Hall of India, New Delhi, 2008.
3. Pannerselvam, R., Design and Analysis of Algorithms, Prentice Hall of India, New Delhi, 2007.
4. Srinivasan, G. "Operations Research-Principles and Applications", Latest edition, PHI Pvt. Ltd., 2010.
5. Taha, H. A., Operations Research, Pearson, 2004.


**Reference Books:**


1. Banks, J., Carson, J. S., Nelson, B. L., and Nicol, D. M., Discrete-Event System Simulation, Third Edition, Pearson Education, Inc., 2001.
2. Goel, B. S. and Mittal, S. K., Operations Research, Pragati Prakashan, Meerut, 1999.
3. Ravindran, Phillips and Solberg, Operations Research Principles and Practice, Willey & Sons, 1987.


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Basics of operations research–OR models–applications. | 1 | 15% |
| | Linear programming – problem formulation | 1 | |
| | Graphical method | 1 | |
| | Simplex method | 1 | |

| | | | |
|---|---|---|---|
| | Big-M method | **1** | |
| | Two–phase method | **1** | |
| | Duality in linear programming | **1** | |
| **II** | Transportation problem – formulation – balanced & unbalanced transportation problems | **1** | **15%** |
| | North west corner rule – least cost method | **1** | |
| | Vogel's method –stepping stone method | **1** | |
| | MODI method | **1** | |
| | Assignment problem – formulation – optimal solution, Hungarian algorithm | **1** | |
| | Variants of assignment problems | **1** | |
| | Traveling salesman problem. | **1** | |
| **FIRST INTERNAL EXAMINATION** | | | |
| **III** | Sequencing problem– terminology and notations – assumptions – problems with *n* jobs through two machines | **1** | **15%** |
| | Problems with *n* jobs through three machines | **1** | |
| | Problems with *n* jobs through *m* machines. | **1** | |
| | Network analysis – basic terms – network construction – time analysis | **1** | |
| | Critical path method (CPM) | **1** | |
| | Programme evaluation and review technique (PERT) | **1** | |
| | Cost considerations in network analysis – crashing | **1** | |
| **IV** | Introduction to queuing theory–terminologies– classification of queuing models | **1** | **15%** |
| | Single server problems | **1** | |
| | Multi server problems | **1** | |
| | Inventory control – variables – deterministic inventory models – purchasing model without shortages | **1** | |
| | Manufacturing model without shortages | **1** | |
| | Purchasing model with shortages | **1** | |
| | Manufacturing model with shortages | **1** | |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Decision theory – steps in decision theory approach – decision making conditions | **1** | **20%** |
| | Decisions under conditions of risk | **1** | |
| | Decisions under uncertainty conditions | **1** | |
| | Decision tree analysis | **1** | |
| | Game theory – games with saddle points | **1** | |
| | Games without saddle points – 2 x 2 games | **1** | |

| | | | |
|---|---|---|---|
| | Graphical method for m x 2 & 2 x n games | **1** | |
| **VI** | Simulation – types of simulation – phases of simulation – applications– advantages and disadvantages | **1** | **20%** |
| | Design of simulation, models & experiments, model validation | **1** | |
| | Generation of random numbers | **1** | |
| | Monte Carlo simulation | **1** | |
| | Queuing simulation model | **1** | |
| | Inventory simulation model | **1** | |
| | Simulation languages | **1** | |

**Question Paper Pattern**

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

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**Part B**
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**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4x10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME374 | THEORY OF VIBRATIONS | 3-0-0-3 | 2016 |

**Prerequisite: ME304 Dynamics of machinery**

**Course Objectives**

- To understand the principles of vibration theory.
- To introduce techniques for solving vibration problems.
- To enable development of mathematical model for engineering problems in vibrations.

**Syllabus**

Introduction to mechanical vibrations; Analysis of free, forced single degree of freedom systems; Damping; Vibration measuring instruments; Multi degree of freedom systems; Eigen value problems; Lagrange's equation; Vibration of continuous systems; Transient vibrations; Introduction to non linear and random vibrations.

**Expected outcome**

The students will be able to

i. formulate differential equations of motion of mechanical systems
ii. determine the natural frequencies of multi degree of freedom systems
iii. understand non linear and random vibrations.

**Text Books**:


1. Graham Kelly S, Schaum's outline of Mechanical Vibrations, Schaum's Outlines,1996
2. Singiresu S Rao, Mechanical Vibrations, Pearson, 2016
3. Thomson, W T , Theory of Vibration with Applications., Prentice Hall India,1981


**References Books**:


1. Den Hartog, J P, Mechanical Vibrations, McGrawHill, 1956.
2. Leonard Meirovitch, Elements of Vibration Analysis,McGraw Hill,1975.

| Course Plan | | | |
|---|---|---|---|
| **Module** | **Contents** | **Hours** | **End Sem. Exam Marks** |
| **I** | Introduction to mechanical vibrations- Simple harmonic motion- Natural frequency -Equation of motion-- Energy method-Rayleigh method | 2 | 20% |
| | Free vibration of single degree of freedom (DOF) systems with damping- Viscous damping- Logarithmic decrement.<br>Coulomb damping-Energy dissipated by damping- Structural damping -Equivalent viscous damping. | 4 | |
| **II** | Forced harmonic vibration- Magnification factor-Transmissibility-Vibration isolation-Base excitation-Rotating unbalance- whirling of shafts- Resonance<br>Vibration measuring instruments. Seismometer-Accelerometer | 5 | 15% |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Two degree of freedom systems-Normal mode vibration-Principal co-ordinates-Coordinate coupling. | 3 | 15% |
| | Beat phenomenon-Undamped vibration absorbers- Vibration dampers. | 2 | |
| **IV** | Multi degree of freedom systems- Matrix formulation- Influence coefficients-Flexibility matrix-Stiffness matrix | 5 | 20% |
| | Eigen Value problem:Eigen value and Eigen vectors-Frequency mode shape -Modal analysis. | 4 | |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Lagrange's equation- Solution to problems using Lagrange's equation. | 4 | 15% |
| | Vibration of continous systems-Vibrating strings- Longitudinal vibration of rods—Torsional vibration of rods | 6 | |
| **VI** | Transient vibrations- Impulse excitation- Convolution integral. | 4 | 15% |
| | Introduction to non linear vibrations and random vibrations | 3 | |
| **END SEMESTER EXAM** | | | |

## Question Paper Pattern

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
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There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

| Course code | Course Name | L-T-P - Credits | Year of Introduction |
|---|---|---|---|
| ME375 | MECHANICAL TECHNOLOGY | 3-0-0-3 | 2016 |

**Prerequisite : Nil**

**Course Objectives**

- To develop an understanding of the basic principles of machine design and machining technology and apply those principles to engineering applications.

**Syllabus**

General principles of engineering design - Design of Machine Elements -structural machine elements subjected to various types of loads, shafts, springs, Bearings.

Metal Cutting Technology - Types of Tools, tool geometry, tool signature - Mechanism of chip formation - Methods of machining, Heat generation in machining, Tool life and tool failure – Machinability- Basic machine tools - Lathe, Shaper, planer and slotter machines, Milling. Hobbing. Broaching, Grinding machines, Drilling and boring machines, Work holding and tool holding devices, Selection of cutting tools, Fundamentals of NC & CNC machine tools

Non-traditional Machining Technology - Abrasive jet machining, Ultrasonic machining, electro chemical machining, Electro discharge machining, Electron beam machining, Photo Chemical machining, Laser beam machining and plasma arc machining.

Industrial Safety - General safety rules - Safety and health provisions - Fire and accident prevention - Principles of safe machine design - Safety in materials handling - Legislations on safety

**Course Expected Outcome**.

On completion of the course, the student will be able to:

i. Explain the concepts and methods of designing and classification of stresses in simple machine members and design of structural machine elements subjected to various types of loading
ii. Define various failure modes, their endurance limit and their association with stress concentration.
iii. Design of Springs and Bearings with appropriate materials selection.
iv. Design of work holding and tool holding devices, Basic machine tools for shaper, planner, slotter milling, hobbing, broaching and grinding machines and select NC & CNC machine tools,.
v. Define the Non-traditional machining technology and design of various machines in this category.
vi. Define the non-traditional unconventional machining technology and design of various machines in this category.

**References/Textbooks**


1. Krishna Rao T., Design of machine Elements, I.K International publishing House Pvt. Ltd.
2. Bhandari V.B., Design of Machine Elements, McGraw Hill Book Company
3. Edward Trent and Paul Right, Metal Cutting, Butterworth- Heinemann
4. Jain R.K, Production Technology, Khanna publishers
5. Jain R.K., Industrial safety, Health and Environment, Khanna publishers
6. Budynas and Nisbett, Shigley's Mechanical Engineering Design, , 8th Ed., McGraw-Hill
7. Charles E.Wilson., Computer integrated machine design, Prentice-Hall.
8. Robert L.Norton., Machine design- an integrated approach, Prentice-Hall.
9. S.Md.Jalaludeen, Machine Design Volume – 1, Anuradha Publications
10. Collett. C.V and Hope A.D., Engineering measurements, Pitman publishing.
11. G.R.Nagpal, Machine Tool Engineering, Khanna Publishers

| Course Plan | | | |
|---|---|---|---|
| **Module** | **Contents** | **Hours** | **Sem. Exam Marks** |
| **I** | **Machine Design Concepts**<br>**1.1** General principles for engineering design: Factors influencing machine design, 1.2 Materials and properties, 1.3 Design considerations: Codes and standards, 1.4 Engineering stress and strain, Stress- strain diagrams, 1.5 Stresses in simple machine members: Axial, bending, torsional, bearing stress, 1.6 Principal stresses, Hoop stress, combined stresses, Simple problems, 1.7 Design considerations, Reliability based design | 7 | 15% |
| **II** | **Design of Machine Elements**<br>2.1 Modes of failure, 2.2 Theories of failure. 2.3 Endurance limit. 2.4 Stress concentration. 2.5 Factor of safety. 2.6 Design of structural machine elements subjected to various types of loads: Static loading, Impact loading, Bending, Torsional loading, Fatigue loading; 2.7 Design of shafts - shafts subjected to pure torsion, pure bending, combined axial, bending and torsion – simple problems, 2.9 Design of springs and Material selection, 2.10 Design of Bearings and Material selection | 9 | 15% |
| **FIRST INTERNAL EXAMINATION** | | | |
| **III** | **Metal Cutting Technology**<br>3.1 Introduction: Historical and Economic Context, 3.2 Types of Tools, tool geometry, tool signature, 3.3 Effect of tool geometry on machining, 3.4 Mechanism of chip formation, types of chips, 3.5 Methods of machining, machining tool diagram, 3.6 Heat generation in machining, 3.7 Tool life and tool failure, 3.8 Selection of cutting tools, cutting tool materials | 6 | 15% |
| **IV** | **Machining Technology**<br>4.1 Machinability, Machinability index, 4.2 Basic machine tools, Lathe, Shaper, planer and slotter machines, 4.3 Milling. Hobbing. Broaching, Grinding machines, 4.4 Drilling and boring machines 4.5 Work holding and tool holding devices, 4.6 Selection of cutting tools, 4.7 Materials for cutting tools 4.8 Fundamentals of NC & CNC machine tools | 6 | 15% |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | **Non-traditional Machining Technology**<br>5.1 Introduction to unconventional machining processes, 5.2 Abrasive jet machining: Abrasive water jet machining, abrasive flow machining, water jet machining, 5.3 Ultrasonic machining, 5.4 electro chemical machining, 5.5 Electro discharge machining, 5.6 Electron beam machining, 5.7 Photo Chemical machining, 5.8 Laser beam machining and plasma arc machining. | 7 | 20% |
| **VI** | **Industrial Safety**<br>6.1 Introduction, general safety rules, 6.2 Safety and health provisions of the Factories Act and Rules, 6.3 Reducing industrial noise, 6.4 Fire and accident prevention, 6.5 Principles of safe machine design, 6.6 Precautions to be taken by operators: Safety in materials handling, 6.7 Legislations on safety, 6.8 Role of OSHA | 7 | 20% |
| **END SEMESTER EXAM** | | | |

## QUESTION PAPER PATTERN

Maximum Marks : 100 Exam Duration: 3 hours

**PART A:** 8 Questions from Module 1&2 (4+4). 6 questions to be answered. 6x5=30 Marks
**PART B:** 8 Questions from Module 3&4 (4+4). 6 questions to be answered. 6x5= 30 Marks
**PART C:** 6 Questions from Module 5&6 (3+3). 4 questions to be answered. 4x10=40 Marks

| Course code | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| ME376 | Maintenance Engineering | 3-0-0-3 | 2016 |

**Prerequisite: Nil**

**Course Objectives:**

- To enable the student to understand the principles, functions and practices of maintenance activities.
- To develop ability in formulating suitable maintenance strategies to achieve reliable manufacturing system.
- To introduce the different maintenance categories and failure analysis tools.
- To equip with essential system diagnosis techniques so as to identify and take appropriate actions on error symptoms and causes of failures.
- To illustrate the techniques used for maintenance management.
- To empower with the skills to manage a manufacturing system to achieve continuous system availability for production.

**Syllabus:**

Maintenance – reliability – maintainability – availability – maintenance systems – condition monitoring – monitoring systems – failure analysis – maintenance effectiveness – quality assured maintenance – maintenance planning and scheduling – maintenance organization – maintenance costs – maintenance budgeting – human factor in maintenance – computer-aided maintenance management system – maintenance integration.

**Expected outcome:**

The students will be able to

i. Understand the relationship of key concepts in reliability engineering and application to maintenance strategies in a manufacturing environment.
ii. Establish maintenance strategies according to system characteristics and design transition programs to implement these strategies.
iii. Manage the manufacturing organization with highest possible availability.

**Text Books:**


**1.** Gupta A. K., Reliability, Maintenance and Safety Engineering, University Science Press, New Delhi, 2009.

2. Rao S. S., Reliability-Based Design, McGraw-Hill, Inc, New York, 1992.
3. Srivastava S. K., Maintenance Engineering and Management, S. Chand & Company Ltd., New Delhi, 1998.

**4.** Venkataraman, Maintenance Engineering and Management, Prentic-Hall of India Pvt. Ltd., New Delhi, 2007.

**Reference Books:**


**1.** Davies, Handbook of Condition Monitoring, Chapman & Hall, 1996.

2. Garg M. R., Industrial Maintenance, S. Chand & Co., 1986.

3. Higgins L. R., Maintenance Engineering Hand book, McGraw Hill, 5th Edition, 1988.

**4.** Mishra R. C. and Pathak K., Maintenance Engineering and Management, PHI Learning Pvt. Ltd., New Delhi, 2009.


**Course Plan**

| Module | Contents | Hours | End Sem. Exam. Marks |
|---|---|---|---|
| I | Maintenance – basic concepts, purpose, functions and objectives of maintenance. | 1 | 15% |
| | Principles, benefits and effects of maintenance | 1 | |
| | Inter-relationship between productivity, quality, reliability and maintainability – maintenance productivity – quality in maintenance. | 1 | |
| | Reliability – basic concepts – bathtub curve – failure rate – mean time before failure. | 1 | |
| | System reliability – reliability of series and parallel systems. | 1 | |
| | Maintainability – mean time to failure – mean time to repair. | 1 | |
| | Availability – inherent, achieved and operational availability – reliability, availability and maintainability (RAM). | 1 | |
| II | Maintenance strategies / systems – types – basis for selection. Breakdown maintenance – corrective maintenance | 1 | 15% |
| | Preventive maintenance – process flow – frequency in preventive maintenance. | 1 | |
| | Predictive maintenance – components – advantages and disadvantages. | 1 | |
| | Condition based maintenance and condition monitoring – monitoring systems. | 1 | |
| | Performance monitoring – visual, tactile and aural monitoring – leakage monitoring. | 1 | |
| | Temperature monitoring – thermography – advantages. | 1 | |
| | Thickness monitoring – acoustic monitoring – smell/odour monitoring. | 1 | |
| **FIRST INTERNAL EXAMINATION** | | | |
| III | Vibration monitoring – vibration fundamentals – vibration analysis. | 1 | 15% |
| | Vibration transducers – types. | 1 | |
| | Machinery vibration trouble shooting – machinery vibration standard, severity chart and acceptable limits. | 1 | |
| | Lubricant monitoring – components and techniques – filter debris analysis & filtergrams. | 1 | |
| | Ferrography – spectroscopic oil analysis program. | 1 | |

| | | | |
|---|---|---|---|
| | Crack monitoring – techniques. | **1** | |
| | Corrosion monitoring – techniques. | **1** | |
| **IV** | Reliability centered maintenance (RCM) – steps – flow diagram – basic guidelines. | **1** | **15%** |
| | Defect and failure – definitions – basics of failures – failure generation – failure analysis. | **1** | |
| | Fault tree analysis (FTA) | **1** | |
| | Event tree analysis (ETA) | **1** | |
| | Root cause analysis (RCA) | **1** | |
| | Failure modes and effects analysis (FMEA) | **1** | |
| | Failure mode effect criticality analysis (FMECA) | **1** | |
| **SECOND INTERNAL EXAMINATION** | | | |
| **V** | Terotechnology – definitions – terotechnology system – terotechnology process – strategies. | **1** | **20%** |
| | Total productive maintenance (TPM) – features –methodology – basic systems of TPM – TPM and terotechnology. | **1** | |
| | Six sigma maintenance. | **1** | |
| | Lean maintenance – 5-zero maintenance concept – 5-S maintenance concept. | **1** | |
| | Business centered maintenance (BCM) – six pillars – success factors. | **1** | |
| | Maintenance effectiveness – overall equipment effectiveness – key performance indicators – maintenance performance measuring indices. | **1** | |
| | Quality assured maintenance – need – maintenance work quality – use of c-chart for quality control in maintenance. | **1** | |
| **VI** | Maintenance planning and scheduling. | **1** | **20%** |
| | Maintenance organization – objectives and characteristics – centralized and decentralized maintenance. | **1** | |
| | Maintenance costs – classification of maintenance costs – maintenance cost analysis – cost effectiveness analysis. | **1** | |
| | Maintenance budgeting – types of maintenance budget – preparation of maintenance budget. | **1** | |
| | Human factor in maintenance – manpower planning for maintenance – objectives and stages of manpower planning – training for maintenance personnel. | **1** | |
| | Computer-aided maintenance management system (CMMS) – functions, applications and advantages of CMMS. | **1** | |
| | Maintenance integration – various steps in integration – scheme of integration of maintenance function with other functions. | **1** | |

## Question Paper Pattern

**Maximum marks: 100** **Time: 3 hrs**

The question paper should consist of three parts

**Part A**
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.