Bharatiya Vidya Bhavan's
**SARDAR PATEL COLLEGE OF ENGINEERING**
(Government Aided Autonomous Institute under Mumbai University)
Andheri (W) Mumbai - 400058

Bachelor of Technology

# Mechanical Engineering Program

**Regulation -2023**

# Course Contents

# Second Year of Mechanical Engineering

(Applicable for Working Professional also)

Semester – III & IV

Academic Year – 2025-26

# List of Courses

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## ES-BTM301 Linear Algebra and Vector Calculus

**Course Pre-requisites: -** Basic Engineering Mathematics

**Course Objectives:**

The objectives of this course are

1. To learn various Matrices, Operations and Important Theorems
2. Introduce Vector calculus
3. To understand the concept of the Fourier Series and its complex form and enhance problem-solving skills.
4. To understand the concept of Complex Variables and Conformal Mapping.

**Course Outcomes:**

Upon successful completion of the course, students should be able to

1. Find the rank of matrices, eigenvalues and Eigen Vectors of matrices.
2. Solve problem based on Fourier Series Expansion.
3. Solve complex variable problems.
4. Solve problems on vector differentiation & vector integration

**Course Content**

| Module | Details | Hrs |
|---|---|---|
| 1 | **Linear Algebra (Matrices)**<br>Revision of basic matrices and types of matrices.<br>Elementary operations and their use in getting the Rank, Normal form of a matrix, PAQ form, Consistency of system of homogeneous and non-homogeneous linear equations. | 05 |
| `2 | **Eigen Values & Eigen Vectors**<br>Eigen Values and Eigen Vectors of a matrix, Cayley-Hamilton theorem, Derogatory and Non-derogatory matrices. Function of a square matrix, Diagonalization of a matrix. | 08 |
| 3 | **Vector Differentiation**<br>Scalar and vector point functions<br>Gradient, Divergence and Curl, Solenoidal and Irrotational Vector Field.<br>Directional Derivative, Angle between two surfaces. | 05 |
| 4 | **Vector Integration:**<br>Vector integrals – Line and Surface Integrals, Work done by a vector field, Conservative force field, Green theorem in plane, Stoke's theorem, Gauss's Divergence theorem. Applications of Vector Integrals to mechanical engineering. | 05 |
| 5 | **Fourier Series**<br>Orthogonal & Orthonormal set of functions. Fourier series, Determination of Fourier constants, Dirichlets conditions. Fourier series for $f(x),\ x \in [c, c+2\pi]$ and $x \in [c, c+2L]$ , Parseval's Identity. | 07 |
| 6 | **Half Range and Complex Form of Fourier Series** | 06 |

| | | |
|---|---|---|
| | Fourier series of Odd and Even functions.<br>Half range Fourier Sine & Cosine series.<br>Complex form of Fourier series. | |
| 7 | **Complex Variables & Mapping**<br>Functions of complex variable, Analytic functions, Cauchy-Riemann equations in Cartesian and polar coordinates. Harmonic functions, Milne Thomson methods to find Analytic function $f(z)$, Orthogonal trajectories.<br>Conformal mapping, Bilinear transformation, cross ratio, fixed points. | 06 |

**Term work**

A total of 10 tutorials relevant to mechanical applications to be taken batch wise covering the entire syllabus.

**Text Books**

1. B S Grewal, "Higher Engineering Mathematics", Khanna Publications, 43rd Edition.
2. N.P.Bali. "Text book of Engineering Mathematics", Laxmi Publications, 9th edition.
3. H.K.Das. "Advanced Engineering Mathematics", S.Chand Publication.

**Reference Books**

1. B. V. Ramama. "Higher Engineering Mathematics" Tata Mc-Graw Hill Publication.
2. R V Churchill "Applications of Complex Variables" Tata Mc-Graw Hill Publication.
3. Murray Spiegel. "Theory and Problems of Fourier Analysis with Applications to BVP" Schaum's Outline Series.
4. R. K. Jain and S.R.K. Iyenger. "Advanced Engineering Mathematics", Narosa Publication.

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## PC-BTM302 Thermodynamics

**Course Pre-requisites- Applied Physics, Chemistry and Mathematics**

**Course Objectives:**

The objectives of this course are to

1. Explain: Fundamental concepts, laws of classical thermodynamics, principle of working and operation of thermodynamic cycles, scope and applications in research and advanced topics.
2. Explain and illustrate: Application of the fundamental principles and the laws of classical thermodynamics for non-flow systems, steady flow systems, and thermodynamic cycles.
3. Explain and illustrate: Thermodynamic analysis of non-flow and steady flow thermodynamic systems, thermodynamic cycles, advanced / emerging systems, scope and methods of modifications for performance improvements.
4. Explain and illustrate: Evaluation of thermodynamic properties for non-flow systems and steady flow systems, performance parameters and performance improvements for thermodynamic cycles, comparison of performance parameters, thermodynamic systems and cycles based on evaluation.

**Course Outcomes:**

Upon successful completion of the course, students should be able to

1. Understand and explain the fundamental concepts of thermodynamics, its scope and applications in few emerging areas
2. Apply the fundamental principles to solve on basic thermodynamic problems
3. Analyse simple thermodynamic systems and advanced few systems
4. Evaluate and compare the performance parameters non-flow and flow systems

**Course Contents:**

| Module | Details | Hrs. |
|---|---|---|
| 1. | **Fundamental Concepts:**<br>• Thermodynamic system, surrounding and universe, control volume, Thermodynamic State, Properties, Process and Cycle.<br>• Thermodynamic Equilibrium, Quasi-Static process.<br>• Work Transfer and Heat Transfer.<br>• Energy, Internal Energy, Enthalpy, Specific and Latent heat, | 05 |
| 2. | **First Law of Thermodynamics:**<br>• Non-flow System undergoing a Cycle and a process, PMM-I.<br>• Steady Flow Energy Equation (SFEE), and its applications to various devices such as boilers, nozzles and diffusers, turbines and engines, compressors and pumps, throttling device, condensers and heat exchangers etc.<br>• Zeroth Law of Thermodynamics, IPTS. | 06 |
| 3. | **Second Law of Thermodynamics:**<br>• Limitations of First Law of Thermodynamics, Cyclic Heat Engine, Energy Reservoirs, Kelvin-Planck and Claussius' statements and their equivalence, | 06 |

| | | |
|---|---|---|
| | PMM-II.<br>• Refrigerator and Heat Pump, Carnot Cycle, Reversed Heat Engine, Carnot Theorem, Absolute Thermodynamic Temperature Scale. | |
| **4.** | **Entropy and Energy:**<br>• Claussius' Theorem, The Inequality of Claussius.<br>• Entropy - a Property, Entropy changes in an irreversible process, Principle of Entropy, Entropy and Direction, Entropy and Disorder.<br>• Available Energy of a Cycle, Law of Degradation of Energy,<br>• Reversible Work and Availability in a Non-flow and Steady Flow Process, Useful Work, Dead State, Irreversibility | 06 |
| **5.** | **Vapor Power Cycles:**<br>• Properties of Pure Substances, p-v, Ts and h-s Diagrams<br>• Ideal and actual Rankine Cycle, Reheat Cycle, Regenerative Cycle, Reheat-Regenerative Cycle, Supercritical cycles,<br>• Use of Steam Tables and Mollier Diagram, Evaluation of efficiency and performance parameters of vapor power cycles. | 07 |
| **6.** | **Gas Power Cycles:**<br>• Air Standard Cycles for I.C. Engines: Otto Cycle, Diesel Cycle and Dual Cycle.<br>• Air Standard Cycles of Gas Turbines: Joule Cycle, Brayton Cycle.<br>• Modified Brayton cycle with Intercooling, Reheating and Regeneration, Jet Propulsion Cycle,<br>• Evaluation of efficiency and performance parameters of gas power cycles. | 07 |
| **7.** | **Advanced Topics:** Fundamental Concepts, working, classification, thermodynamic analysis and applications of<br>• Fuel Cells<br>• Low Temperature systems<br>• Cogeneration and Trigeneration systems<br>• EV – Battery Thermal Management | 05 |

**Course activities shall comprise of:**

1. At least one assignment on each module comprising questions based on theoretical concepts and numerical examples.
2. Participation and Report of academic activities related to the course such as industry expert lecture/ industry visit etc organized by faculty.
3. Technical presentations / Reviews/Reports on topics from the course contents with industry/ research applications.

**Internal Assessment Criterion:**
Attendance – 5 Marks, Assignment Work- 10 Marks, Viva-voce/ MCQ Test – 10 Marks.

**Text Books:**
1. Cengel, Yunus A., and Boles, Michael A., Thermodynamics An Engineering Approach,

McGraw Hill Education, New York
2. Holman, J.P., Thermodynamics, McGraw Hill, New York
3. Nag, P.K., Engineering Thermodynamics, McGraw Hill Education

**Reference Books:**

1. Achuthan, M., Engineering Thermodynamics, Prentice Hall India Pvt., Limited
2. Saad, Michel A., Thermodynamics for Engineers- Principles and Practice
3. Eastop, T. D., and A. McConkey, Applied Thermodynamics for Engineering Technologists
4. Sonntag, Richard Edwin, Claus Borgnakke, Gordon John Van Wylen, and Steve Van Wyk. Fundamentals of Thermodynamics. Wiley, New York
5. Nag, P.K., Power Plant Engineering, McGraw Hill Edu. Private Ltd.
6. Barron Randall F., Cryogenic Systems, Oxford University Press, New York

**Recommended NPTEL/ IITBombayX Lectures / Courses:**

1. Thermodynamics IITBombayX Course by Prof. U.N. Gaitonde, IIT Bombay https://www.iitbombayx.in/courses/thermodynamics-5
2. Thermodynamics Video Lectures by Prof. U.N. Gaitonde, IIT Bombay [Online]
3. Basic Thermodynamics NPTEL Course Lectures by Prof. S.K. Som, IIT Kharagpur https://nptel.ac.in/courses/112/105/112105123/

**Mapping of CO of the course PC-BTM403 with POs/PSOs:**

| | Program Outcomes (PO) | | | | | | | | | | | | PSO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | 1 | - | - | 1 | 1 | - | - |
| CO2 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | 1 | - | - | 1 | 1 | - | - |
| CO3 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | - | - | - | 1 | 1 | - | - |
| CO4 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | 1 | - | - | - | 1 | - | - |

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## PC-BTM303 Material and Manufacturing Science

**Pre-requisites**: - Basic Physics, Chemistry and Mathematics

### Course Objectives:

The objective of this course is to

Make students familiar with the mechanical, physical and chemical properties of common engineering materials- metals, ceramics, polymers and composites with the rationale behind these properties and to develop a good understanding of these.

### Course Outcomes:

Students shall be able to

1. Explain basic concepts of materials science and metallurgy in terms of material properties at the micro as well as macro-scale and discuss economic, environmental and social issues of material usage.
2. Students will understand and optimize machining and metal forming processes, considering tool life, wear, and load estimation.
3. Demonstrate the concept of iron-carbon equilibrium diagrams & phase diagrams and understand the basic terminologies associated with metallurgy—construction and identification of phase diagrams and reactions.
4. Describe different types of heat treatment methods to tailor the properties of Fe-C alloys and examine the properties of nonferrous, ceramic and composite materials.

### Course contents:

| Module | Description | Hours |
|---|---|---|
| 1 | **Introduction:**<br>Fundamentals of Metallurgy behind common engineering materials<br>**Atomic Arrangements:**<br>Lattice, Unit cells, Crystal Structure: Unit cells, Lattice Planes and Miller Indices.<br>**Phase diagrams:**<br>Equilibrium phase diagrams, Alloys, substitutional and interstitial solid solutions-Phase diagrams, Kinetics of nucleation and growth, Gibbs-Phase rule, Phase transformations and TTT diagrams.<br>**Iron-carbon equilibrium diagram:** Invariant Reactions, Microstructural aspects of ledeburite, austenite, ferrite and cementite, cast iron lever rule. | 8 |
| 2 | **Heat Treatment:** Different types of heat treatment like annealing, normalizing, tempering, austempering, stress relieving etc. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening. Material Selection for Heat Treatment Applications. | 6 |

| | | |
|---|---|---|
| 3 | **Alloys**: properties of stainless steel and tool steels, merging steels- cast irons; grey, white, malleable and spheroidal cast irons- copper and copper alloys; brass, bronze and copper-nickel; Aluminium and Al-Cu – Mg alloys- Nickel based super alloys and Titanium alloys. criteria and considerations for material selection based on application, performance, and processing requirements. | 5 |
| 4 | **Ceramic, Composites & Nanomaterials:** Ceramic materials, application of ceramics, properties of ceramics, inorganic glasses. **Composites:** types, characteristics and applications **Introduction to Nano materials:** Nano structured materials. Nano clusters & Nano crystals. | 5 |
| 5 | **Powder Metallurgy:** Technologies of metal powder production, Methods of characterization of metal powders properties, Additive manufacturing technologies and properties of parts produced from metal powders, Application in Additive Manufacturing of Metallic Parts. | 6 |
| 6 | **Mechanics of Machining** Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining | 7 |
| 7 | **Metal Forming Processes** Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes | 5 |

**Text Books:**

1. Callister, William D., and David G. Rethwisch. Materials science and engineering: an introduction. New York, Wiley.
2. Kodgire, V. D., and S. V. Kodgire. "Material science and metallurgy." Everest Publication.
3. Balasubramaniam, R. Callister's Materials Science and Engineering: Indian Adaptation (W/Cd). John Wiley & Sons.
4. V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited.
5. Manufacturing Science - Ghosh and Mallik (EWP)

**Reference Books:**

1. Lawrence, H., and Van Vlack. "Elements of materials science and engineering." (1989).
2. Guy, Albert G. *Physical metallurgy for engineers*. Addison-Wesley Pub. Co., 1962.

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## Mapping of CO of the course PC-BTM406 with POs/PSOs:

| | Program Outcomes (PO) | | | | | | | | | | | | PSO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 3 | 2 | - | 2 | 1 | - | 2 | - | 2 | 1 | - | - | - |
| CO2 | 3 | 3 | 3 | 3 | - | - | 1 | - | 2 | - | 2 | 1 | - | - | - |
| CO3 | 3 | 3 | 3 | 3 | - | - | 1 | - | 2 | - | 2 | - | - | - | - |
| CO4 | 3 | 3 | 3 | 3 | - | - | 1 | - | 2 | - | 2 | - | - | - | - |

## PC-BTM304 Strength of Materials

**Course Pre-requisites: - Mechanics and Mathematics**

**Course Objectives:**

1. To determine the internal forces developed in structural members.
2. To determine the stresses and strains produced in the structural members and machine components and their deformations under various types of loads.
3. To understand analytical methods for determining the strength, stiffness and stability of various load-carrying structural members and machine components

**Course Outcomes:**

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

1. Describe the concepts and principles, understand the theory of elasticity including strain/displacement and Hooke's law relationship and perform calculations, relative to the strength and stability of mechanical components.
2. Calculate, develop and analyze the SFD and BMD for various types of beams; calculate the bending and shear stresses; Solve torsion problems in circular bars.
3. Define the characteristics and calculate the magnitude of combined stresses in individual members by application of Mohr's circle of stress; analyze solid mechanics problems using classical methods and energy methods.
4. Calculate the deflection at any point on a beam subjected to a combination of loads; solve for stresses and deflections of beams under different loading.

**Course Contents:**

| Module | Details | Hrs |
|---|---|---|
| 01 | **Introduction**<br>• Definitions of stress and strain, axial tensile and compressive stresses, shear stress and strain.<br>• Definitions of Hooke's law, elastic limit, modulus of elasticity, yield stress, ultimate stress, modulus of rigidity, bulk modulus, Poisson's ratio, factor of safety, Volumetric strain for tri-axial loading. | 4 |
| 02 | **Simple Deformations under Axial Loading**<br>Deformation of stepped bars, tapering bars, deformation due to self-weight<br>**Thermal stresses:** Calculation of thermal stresses in structural components<br>**Energy Considerations:** Strain energy, Resilience, Calculation of stresses due to suddenly applied load, impact load, Strain energy stored due to shear. | 6 |
| 03 | **Shear Force and Bending Moment in beams**:<br>• Shear force and bending moment diagrams for statically determinate beams including beams with internal Hinges for different types of loading<br>• Relationship between rate of loading, shear force and bending moment. | 6 |
| 04 | **Bending stresses in beams:** | 9 |

| | | |
|---|---|---|
| | • Classical flexural formula for straight beams<br>• Bending stress distribution for different sections<br>**Shear stresses in beams:**<br>Distribution of shear stress across commonly used plane sections | |
| **05** | **Principle stresses (2D Problems):**<br>• General equations for transformation of stress<br>• Principal planes and principal stresses, maximum shear stress<br>• Mohr's circle | **6** |
| **06** | **Deflection of beams**:<br>Deflection of beams using double integration and Macaulay's method | **5** |
| **07** | **Thin cylindrical and spherical shells:**<br>Stress and strain in thin cylinders and spheres due to internal pressure<br>**Buckling of columns:**<br>Euler's theory of columns<br>One to two case studies from the latest technical articles from prescribed journals in the application of solid mechanics to real-life problems. | **6** |

**Text Books:**

1. S. S. Rattan, Strength of Materials, Tata McGraw-Hill."
2. Uday Shanker Dixit, Nelson Muthu, S.M. Kamal. *Strength of Materials*, AICTE, (2023).
3. Beer, Ferdinand P., R. Johnston, J. Dewolf, and D.Mazurek. "Mechanics of Materials, McGraw-Hill." (2006).

**Reference Books:**

1. Gere, James M., and S. P. Timoshenko. "Mechanics of materials Brooks." Cole, Pacific Grove, CA
2. Egor P. Popov, Engineering Mechanics of Solids, Prentice Hall of India, New Delhi
3. R. Subramanian, Strength of Materials, Oxford University Press
4. Journal of the Mechanics and Physics of Solids, Elsevier ScienceDirect
5. Journal of Applied Mechanics, ASME.

**Mapping of CO of the course PC-BTM302 with POs/PSOs:**

| | Program Outcomes (PO) | | | | | | | | | | | | PSO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 3 | 2 | - | 1 | - | - | 1 | 1 | - | 1 | 1 | 1 | - |
| CO2 | 3 | 3 | 3 | 2 | - | 1 | - | - | 1 | 1 | - | 1 | 1 | 1 | - |
| CO3 | 3 | 3 | 3 | 2 | - | 1 | - | - | - | 1 | - | 1 | 1 | 1 | - |
| CO4 | 3 | 3 | 3 | 2 | - | 1 | - | - | 1 | 1 | - | - | 1 | 1 | - |

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## PC-BTM305 Computer Aided Mechanical Drawing

**Course Pre-requisites: - Engineering Graphics / Engineering Drawing**

**Course Objective:**

In this course, students will:

1. Learn to draw and draft intersecting lines and curves of various interpenetration of solids like prism-prism, prism-pyramid, cylinder-cylinder, cone-cylinder.
2. Learn to draw free hand sketches of different standard components like, nuts, bolts, screws, washers, studs, keys etc.
3. Learn to draw free hand sketches of different types of threads, its applications, thread symbols and standard thread holes.
4. Learn how to draw and draft assembly and detail production drawings of the various mechanical systems like shaft joints, couplings, bearings, belt pulley, valves, jigs and fixtures etc. with bill of material, half section view, detail callout view etc.

**Course Outcome:**

Upon successful completion of this course, students should be able:

1. To create and compose engineering drawings for standard machine components on CAD software.
2. To sketch free hand proportionate illustrative representation of common machine components.
3. To assemble various standard machine components on CAD Software.
4. To plot assembly and detail production drawings with Bill of Material.

**Course Contents:**

| Module | Details | Hrs. |
|---|---|---|
| 01 | **Solid Geometry:** Intersection of surfaces and Interpenetration of solids- Intersection of prism or cylinder with Prism, cylinder or cone (both solids in simple and offset position only). | 03 |
| 02 | **Free Hand Sketching of:**<br>**Machine elements** such as bolts, nuts, washers, studs, components tapped holes;<br>**Types of Conventional Threads**; V-form and Square form, Conventional representation of assembly of threaded parts in normal and sectional views;<br>**Limits fits and tolerances:** dimensioning with tolerances indicating various types of fit in details and assembly drawings. | 02 |
| 03 | **Details and Assembly Drawing:** Introduction to unit assembly drawing, steps involved in preparing assembly drawing from details and vice versa.<br>**Preparation of details & assembly drawings of** Cotter joints, knuckle joint.<br>**Free Hand sketches of Keys**: sunk, parallel, woodruff, saddle, feather etc. | 03 |
| 04 | **Preparation of Details & Assembly Drawings of:**<br>**Coupling** - simple, muff, flanged, protected flange coupling, Oldham's | 02 |

| | | |
|---|---|---|
| | coupling and universal Coupling.<br>**Bearings-** Simple Block Bearing, Plummer Block Bearing, and Footstep bearing. | |
| 05 | **Preparation of Details & Assembly Drawings of**<br>**Belt Pulleys**- V-belt, rope belt, fast and loose pulleys,<br>**Valves** - Air cock, Blow off cock, Steam stop valve, gates valve, globe valve, non-return valve. | 02 |
| 06 | **Preparation of details & assembly drawings of**<br>**I.C. Engine Parts:** piston, connecting rod, cross head and crankshaft.<br>**Pipe Joints:** flanged joint, spigot and socket joint, stuffing box, expansion joint, union joint. | 01 |
| 07 | **Preparation of details & assembly drawings of**<br>Jigs & Fixtures, Clapper block, Single tool post, Crane Hook, Lathe & Milling tail stock. Exporting CAD files for 3d printing. Data Management through CAD | 01 |

**Text Books:**

1. Bhatt, N. D., and V. M. Panchal. Machine Drawing. Charotar, 1991.
2. Dhawan, R. K. Machine Drawing. S. Chand Limited, 1998.

**Reference Books:**

1. Narayana, K. L., P. Kannaiah, and K. Venkata Reddy. Machine drawing. New Age International, 2009.
2. John, K. C. Textbook of Machine Drawing. PHI Learning Pvt. Ltd., ed.1.

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## PC-BTM353: Material and Manufacturing Science Laboratory

**Course Co-requisites: Material and Manufacturing Science**

**Course Objective:**

1. To familiarize with use of optical laboratory microscope
2. To acquaint with microstructures of Materials.
3. To familiarize with microstructures of steel under different heat-treated conditions.

**Course Outcomes:**

Students shall be able to

1. Demonstrate the understanding of the procedure to prepare samples for studying microstructure using microscope (metallography).
2. Interpret different phases present in different steels and cast irons.
3. Interpret different failures and dislocations in different material samples.
4. Identify effects of Annealing, Normalizing and Hardening on microstructure of medium carbon steel.

**List of Experiments:**

The laboratory work shall consist of a journal based on the below-mentioned laboratory experiments.

1. Study of Metallurgical Microscope.
2. Preparation of Specimen for microscopic examination of plain carbon steel and C.I.
3. To observe and analyze the microstructure of plain carbon steels of various compositions.
4. To observe and analyze the microstructure of various types of C.I.
5. To observe and analyze the microstructure of various types of alloy steels.
6. To observe and analyze the microstructure of non–ferrous metals and their alloys.
7. To execute surface hardening process, testing and study of microstructure.
8. Experiment with the effect of carbon content in different metallic materials.
9. Experiment on composite material (different matrix and different reinforcement)
10. Characterization of smart materials, Shape Memory alloys

**Course Activities:**

The activities will comprise of following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. MCQ based on topics mentioned in the latest GATE syllabus
4. Oral Examination

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## PC-BTM354: Strength of Materials Laboratory

**Course Co-requisites: - Strength of Materials**

**Course Objectives:**

1. To acquire the ability to set up an experiment.
2. To record and analyze data from experiments.
3. To correlate experiment results against theoretical predictions
4. To discuss the significance of material testing techniques

**Course Outcomes:**

Upon successful completion of the course, students should be able to

1. Explain the underlying principle of the experiment, outline the experimental procedure and describe the parts of the experimental setup
2. Accurately record experimental observations and examine the correctness of experimental readings
3. Analyze and interpret data obtained through the experiment
4. Prove compliance of experimental data with theory and justify in case results do not comply with theory and/or standard values

**The list of Experiments to be conducted is as follows.**

1. Tension test on mild steel bar (stress-strain behavior, modulus determination)
2. Tension Test on tor-steel
3. Test on cast iron (transverse, tension)
4. Shear test on mild steel, cast iron, brass
5. Torsion test on mild steel bar/cast iron bar
6. Brinell hardness test
7. Rockwell hardness test
8. Izod impact test/Charpy test
9. Flexural test on beam (central point load) *
10. Flexural test on beam (two-point load) *

* For experiments no. 9 and 10, plot the load-deflection curve and find the value of Young's modulus.

**List of experiments from Virtual Laboratories (http://vlab.co.in/):**

1. Basic Engineering Mechanics and Strength of Materials lab (http://eerc01-iiith.vlabs.ac.in/index.php)
2. Strength-of-Materials lab (http://sm-nitk.vlabs.ac.in)

**Course Activities:**

The activities will comprise of following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. MCQ based on topics mentioned in latest GATE syllabus
4. Oral Examination

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## PC-BTM355 Machine Shop Practice

**Course Pre-requisites:** Workshop Practice

**Course Objectives:**

The objectives of this course are:

1. to demonstrate different machines, their parts and the functionality of these mechanical manufacturing machines
2. to demonstrate the use of various tools required in mechanical manufacturing processes
3. to demonstrate the Job Drawing, Mechanical Manufacturing Processes required to finish the job
4. to demonstrate various safety protocols to be followed during specific manufacturing process

**Course Outcomes:**

At the end of the course, the students shall be able to

1. identify the correct manufacturing machine for the given operation and demonstrate its construction and working
2. demonstrate the use of various tools required in mechanical manufacturing processes
3. interpret the Job Drawing; Plan and Execute the mechanical manufacturing processes required to finish the job
4. demonstrate and practice various safety instructions to be followed during the specific manufacturing processes and maintenance checklist for the machines and equipment

**Course Contents:**

| Job No. | Details | Hrs. |
|---|---|---|
| 01 | One job on a lathe machine in the machine shop involved:<br>Plain turning, facing, precision turning, grooving, centre drilling, external threading and taper turning. | 06<br>04 |
| 02 | One job on a shaper in a machine shop involved the machining of horizontal and inclined surfaces. | 04 |
| 03 | One job on arc welding exercise in a welding shop to make a composite joint such as a T-Joint. | 04 |
| 04 | One job on forging of parting tool in smithy shop | 04 |
| 05 | One job on forging cutting tools used on lathes, such as boring tool | 04 |

Practice work/Job shall be aligned with the current usage/ requirements of the various sections of the institute campus and learning attributes to convert assignments into utility value.

**In Semester Evaluation of Laboratory Work**

- Attendance and Attitude in Lab = 10 marks.
- Finished Job Submission and Manual Submission = 30 marks.
- Viva/Oral during Submission = 10 marks.

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**Reference Materials:**

**Books:**

1. Elements of Workshop Technology Vol 1: Manufacturing Processes, S.K. Hajra Choudhury, A. K. Hajra Choudhury, Nirjhar Roy, Media Promoters and Publishers Pvt. Ltd..
2. Elements of Workshop Technology Vol 2: Machine Tools, S.K. Hajra Choudhury, Nirjhar Roy, Media Promoters and Publishers Pvt. Ltd.
3. Workshop Technology Part 1, W. A. J. Chapman, Routledge.
4. Workshop Technology Part 2, W. A. J. Chapman, Routledge.
5. Mechanical Workshop Practice, K. C. John, Second Edition, PHI Learning Private Limited.

**Video links**:

1. https://www.youtube.com/@AniMechEdu .

**Website Links:**

1. https://themechanicalengineering.com/lathe-machine/
2. https://themechanicalengineering.com/forging-tools/
3. https://themechanicalengineering.com/resistance-welding/
4. https://stonemachinery.com/pdfs/Lathe-Maintenance-40214-201-Rev-B.pdf

| CO/PO Mapping | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| CO2 | 2 | - | - | - | 3 | - | - | - | - | - | - | - |
| CO3 | - | - | - | - | 3 | - | - | 3 | 2 | - | - | - |
| CO4 | - | - | - | - | - | - | 3 | 2 | - | - | - | - |

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## VE-BTM001 Health Safety and Sustainable Environment

**Course pre-requisites: Engineering sciences**

**Course Objective:**

The objective of this course is to motivate and sensitize the students to the ever-increasing environment problems and make them aware of the fundamentals of occupational safety and health along with prevailing laws in the world and India.

**Course Outcomes:**

Upon successful completion of the course, students should be able to

1. Understand fundamentals of occupational health and safety and management system and apply it.
2. Conversant with safety engineering terms and will apply the hazard analysis techniques
3. Based on knowledge of impacts, it will motivate students to reduce destruction of wetlands and ecology system
4. Able to know causes of pollution and waste mismanagement, accordingly different techniques can be applied to reduce its effect.

**Course Content**:

| Module | Details | Hrs. |
|---|---|---|
| 01 | **Introduction to Occupational Safety and Health (OSH)**: Motivation, Definition, Objectives, Principles of OHS, Work environment, OSH status, Cycle of neglect, Legal framework for OSH. **Occupational Health and Safety Management System:** Integrity of system, Residual risk and entropic risk, Risk mitigation strategy, philosophy of an organization, OSHAS 18001-2007, Safety management system, ISO 45001, Guiding principles. | 04 |
| 02 | **Introduction to safety engineering:** Industrial accidents as case study, Safety issues in material handling systems, Peterson model of accident causation, Basic terminology of safety engineering, Hazard theory and triangle, Hazard causal factors, Risk, ALARP, PtD, | 04 |
| 03 | **Hazard identification and its analysis:** Different analysis techniques, PHL's, PHA's, HAZOP's and FEMA's methodology, overview, worksheet, checklist, stepwise implementation procedure, IMRI, hazard control hierarchy, FMEA approaches | 04 |
| 04 | **Fault Tree & Event Tree Analysis:** Event symbols, gate symbols, Fault tree construction, P-S-C concept, fault tree quantification, gate by gate method, Set method, Cut set method, Mocus algorithm, Event tree analysis, quantification, risk profile. | 04 |
| 05 | **Environmental sustainability and management: Part 1** **Waste management:** Definition, Basel convention, types, classification, sources, magnitude of | 04 |

| | | |
|---|---|---|
| | problem of waste, waste hierarchy, impacts of waste., nuclear waste, soil pollution | |
| **06** | **Environmental sustainability and management: Part 2**<br>**Wetlands and Ramsar convention:**<br>Conventions and Treaties-RAMSAR Convention, Convention on Biological Diversity, Conventions on conservation of wild animals, types and classification of wetlands, Biodiversity and its sustainable use. | **04** |
| **07** | **Environmental sustainability and management: Part 3**<br>**Environmental Engineering:**<br>Air pollution, water pollution: sources, types, impact, characterization, useful minimization options, ozone depletion, Convention on Climate Change. | **04** |

**Text Books:**

1. Goetsch, David L. "Occupational Safety and Health for Technologists, Engineers, and.".
2. Krishnaswamy J., Daniels R.J.R., Environmental studies, Wiley India Private Ltd. New Delhi
3. Basak, Anindita. Environmental studies. Pearson Education India.

**References:**

1. Alli, Benjamin O. "Fundamental principles of occupational health and safety." (2001).
2. Gaur, R. C. Basic environmental engineering. New Age International Pvt Ltd Publishers,
3. ISO 14001:2004(E) - Environmental management systems Requirements with guidance for use, (2004).
4. NPTEL Course: Industrial Safety Engineering by Prof. Jhareswar Maiti.

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## ES-BTM401 Statistics, Probability and Laplace Transform

**Course Pre-requisites: -** Basic Mathematics

**Course Objective:**

The objectives of this course are

1. Introduce Statistical methods, probability distribution and testing of hypothesis.
2. Introduce testing of Hypothesis
3. To learn the Laplace Transform and its application to solve differential equations.

**Course Outcomes:**

Upon successful completion of the course, students should be able

1. Solve problems in basic statistics, probability, and probability distribution.
2. Solve the problem based on the testing of the hypothesis.
3. Solve problems based on Laplace and Inverse Laplace Transform. Apply the theory of Laplace transforms to evaluate real integrals and solve initial and boundary value problems.

**Course Content**

| Module | Details | Hours |
|---|---|---|
| 1 | **Statistics:** Correlation, Karl Pearson coefficient &Spearman's rank Correlation coefficient, linear regression, lines of regression. | 06 |
| 2 | **Discrete Random Variables:** Random variables, Probability distribution for discrete random variables, Expected value and Variance, Binomial Distribution and Poisson Distribution. | 06 |
| 3 | **Continuous Random Variables:** Probability Density Function for continuous random variable, Normal Distribution. | 04 |
| 4 | **Sampling Theory:** Sampling distribution. Test of Hypothesis. Level of significance, critical region. Large and Small Samples. Test of significance for Large Samples: Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two samples. Test for significance of the difference between sample S.D and population S.D, Test for significance of the difference between the S.D of two samples. | 06 |
| 5 | **T-Test:** Student's t-distribution and its properties. Test of significance of small samples. Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two samples, Chi-square distribution and its properties. | 06 |
| 6 | **Laplace Transform**<br>Function of bounded variation (Statement only) Laplace Transform of $1, e^{at}, \sin at, \cos at, \sinh at, \cosh at, t^n, erf\left(\sqrt{t}\right), J_0(t)$, Shifting theorems, change of scale, $L\{t^n f(t)\}, L\left\{\frac{f(t)}{t}\right\} L\left\{\frac{d^n f(t)}{dt^n}\right\} L\left\{\int_0^t f(u)du\right\}$<br>Convolution theorem, Evaluation of real integrals using Laplace Transform | 07 |

| | | |
|---|---|---|
| **7** | **Inverse Laplace Transform**<br>Evaluation of Inverse Laplace Transform using Partial Fractions, Convolution Theorem, Shifting Theorems and other properties. Application of Laplace Transform to solve initial & boundary value problems involving ordinary differential equation with one dependent variable. | **07** |

**Course activities shall comprise of**

A total of 10 tutorials **relevant to mechanical applications** to be taken batch wise covering the entire syllabus.

**Text Books**

1. B S Grewal, "Higher Engineering Mathematics", Khanna Publications.
2. H.K.Das. "Advanced Engineering Mathematics", S.Chand Publication.
3. Murray Spiegel. "Probability and Statistics" Schaum's Outline Series.
4. T Veerarajan, "Engineering Mathematics", Tata McGraw-Hill.

**Reference Books:**

1. B. V. Ramanna. "Higher Engineering Mathematics" Tata Mc-Graw Hill Publication.
2. N.P.Bali. "Text book of Engineering Mathematics", Laxmi Publications.
3. Murray Spiegel. "Laplace Transform" Schaum's Outline Series.
4. R. K. Jain and S.R.K. Iyenger. "Advanced Engineering Mathematics", Narosa Publication.

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## PC-BTM402 Fluid Mechanics

**Course Pre-requisites: Engineering Mathematics**

**Course Objectives:**

The course's objective is to familiarize students with the basic behaviour of static and dynamic fluids so that they can use this understanding to acquire deeper knowledge of the domain and solve real-life problems.

**Course Outcomes:**

On successful completion of the course, students will be able

1: to define the fundamental principles of fluid mechanics and related machines,
2: to identify, describe and explain the basic principles with applications,
3: to apply the knowledge of fluid mechanics, perform the related calculations and solve real-life flow problems,
4: to analyse a given flow system and design and develop a simple flow system.

**Course Contents:**

| Module | Description | Hrs. |
|---|---|---|
| 1 | **Fundamental Concepts:** Continuum, fluid properties - density, pressure, viscosity, surface tension, compressibility. Classification of fluid – Newtonian and Non-Newtonian, Viscous and Inviscid, Compressible and Incompressible. | 04 |
| 2 | **Fluid Statics:** Pascal's law, Derivation of basic hydrostatic equation, Application to manometer, Forces on the submerged surfaces, Fluid in rigid body motion, The concept of buoyancy, Archimedes' statement and stability of the floating bodies. | 06 |
| 3 | **Fluid Kinematics:** Approach of fluid flow description- Lagrangian and Eulerian, Velocity and Acceleration of flow, Classification of flow field – one, two and three-dimensional, steady and unsteady, uniform and non-uniform, rotational and irrotational, Laminar and turbulent. Flow patterns: streamlines, path lines and streak lines. | 06 |
| 4 | **Fluid Dynamics:** Methods of dynamic flow analysis- Integral and Differential approach. Reynolds Transport Equation, Integral form mass and momentum equations and their application for flow analysis. Differential form mass and momentum equations, Standard flow equations- Navier–Stokes equations, Euler's equations and Stokes equations. Cases of exact solutions from NS equation, Incompressible inviscid flow –Using Euler's equation to develop Bernoulli's equation and using it to solve flow problems. | 08 |

| | | |
|---|---|---|
| 5 | **Viscous Flows:**<br>Classification of viscous flow based on Reynolds number - laminar and turbulent flow. Characteristics of a turbulent flow. Concept of the boundary layer<br>Internal Flows- Developing and developed flow, Laminar and turbulent velocity profiles. Using laminar velocity profile to calculate - flow rate, pressure drop, shear stress, friction factor, etc. Moody's diagram and estimating head loss and pumping power for different pipe flow arrangements.<br>External Flows - The development of BL over a flat plate and its measurement, Flow over real immerged bodies, flow separation and methods to control it- streamlined and bluff bodies. Effect of drag and lift over the bodies and its measurement. | 08 |
| 6 | **Compressible Flow:**<br>Characteristics of compressible flow, Mach number and classification of high-speed flows. Stagnation and sonic properties, Effect of area variation on flow properties in isentropic flow, Isentropic flow through a converging nozzle – critical pressure ratio and chocked flow. | 06 |
| 7 | **Fluid Mechanics of Fluid Machines:**<br>Classification of fluid machines, Turbo-machinery Analysis, Hydraulic Turbine, Pumps, Compressors, Fans and Blowers. | 04 |

**Recommended Books:**

1. Fox and McDonald, "*Introduction to Fluid Mechanics*", John Wiley & Sons.
2. Frank M. White, "*Fluid Mechanics*", McGraw Hill,
3. Streeter V L and Wylie E B, "*Fluid Mechanics*", McGraw Hill,
4. Munson B R and Huebsch W W, "*Fundamentals of Fluid Mechanics*", Wiley,
5. Shaughnessy E J, "*Introduction to Fluid Mechanics*", Oxford University Press,
6. Yunus Cengel and John Cimbala, "*Fluid Mechanics*", Tata McGraw Hill.
7. Potter M C, "*Mechanics of Fluids*", Cengage Learning;

## Mapping of CO of the course PC-BTM403 with POs/PSOs:

| | Program Outcomes (PO) | | | | | | | | | | | | PSO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | 1 | - | - | 1 | 1 | - | - |
| CO2 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | 1 | - | - | 1 | 1 | - | - |
| CO3 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | - | - | - | - | 1 | - | - |
| CO4 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | - | - | - | - | 1 | - | - |

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## PC-BTM403 Mechanical Measurement and Control

**Course Pre-requisites: - Applied Physics**

**Course Objectives:**

The objective of the course is to impart fundamental knowledge of mechanical measurement techniques, data analysis and control systems with its application to the measurement of several mechanical engineering quantities and systems.

**Course Outcomes:**

Upon successful completion of the course learner will be able:

1. To apply the skill to categorize a generalized measurement system and identify the various static characteristics associated with measuring instruments.
2. To develop the skill for the selection of sensors and transducers for specific applications.
3. To select measurement systems for specific applications.
4. To comprehend different types of control systems and time response analysis.

**Course contents:**

| Module | Description | Hrs. |
|---|---|---|
| 1 | **Introduction:** Significance of Mechanical Measurements, Need of Inspection, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, Modifying and Interfering.<br>**Static characteristics:** Static calibration, Linearity, Static Sensitivity, Accuracy, Precision, Threshold, Resolution, Reproducibility, Hysterisis, Drift, Range and Span etc.<br>**Dynamic characteristics**: Order of instruments, dynamic behavior under standard inputs and key terminology.<br>**Errors in measurement and data analysis:** Types of errors, factor influencing measurement, methods of elimination, Probable errors, Uncertainty and Uncertainty analysis,<br>Statistical analysis of measured data, Estimation of Limiting Error, Regression technique | 05 |
| 2 | **Sensors and Transducers:** Strain Gauges, Construction, Types and sensitivity of strain gauges, Accelerometers, Force Sensors, Load Cells, Torque Sensors, Pressure Sensors, Microphones, Impact Hammers and Fiber Optic Sensors.<br>**Smart Actuator and its Techniques** – Role of Actuators and Actuator materials, Piezoelectric and Electrostrictive Materials, Magnetostructural Materials, Shape Memory Alloys, Electro rheological fluids, Electromagnetic actuation. Smart Sensors. | 04 |
| 3 | **Displacement measurement:** Potentiometers, LVDT, Capacitance type, Digital transducers (Optical Encoder), Comparators.<br>**Measurement of Surface Characteristics:** Measurement of straightness, flatness, squareness, parallelism, roundness and cylindricity, non-contact profiling systems, | 05 |

| | | |
|---|---|---|
| | Measurement of form and surface finish.<br>**Angular velocity measurement:** Tachometers, Tachogenerators, Digital tachometers, Stroboscopic methods.<br>**Acceleration measurement:** Theory of accelerometers and vibrometers, Practical accelerometers, strain gauge based and piezoelectric accelerometers. | |
| 4 | **Temperature Measurement, Pressure Measurement, Flow Measurement:**<br>**Pressure measurement:** Pressure standards, Elastic pressure transducers viz. Bourdon Tubes, Diaphragms, Bellows and Piezoelectric pressure sensors,<br>**High-pressure measurement:** Bridgman gauges. Calibration of pressure sensors.<br>**Vacuum measurement:** Vacuum gauges viz. Mcleod gauge, Pirani gauge, Ionization gauge, Thermal conductivity gauge, Knudsen gauge etc.<br>**Temperature measurement:** Thermodynamic Temperature Scale and IPTS, Electrical methods of temperature measurement viz. Resistance Thermometers, Thermistors, Thermocouples, Pyrometers.<br>**Flow measurement:** Venturimeter, Orifice meter, flow nozzles, Pitot tube, Rotameter, Hot wire Anemometrs, Turbine flow meters, Laser Doppler Anemometer etc.<br>Miscellaneous measurement: Measurement of liquid level, humidity etc. | 08 |
| 5 | **Open loop and Closed loop system:**<br>Mathematical modelling of mechanical, fluid system and thermal systems. Transfer Function. Block diagram reduction techniques, signal flow graphs. | 06 |
| 6 | **Time response of control system**<br>Time response of control system, analysis of steady-state error. Standard test signals and transient response of first and second order systems. static and dynamic error constants. | 05 |
| 7 | **Digital Instrumentation and Modes of Control:**<br>Data Acquisition System, Signal Conditioning Systems, Op-Amplifier. Internet-based measurement (Connecting Measurement systems to the internet). | 03 |

**Text Books:**

1. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
2. Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi
3. Control System Engineering by Nagrath I.J. and Gopal M, Wiley Eastern Ltd
4. Modem Control engineering: by K. Ogata, Prentice Hall .
5. Instrumentation and Control System, W. Bolton, Elsevier

**Reference Books**

1. J.P. Holman, “Experimental Methods for Engineers”, McGraw Hills International Edition, 2010.
2. S.P. Venkateshan, “Mechanical Measurements”, Ane Books, India, 2008.
3. C.S. Rangan, G.R. Sharma, V.S.V. Mani, “Instrumentation Devices and System”, Tata Mcgraw Hill, New Delhi, 2006.
4. Control systems by Dhanesh Manik, Cengage Learning.

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## Other Resources

1. NPTEL Course: Principles of measurement By Prof. Dipankar N Basu, Department of Mechanical Engineering, IIT Guwahati :-Web linkhttps://nptel.ac.in/courses/112/103/112103261/
2. NPTEL Course: Control Engineering By Prof. Ramkrishna Pasumarthy, Department of Electrical Engineering, IIT Madras :-Web link- https://nptel.ac.in/courses/108/106/108106098/
3. NPTEL Course: Mechanical Measurement System By Prof. Ravi Kumar, Department of Mechanical & indutsrial Engineering, IIT Roorkhi :- Web linkhttps://nptel.ac.in/courses/112/107/112107242/

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 1 | | | | | | | | 2 | 2 | |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | | | | | | 2 | 2 | |
| CO3 | 3 | 3 | 3 | 3 | 3 | | | | | | | | 2 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | | | | 2 | 2 | 2 | 2 | 1 |

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## PC-BTM404 Kinematics of Machinery

**Course Pre-requisites: Basic Mechanics**

**Course Objectives**

1. To provide basic concept of kinematics analysis of machines and machine members.
2. To give basic knowledge on kinematic design of machinery.
3. To understand the relationship between geometry and motion of the part of the machine.
4. To create a basic foundation for static and dynamic force analysis and ultimately for mechanical transmission system.

**Course Outcome:**

Upon successful completion of the course, student will be able to

1. Identify and understand the mechanisms for various applications,
2. Apply the basic kinematic principles for design of machine elements,
3. Analyze mechanisms using graphical and analytical methods,
4. Construct graphically and design the gear and cam profile.

**Course Contents:**

| Module | Details | Hrs. |
|---|---|---|
| 01 | **Basic Kinematics:**<br>**Structure, Machine, Link and its types**<br>**Kinematics pair -**Lower pair and higher pair, Form closed pair and force closed pairs, Based on relative motion permitted such as revolute, prismatic, cam, helical, globular.<br>**Kinematics chain and Mechanisms:** Grublers criterion for movability of chains and mechanisms, Limitations of Grublers Criteria. | 07 |
| 02 | **Inversion of chain:** Study of various mechanisms derived from inversions of following chains (with regard to motion of links of mechanisms, motion modification, quality of motion transmission (uniform, non-uniform, SHM, Non-SHM), limiting positions, dead positions, quick return property, applications). -- Four bar chain (Grashoffian, and non-Grashoffian), Single slider crank chain, and Double slider crank chain. | 07 |
| 03 | **Velocity and Acceleration Analysis of mechanisms (mechanisms up to 6 links).**<br>Velocity analysis by instantaneous centre of rotation method (Graphical approach).<br>Velocity and acceleration analysis by relative method (Graphical approach), Position analysis of links, velocity and acceleration analysis of slider crank mechanism using complex algebra. | 06 |
| 04 | **Mechanism with lower pairs:** Exact Straight line generating Mechanisms – Peaucellier and Harts (**Walking mechanism-Theo Jansen**), Approximate straight line generating Mechanisms – Watts, Roberts, Evans and Chebyshev. Offset slider crank mechanisms, Pantograph, Hooks joint (Single and Double) Steering gear mechanisms – Ackerman, Devis. | 06 |
| 05 | **Cam and Follower-** classification, motion analysis and plotting of displacement-time, velocity –time, acceleration-time for uniform velocity, UARM, SHM & Cycloidal motion (combined motions during one stroke excluded), generation of cam profile for roller and flat face follower, | 06 |
| 06 | **GEARS:** Law of gearing, Conjugate profile and its graphic construction, Involute and cycloid gear tooth profile, Construction of involute profile, Path of contact, arc of contact, contact ratio for involutes tooth. Interference in involutes gears. Critical Numbers of teeth for interference free motion. Methods to control interference in involutes gears, introduction to Cyclo drive for single-stage large speed reduction. CVT drive | 06 |

| | | |
|---|---|---|
| | Gear Trains: Kinematics and dynamic analysis of- simple gear trains, compound gear trains, reverted gear trains, and epi-cyclic gear trains with spur, or bevel gear combination | |
| 07 | Two-three case studies on KOM related topic from Latest Journals | 04 |

**Course Activities:**

1. **THEORY ORIENTED:**

- Assignment based on topics covered.
- MCQ based on topics mentioned in latest GATE syllabus
- ADAMS Software

2. **PROBLEM ORIENTED:**

**A Graphic work (on half imperial drawing sheets)**

1. Inversion of kinematic chain, limiting position and dead position- 4P
2. Location of instant center, Velocity analysis by ICR- 4P
3. Velocity and acceleration analysis by relative method- 4P
4. Construction of cam profile-1P
5. Construction of x-t, v-t, a-t, curves of follower motions- 1P

**B Analytical / Numerical work**

1. Numerical Problems on gear -5P
2. Numerical Problems on slider crank mechanism for vel/acc. analysis -2P
3. Any two problem using computer programming. (C++/MATLAB)-2P

**C. Demonstration with physical models of mechanisms**

**D. Simulation of motions of mechanism using CAD package (e.g. CATIA).**

**Recommended Books:**

1. Rattan S.S. "*Theory of Machines"* Tata McGrahill, ed 3, 2016.
2. Theory of machine and Mechanisms, 2nd Edition by J.E. Shigley, Mc-Graw Hill, New Delhi,1994.
3. P.L. Ballaney, *"Theory of Machines and Mechanisms"*, Khanna Publishers, 2003.
4. Bevan Thomas, "Theory of Machines" 3rd edition, CBS publication.

**Reference Books:**

1. Rane U.S., video playlist: https://www.youtube.com/playlist?list=PLB059985630300733
2. Reference: Physics Videos by Eugene Khutoryansky, https://www.youtube.com/@EugeneKhutoryansky
3. A. Ghosh, A.K. Mallik, *"Theory of Mechanisms and Machines"*, East West Press, ed.3, 1999.
4. Journal of Mechanisms and Robotics, ASME.
5. Journal 'Mechanism and Machine Theory', Elsevier ScienceDirect.

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## PC-BTM405 Dynamics of Machinery

**Course Pre-requisites: Basic Mechanics**

**Course Objective:** The students, after studying these topics, should be able to

1. Understand the fundamentals involved in the working of machines.
2. Understand the construction and principle of working of different machine components and sub-assemblies.
3. Provide the necessary tools to systematically synthesize a system and arrive at critical shapes and dimensions.
4. Provide an understanding of vibration systems in mechanical engineering.

**Course Outcomes:**

Upon successful completion of the course, students should be able to

1. To examine the construction and analyze the motion of mechanical subsystems such as dynamometers, governors, gyroscopes, and gear trains.
2. To analyze static and dynamic balancing of rotor and reciprocating mass systems.
3. To define damped and undamped SDOF vibration system
4. To derive governing equations of motion for damped and undamped vibration systems.

| Module | Descriptions | hrs |
|---|---|---|
| **01** | Dynamometers–Absorption and transmission dynamometers, Study and analysis of absorption type dynamometer –Proney brake, Rope brake, dynamometers, Study and analysis of transmission type dynamometers. Flywheel: Turning moment diagram, Fluctuation of energy and speed. | **04** |
| **02** | Gyroscope: Introduction- Gyroscopic couple and its effect on spinning bodies, Gyroscopic effect on naval ships during steering, pitching and rolling, Ship stabilization with gyroscopic effect. Two wheeler and four wheeler on curved path- effect of gyroscopic and centrifugal couples, maximum permissible speeds on curve paths, Gyroscopic effect due to lateral misalignment of rigid disc mounted on shaft. | **04** |
| **03** | Governors: Comparison between governors and flywheel, Types- centrifugal governors, inertia governors, Force analysis of gravity loaded governors– Watt, Porter, Proell, Force analysis of spring-loaded governors-Hartnell, Hartung, Wilson Hartnell, Force analysis of spring and gravity loaded governor, Performance characteristics of governor stability, sensibility, isochronisms, Hunting, governor effort and governor power, coefficient of insensitiveness, introduction to MEMS based gyroscopes | **04** |
| **04** | Brakes and Clutches: Working Principles, Mechanisms and Types | **04** |
| **05** | Basic Concepts of Vibration: Vibration and oscillation, causes and effects of vibrations, Vibration parameters -spring, mass, damper, Damper models, Motion periodic, non-periodic, harmonic, non–harmonic, Degree | **04** |

| | | |
|---|---|---|
| | of freedom, static equilibrium position, Vibration classification, Steps involved in vibration analysis, Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, torsional system, | |
| **06** | Free Damped Single Degree of Freedom Vibration System: Viscous damped system- underdamped, critically damped, overdamped. Logarithmic decrement. Coulomb's damping. Combined viscous and coulomb's damping. Critical speed of shafts. | **04** |
| **07** | Balancing: Static and dynamic balancing of multirotor system, Balancing of reciprocating masses In-line engines, V-engines | **04** |

**Text Books:**

1. Bevan, Thomas. The theory of machines. Pearson Education India, 1944.
2. Rattan, Sarjit S. Theory of machines. Tata McGraw-Hill, 2005.
3. Ballaney, P. L. Theory of machines. Khanna, 1980.
4. Grover, Gopal Krishan. Mechanical Vibrations: MKS System. Nem Chand, 1972.
5. Kelly, S. Graham. "Fundamentals of mechanical vibrations." (1992).
6. Rao, Singiresu S., and Fook Fah Yap. Mechanical vibrations. Vol. 4. New York: Addison-Wesley, 1995.

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## PC-BTM452 Fluid Mechanics Laboratory

**Course Co-requisites: Fluid Mechanics**

**Course Objectives:**

The objective of this course is to enhance the practical knowledge and understanding of course BTM403 through live examples and by performing experiments that involve principles of fluid mechanics

**Course Outcome:**

On successful completion of the course, students will be able

**CO1:** to define the fundamental principles of fluid mechanics in better way
**CO2:** to illustrate the basic principles of fluid mechanics through experiments.
**CO3:** to collect the experimental data and perform calculations
**CO4:** to analyse, interpret and conclude the experimental results.

| Exp. No. | Details of Laboratory Experiments | Hrs |
|---|---|---|
| 1. | To determine specific gravity of a given liquid | 02 |
| 2. | To verify Archimedes principle and to determine specific gravity of a concrete block | 02 |
| 3. | To determine the coefficient of discharge of a given orifice plate | 02 |
| 4. | To determine kinematic viscosity using Hagen-Poiseuille setup and prove that head loss is proportional to volume flow rate | 02 |
| 5. | To determine the coefficient of discharge of a given Venturimeter | 02 |
| 6. | To determine Darcy Friction factor for pipes of different diameters | 02 |
| 7. | To carryout experiment on a given experimental setup to verify Bernoulli's theorem | 02 |
| 8. | To determine coefficient of impact of a jet in flat and inclined plate | 02 |
| 9. | *To carry out mini project in groups | |
| 10. | #To perform numerical calculations on flow problems related to real life cases | 08 |

* Mini project topic will be allocated to different groups consisting of 2-3 students. Group is expected to explore through internet resources/books/magazines and prepare a report as per the problem definition and submit it.

# At least one assignment on each of the module of the theory course BTM 403 needs to be completed.

**Recommended Books:**

1. *Fluid Mechanics Laboratory Manual*, Department of Mechanical Engineering, SPCE.

**Course Activities:**

The term work will comprise of following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Examination (MCQ) based on topics mentioned in latest GATE syllabus
4. Oral Examination

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## PC-BTM453 Mechanical Measurement and Control Laboratory

**Co-requisites**: - **PC-BT403**

**Course Objectives:**

The objectives of this course are

1. To impart hands on different mechanical engineering measurement system
2. To understand the methodology to characterize the measurement systems and error analysis
3. To design the measurement system.
4. To Synthesis of measurement systems

**Course Outcomes:**

On successful completion of the course, the learner should be able to

1. Calibrate the mechanical engineering measurement system.
2. Characterize the measurement system, find the error, and perform uncertainty analysis
3. Design measurement system for engineering applications
4. Synthesize measurement system/sensor

**List of Experiments: List of Experiments:**

1. Characterization of dead weight pressure gauge tester and error analysis.
2. Investigating the development of strain gauge-based measurement systems.
3. Characterization of strain gauges and error analysis.
4. Investigating the development of Linear Variable Differential Transducer (LVDT) based displacement measurement systems and characterization of LVDT.
5. Calibration of Stroboscope Speed Measurement System.
6. Calibration of Contact Probe-type Digital Tachometer.
7. Investigating transient response analysis of Resistance type temperature detector, mercury in glass thermometer and thermocouple
8. Characterization of temperature measurement systems
9. Characterization of Bernoulli's fluid flow measurement systems
10. Characterization of optical and magnetic encoders
11. Study of IoT-based architecture for smart measurement system

**Course Activities:**

The term work will comprise the following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Mini project on developing a measurement system or characterization of the sensor in a group of 3 students.
4. Oral Examination or MCQ based Examination

**Text Books:**

1. E.O.Dobelin, “Measurement Systems (Applications and Design)”, McGraw Hill.
2. A.K. Sawhney&PuneetSawhney, “Mechanical Measurements and Instrumentation & Control”, Dhanpat Rai & Co., Twelfth Edition.
3. Thomas Beckwith, N. Lewis Buck, Roy Marangoni, “Mechanical Engineering Measurement”, Narosa Publishing House, Bombay.
4. B.C. Nakra and K.K. Chaudhry, “Instrumentation Measurement and Analysis”, Tata McGraw Hill. Third Edition.
5. A.K. Thayal, “Instrumentation and Mechanical Measurements".Galgotia Publications Pvt. Ltd.

**Reference Books**

1. E.O. Dobelin, “Engineering Experimentation”, McGraw Hills International Edition
2. J.P. Holman, “Experimental Methods for Engineers”, McGraw Hills International Edition.
3. S.P. Venkateshan, “Mechanical Measurements”, Ane Books, India.
4. C.S. Rangan, G.R. Sharma, V.S.V. Mani, “Instrumentation Devices and System”, Tata Mcgraw Hill, New Delhi.

**CO-PO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 1 | | | | | | | | 2 | 2 | |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | | | | | | 2 | 2 | |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | | | | 2 | 2 | 2 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | | | | | | | | 2 | 2 | 1 |

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## PC-BTM455 Dynamics of Machinery Lab.

**Course Co-requisites: PC-BTM405**

**Course Objective:**

The students after studying these topics should be able to

5. Understand fundamentals involved in working of machines.
6. Understand construction and principle of working of different machine components and sub-assemblies.
7. Provide the necessary tools to systematically synthesize a system and arrive at a critical shapes and dimensions.
8. Provide understanding of vibration systems in mechanical engineering.

**Course Outcomes:**

Upon successful completion of the course, students should be able

1. To examine construction and analyze motion of mechanical subsystems such as clutches, breaks, dynamometers, governors, gyroscope, gear trains.
2. To analyze static and dynamic balancing of rotor and reciprocating mass systems.
3. To examine SDOF vibration system
4. To investigate motion for damped and undamped vibration systems.

**Course Contents**

**List of Experiments:**

1. To measure brake power of pelton turbine using rope and brake dynamometer.
2. To find the gyroscopic couple acting on a rotating disc.
3. To determine performance characteristic curve of sleeve position against controlling force and speed of porter governor and proell governor.
4. Study of different types of Brakes and Clutches.
5. To calculate the position of counter balancing weight in rotating mass systems for Static and Dynamic Balancing.
6. Experimental and theoretical investigation of whirling of shaft.
7. To determine periodic time for simple pendulum.
8. To determine the radius of gyration ‘k’ of given compound pendulum.
9. To study the longitudinal vibrations of helical spring and to determine the frequency or period of vibration (oscillations) theoretically and actually by experiment.
10. To study the un-damped free vibration of equivalent spring mass system.

**Course Activities:**

The term work will comprise of following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Examination (MCQ) based on topics mentioned in latest GATE syllabus
4. Oral Examination

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## PC-BTM456 Assembly Shop Practice

**Pre-requisites**: - Workshop Practice, Machine Shop Practice

**Course Objectives:**

The objectives of this course are

1. to demonstrate different machines, their parts and the functionality of these mechanical manufacturing machines,
2. to demonstrate the use of various tools required in mechanical manufacturing processes,
3. to demonstrate the Assembly Drawing, Mechanical Manufacturing Processes required to finish the jobs in assembly,
4. to demonstrate various safety protocols to be followed during specific manufacturing processes and maintenance checklist for the machines and equipment

**Course Outcomes:**

At the end of the course, the students shall be able

1. to identify the correct manufacturing machine for the given operation and demonstrate its construction and working,
2. to demonstrate the use of various tools required in mechanical manufacturing processes,
3. to interpret the Assembly Drawing; Plan and Execute the Mechanical Manufacturing Processes required to finish the jobs and assemble them together as given,
4. to demonstrate and practice various safety instructions to be followed during the specific manufacturing processes and maintenance checklist for the machines and equipment,

**Course Contents:**

| Job No. | Details | Hrs. |
|---|---|---|
| 01 | One composite job of assembly of minimum three components produced using conventional lathe, shaper, milling, drilling, grinding machines and CNC Lathe & CNC Milling machines involving the operations of precision turning, taper turning, taper boring, internal threading, shaping plain flat surfaces, milling, drilling, surface grinding.<br><br>Assignment on Product Development. | 18 |

**In Semester Evaluation of Laboratory Work**

- Attendance and Attitude in Lab = 10 marks.
- Finished Job Submission and Manual Submission = 30 marks.
- Viva/Oral during Submission = 10 marks.

**Reference Materials:**

**Books:**

1. Elements of Workshop Technology Vol 1: Manufacturing Processes, S.K. Hajra Choudhury, A. K. Hajra Choudhury, Nirjhar Roy, Media Promoters and Publishers Pvt. Ltd., January 2008.
2. Elements of Workshop Technology Vol 2: Machine Tools, S.K. Hajra Choudhury, Nirjhar Roy, revised 15th Edition, Media Promoters and Publishers Pvt. Ltd., January 2010.
3. Workshop Technology Part 1, W. A. J. Chapman, Fifth Edition, Routledge, 2011.
4. Workshop Technology Part 2, W. A. J. Chapman, Fourth Edition, Routledge, 2013.
5. Mechanical Workshop Practice, K. C. John, Second Edition, PHI Learning Private Limited, 2010.

**Video links**:
1. https://www.youtube.com/@AniMechEdu .

**Website Links:**
1. https://themechanicalengineering.com/lathe-machine/
2. Difference Between Horizontal and Vertical Milling Machine (themechanicalengineering.com)
3. Milling Cutter: Definition, Types in detail, Geometry Material (themechanicalengineering.com)
4. Shaper Machine: Definition, Parts, Working Principle, Types, Operation, Advantages, Application (themechanicalengineering.com)
5. Grinding Machine: Definition, Parts, Working Principle, Operation, Advantages, Application (themechanicalengineering.com)
6. https://stonemachinery.com/pdfs/Lathe-Maintenance-40214-201-Rev-B.pdf

| CO/PO Mapping | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| CO2 | 2 | - | - | - | 3 | - | - | - | - | - | - | - |
| CO3 | - | - | - | - | 3 | - | - | 3 | 2 | - | - | - |
| CO4 | - | - | - | - | - | - | 3 | 2 | - | - | - | - |

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## MI-BT021 Minor 1

The course content of all Minors offered by the institute during an academic year is provided separately. Students are advised to visit the list of Minors to see the details of the associated courses and their course contents.