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

COURSE CONTENTS

(S.Y. B.Tech. in Mechanical Engineering)

(Under Regulations 2022)

Year: 2023-24

List of Courses

BS-BTM301 Applied Mathematics I

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 concept of Fourier Series, its complex form and enhance problem solving skills.
4. To understand concept of Complex Variables and Conformal Mapping.

Course Outcomes:

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

1. Find rank of matrices, Eigen Values and Eigen Vectors of matrices.
2. Solve problem based on Fourier Series Expansion.
3. Solve Complex Variables problems.
4. Solve Problems on Vector Differentiation & Vector Integration

Course Content

Module	Details	Hrs
1	**Linear Algebra (Matrices)** Revision of basic matrices and types of matrices. 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** 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** Scalar and vector point functions Gradient, Divergence and Curl, Solenoidal and Irrotational Vector Field. Directional Derivative, Angle between two surfaces.	05
4	**Vector Integration:** 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** 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** Fourier series of Odd and Even functions. Half range Fourier Sine & Cosine series.	06

	Complex form of Fourier series.	
7	**Complex Variables & Mapping** 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. 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.

PC-BTM302 Strength of Materials
Course Pre-requisites: - ES-BT104, ES-BT204

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 No.	Details	Hrs
01	**Introduction** • Definitions of stress and strain, axial tensile and compressive stresses, shear stress and strain. • 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** Deformation of stepped bars, tapering bars, deformation due to self-weight **Thermal stresses:** Calculation of thermal stresses in structural components **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**: • Shear force and bending moment diagrams for statically determinate beams including beams with internal Hinges for different types of loading • Relationship between rate of loading, shear force and bending moment.	6
04	**Bending stresses in beams:** • Classical flexural formula for straight beams • Bending stress distribution for different sections	9

	Shear stresses in beams: Distribution of shear stress across commonly used plane sections **Shear stresses due to torsion**: • Stress and deflection during torsion of circular shafts – solid, hollow and stepped • deflection of shafts fixed at both ends	
05	**Principle stresses:** • General equations for transformation of stress • Principal planes and principal stresses, maximum shear stress • Mohr's circle	**6**
06	**Deflection of beams**: Deflection of beams using double integration and Macaulay's method	**5**
07	**Thin cylindrical and spherical shells:** Stress and strain in thin cylinders and spheres due to internal pressure **Buckling of columns:** Euler's theory of columns 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.

PC-BTM305 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 No.	**Details**	**Hrs.**
1.	**Fundamental Concepts:** • Thermodynamic system, surrounding and universe, control volume, Thermodynamic State, Properties, Process and Cycle. • Thermodynamic Equilibrium, Quasi-Static process. • Work Transfer and Heat Transfer. • Energy, Internal Energy, Enthalpy, Specific and Latent heat,	05
2.	**First Law of Thermodynamics:** • Non-flow System undergoing a Cycle and a process, PMM-I. • 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. • Zeroth Law of Thermodynamics, IPTS.	06

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

Term work 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 / Review /Report on topics from the course contents with industry/ research applications.

Term work 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/

PC-BTM306 Manufacturing Science
Course Pre-requisites: - BS-BT105, BS-BT106, BS-BT205, BS-BT206

Course Objectives:
The objective of this course is:

- To give fundamental insights about different manufacturing processes keeping product quality and economics of manufacturing process in mind.
- To transfer knowledge about process parameters and capabilities of manufacturing processes like material removal, joining, metal casting and surface modification processes.
- To impart basic working principles of parts and system working of various machine tools like, Lathe, Milling, Drilling, Surface Grinding machine tools.
- To learn and apply the concepts of machining for particular component, by deciding sequence of operations and concerned machine tool requirement for same
- To make the students aware of the basic welding processes and their specific method of application. To learn and apply the concepts of non-conventional manufacturing processes for products of different design and material

Course Outcomes:
Upon successful completion of the course, students should be able

1. to understand fundamentals of manufacturing processes, performance & ability
2. to select/apply appropriate the metal joining, metal casting, metal removal processes for manufacturing of a component/system to suit an application
3. to analyze the non-conventional machining processes and other manufacturing processes for imparting desirable properties to product
4. to explain construction, working principles of machine tools, which enables them to decide sequence of machining process to achieve economics of machining

Course contents:

Sr. No.	Description	Hours
1	**Metal Casting Processes:** Fundamentals of metal casting processes, Gate system (analysis of filling time, freezing ratio and its detailed design), Pattern (Material, allowances, design requirements, numerical based pattern size), Accessories (chill, chaplets, core), Difficulties in sand metal casing process, Defects in metal casted components, Case study of development of metal casted component by using computational tool (Industry methods), Die casting processes, Special Metal casting processes like centrifugal casting, , investment mold casting, Plaster mold casting, continuous casting. etc. **Plastic molding**: Compression molding, Injection molding, Blow molding, Transfer molding shell molding etc	06
2	**Metal Joining Processes**: Fundamental of joining process, its requirements from satisfactory quality and performance aspect, Classification based on different criteria, Mechanism of joining in fusion welding, solid state welding processes, Defects in welded components, its non-destructive testing (NDT) techniques, Analysis of welding process from optimization	**6**

	of welding speed for satisfactory weld quality. Arc welding (power source, electrode, material and different process types and its application), Gas welding, Resistance welding, Friction stir welding, Diffusion welding, Thermite welding, Explosive welding etc., Weld joint types, weldability. **Soldering, braze welding and brazing**: Process, its parameters and material application	
3	**Lathe machine tool**: Fundamental of machining process, Classification of lathe machine tools (their construction, material and working), different operations of lathes machine tool, attachments and accessories, type of cutting tools, operating parameters (cutting speed, feed, depth of cut and machining time). Economics of machining, environmental aspects of machining waste, Learn approach to optimize machining process. Tool room, Capstan and turret lathes. **Advancements in machine tool technology**: NC, CNC, accessories to condition and monitor machines tool processes, machining centers and types.	**6**
4	**Milling machine tool**: Fundamental of milling operation, Classification, Construction, degrees of freedom offered by machine elements and study of sub systems of different types of milling machine tool (such as universal, vertical). Milling Cutters and their applications, Operation on milling machine tool. Work holding devices (its types and applications), Indexing devices (dividing head types and numerical based of system element selection). Use of above knowledge and its application in selecting resources for obtaining finish component. **Drilling machine tool**: Fundamental of drilling operation, Types of drilling machine tools, types of drilling tool and its operations such as drilling, boring, reaming, spot facing, counter boring, counter sinking and tapping. Selection of work holding device and machine tool to optimize the process and make it possible within minimum set up.	**6**
5	**Non-Conventional Material removal Processes**: Ultrasonic Machining (USM), Water-Jet Machining & Abrasive-Jet Machining, Chemical Machining, Electrochemical Machining (ECM), Electrical-Discharge Machining (EDM), High-Energy-Beam Machining, Laser-beam machining (LBM) – Electron-beam machining (EBM)	**6**
6	**Jigs and Fixtures**, Introduction to jig and fixture (JF) system, analysis of economical manufacturing process using JF system, principles of locating, support and clamp elements (its design and manufacturing considerations) Types of (locating, support and clamp elements) and their particular suitable applications. Jig Bush and jig plate (its types, design requirements), Design and manufacturing requirements of JF system (Fool proofing means etc) Different configurations of JF system (such as Box Jig, pot jig, standard jig, etc.) **Case study** discussion to solve problem for specific design of metal component product(from selection, manufacturing sequence, concept drawing of assembly steps till finalizing bill of material)	**6**

7	**Grinding machine tool and its fundamental surface finishing process**: Fundamentals of grinding process, Essential requirements for efficient finishing, tool variables (such as material and operating parameters) affecting fine machinability, Grinding wheel (fundamentals to use while selecting appropriate wheel specifications to suit application). Classification of Grinding machine tool based on different criteria, study of pedestal, cylindrical surface, centre less and tool and cutter grinding machine tool (Operations), Dressing and truing of grinding wheels. **Surface Integrity parameters and its importance**.	**6**

Term Works:

1. One assignment on each module of the syllabus.
2. One Guest lecture by industry/Research expert / Industry visit to a manufacturing industry
3. MCQ based on topics mentioned in latest GATE syllabus

Reference material:

1. S. Kalpakjian & S.R. Schmid, "Manufacturing Engineering and Technology, fourth edition", PEARSON
2. O.P. Khanna, "A Textbook of Production Technology", Dhanpat Rai Publications
3. Dr. P.C. Sharma, "Production Technology", S Chand and Co.
4. M. Lal and O P Khanna, "Textbook of Foundary Technology", S Chand and Co.
5. G. Boothroyd & W.A. Knight, "Fundamental of Machining and Machine Tools", CRC.
6. Milton C. Shaw, "Metal Cutting Principles", Oxford University Press
7. W. A. J. Chapman, "Workshop Technology- Part I, II and III", Edward Arnold
8. S K & A K Hajra Choudhary, "Workshop Technology, Vol. I, II", Media promotors andpublishers Pvt. Limited,

Recommended e-resource:

https://onlinecourses.nptel.ac.in/noc22_me71/announcements

HS-BTM307 Organizational Communication and Interpersonal Skills

Course Pre-requisites: - Communication Skills Semester II

Course Objectives

The objectives of this course are

1. To equip the students with competencies to manage themselves in organizations with a scientific outlook towards communication.
2. To develop career orientation through an understanding of professional writing skills, Resume', Mock interviews and Group discussions
3. To develop inter personal and intra personal skills of the students and Presentation skills
   To facilitate an insight into the functioning of individuals, Teams, and groups

Course Outcomes

After completing this course, the student will be able

1. To participate in the campus selection process with special focus on Technical writing, Resume writing and Group Discussion
2. To prepare himself/herself for the campus Interviews
3. To develop professional behaviour for entry into the professional world and think logically, ethically to solve problems in professional life
4. To demonstrate essential skills like email etiquette, Interpersonal skills, Corporate and social etiquette, Negotiation and emotional intelligence

Course Content

Module No.	Details	Hrs.
1.	**Report Writing** • Methods of Data Collections • Objectives of report writing, • Language and style in a report, • Types of reports, • Formats of reports: Memo, Letter, and Project report Survey based. *(A Computer- aided presentation of the project report)*	06
2.	**Business & Technical Writing** • Types of meetings, Notice, Agenda, Minutes of the meetings, Strategies for conducting effective meetings. • Email Writing: (Netiquette) • Technical paper writing • Proposal writing	05
3.	**Etiquette and Mannerism** • Introduction to Corporate Etiquette • Grooming, Clothing & Accessorizing • Technology Etiquette (social media, Email, Telephone)	02
4.	**Resume Skills** **Preparation and Presentation-** • Introduction of resume and its importance • Difference between a CV, Resume and Bio data • Essential components of a good resume **Common Errors-**	03

	• Common errors people generally make in preparing their resume • Prepare a good resume of her/his considering all essential component	
5.	**Employment Skills** • Group Discussion • SWOT Analysis • Interview Skills **Preparation and Presentation** • Meaning and types of interviews (F2F, telephonic, video, etc.), • Dress Code, Background Research, Do's and Don'ts, • Situation, Task, Approach and Response (STAR Approach) for facing an interview, • Interview procedure (opening, listening skills, closure, etc.), • Important questions generally asked in a job interview (open and closed ended questions). **Simulation** • Observation of exemplary interviews. • Comment critically on simulated interviews. **Common Errors** • Discuss the common errors generally candidates make in interview • Demonstrate an ideal interview	06
6	**Exploring Career Opportunities** • Knowing yourself – personal characteristics, • Knowledge about the world of work, requirements of jobs including self-employment, • Sources of career information • Preparing for a career based on their potentials and availability of opportunities	02
7	**Interpersonal Communication and Soft Skills** • Creating and delivering effective presentations • Team building • Leadership skills • Time management • Negotiation and persuasion skills • Stress management • Emotional intelligence **Other Organizational Skills** • Organizational diversity and inclusion • Ethics, Human Values and Social Responsibilities	08

Self-study: Types of letters

List of Assignments:

1. Meeting documentation: Role play and written assignment

2. Practical sessions on Group Discussion topics
3. Mock Interviews, Job application and resume writing.
4. Etiquettes case study and role play. MCQ's
5. Three assignments on report-writing (A Bound report to be submitted on topic given in partial fulfillment of the syllabus report writing, Report content will be graded and counted during presentation, a printed copy of the presentation and a soft copy in the form of CD to be attached with the report).
6. Technical Proposal (Group activity, document of the proposals)
7. Interpersonal Skills: Case Studies, Group Activity and assignments
8. Presentations and seminar on module no. 4, 5 with Power point
9. Role play and videos taken by students.

Distribution of Term Work/ Practical marks shall be as follows: (total 50 marks).

1. Project report presentation: **10 marks**
2. Presentations on Interpersonal topics: **05 Marks**
3. Group Discussion: 05 **marks**
4. Mock Interviews: **05**

Text Books

1 Report Writing for Business, Lesiker and Petit, Mc Graw Hill
2 Technical Writing for Professional Communication, Huckin and Olsen, Mc Graw Hill
3 Personal development for Life and Work, Wallace and Masters, Thomson Learning
4 Effective Business Communication, Herta Murphy, Mc Graw Hill
5 Organizational Behaviour, Fred Luthans, Mc Graw Hill
7 Business Correspondence and Report Writing, R.C. Sharma and Krishna Mohan, Tata McGraw Hill
8 Soft skills, Dr. K.Alex, S. Chand and company
9 Organizational Behaviour, Robbins Stephens, Pearson Education

Reference Books

1 How to Speak Fluently, Jones, Indian Publishing House
2 Speaking English Effectively, Krishna Mohan and N.P. Singh, Macmillan
3 "Business Communication - Concepts Cases and Applications", Chaturvedi and Chaturdevi, Pearson
4 "Communication Skills for Engineers", Sunita Mishra and C. Murlikrishna, Pearson
5 Business Communication- "Building Critical Skills", Kitty O Locker , McGraw Hill
6 "Body Language", Alan Pease, Manjul Publications
7 "The Craft of Business Letter Writing", Monipally, Tata McGraw Hill
8 Soft Skills and Professional Communication, Francis Peter, Tata McGraw Hill
9 50 ways to improve your Business English, Ken Taylor, Summertown Publishing
10 50 ways to improve your Presentation Skills in English, Bob Dignen

PC-BTM352 Strength of Materials Laboratory

Course Pre-requisites: - PC-BTM302

Course Objectives:

1. To acquire 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 significance of material testing techniques

Course Outcomes:

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

1. Explain underlying principle of the experiment and outline experimental procedure and describe the parts of the experimental setup
2. Accurately record experimental observations and examine 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

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 experiment no. 9 and 10, plot load deflection curve and find 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)

Term Work:

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. MCQ based on topics mentioned in latest GATE syllabus
4. Oral Examination

PC-BTM399 Machine Shop Practice
Course Pre-requisites: Workshop Practice – I & II (ES-BT199 & ES-BT299)

Course Objectives:
The objectives of this course are:
1. to demonstrate different machines, its parts and functionality of these mechanical manufacturing machines
2. to demonstrate 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 correct manufacturing machine for the given operation and demonstrate its construction and working
2. demonstrate 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 specific manufacturing process and maintenance check list for the machines and equipments

Course Contents:

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

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

MC-BTM002 Indian Traditional Knowledge

Course Pre-requisites: - Mandatory course

Course Objective:

The objectives of this course are:

- To impart knowledge about the Indian tradition, Fundamental unity, Human values, Indian traditional knowledge systems and scriptures.
- To impart knowledge about the Indian traditional health care and medical practices, technologies, engineering and architecture in ancient India, scientific, technological developments and contributions of ancient Indian sages and scholars.
- To impart knowledge about the Indian tradition of arts, music and dance, linguistics, significant literature and epics.
- To impart knowledge about the ancient Indian philosophy, its scientific, social and logical perspectives and relevance in modern times.

Course Outcomes:

Upon successful completion of the course, students should be able

1. To understand the Indian tradition, Fundamental unity, Indian traditional knowledge systems and scriptures.
2. To understand the Indian traditional health care and medical practices, technologies, engineering and architecture in ancient India, scientific, technological developments and contributions of ancient Indian sages and scholars.
3. To understand the Indian tradition of arts, music and dance, linguistics, significant literature and epics.
4. To understand the ancient Indian philosophy, its scientific, social and logical perspectives and relevance in modern times.

Course Contents:

Sr. No.	Description	Duration (hrs.)
1	**Indian Tradition:** Introduction to Indian tradition, Fundamental unity of India, India's role in world civilization. The Indian way of life: Scientific outlook and Indian values.	06
2	**Basic structure of Indian Knowledge System:** Exposure to Indian Traditional Scriptures, Vedas (Rigveda, Yajurveda, Atharvaveda and Samaveda), Upvedas (Ayurveda, Dhanurveda, Gandharvaveda, Sthapatya), Vedangas (Shiksha, Kalp, Nirukta, Vyakaran, Jyotish),	06
3	**Indian Knowledge System and Modern Science:** Co-existence of Science and Spirituality in ancient India, Superior intelligence and contributions of Indian sages and scholars such as Maharshi Kanad, Aryabhatta, Bhaskaracharya, Varahmihir etc, Development of science, Engineering, Technology and Architecture in ancient India.	06
4	**Indian Traditional Health Care:** Indian health care techniques: Yoga, Pranayam etc, Ayurveda and medical practices in Indian tradition, Yog	06

	Shastra founder Patanjali, Medical practitioners such as Charak, Sushrut etc. and their contributions, Significance of ancient Indian health care, fitness and medical practices in modern India and world.	
5	**Indian Artistic Tradition:** Art and Art forms in ancient India such as painting, sculpture etc, Traditional Indian music and dance, etc.	06
6	**Indian Linguistic Tradition:** Ancient Indian languages and literary Heritages, Contributions of Panini, Kalidas etc. Phonology, Morphology, Syntax and Semantics.	06
7	**Indian Philosophical Tradition:** (Sarvadarshan) - Nyay, Vaisheshik, Sankhya, Yoga, Meemansa, Exposure to Philosophy of Charvaka, Bhagwan Mahaveer Vardhaman, Bhagwan Gautam, Sant Kabeer, Guru Nanak Dev, Sant Dnyaneshwar etc, Relevance of ancient philosophy in modern India and world.	06

Term Activities:

1. Group discussions, presentations, report writing etc. on various topics in curriculum.
2. Participation in programs such as expert lectures, academic sessions, seminars etc. organized by Faculty for providing exposure to various aspects in curriculum.
3. Awareness to Maharashtra /local traditional knowledge to be given which may include local cuisines.

Text Books:

1. Bhavan's Know India Series-1, Bhartiya Vidya Sar-1 (**AICTE approved**), edited by Shashibala, Om Vikas, and Ashok Pradhan, Bharatiya Vidya Bhavan, New Delhi
2. Bhavan's Know India Series-1, Bhartiya Vidya Sar-2 (**AICTE approved**), edited by Shashibala, Om Vikas, and Ashok Pradhan, Bharatiya Vidya Bhavan, New Delhi
3. Ajwani L.H., Immortal India, Vora & Co. Publishers
4. Swami Jitatmananda, Modern Physics and Vedanta, Bharatiya Vidya Bhavan.
5. Krishnamurthy V., Science and Spirituality- A Vedanta Perception, Bharatiya Vidya Bhavan.
6. Raman V.V., Glimpses of Indian Heritage, Popular Prakashan,1993.

Reference Books:

1. Sivaramakrishnan V., Cultural Heritage of India- Course Material, Bharatiya Vidya Bhavan, Mumbai 5th edn., 2014.
2. Chaterjee S.C. and Datta D.M., An Introduction to Indian Philosophy, University of Calcutta, 1984.
3. Krishna Chaitanya, Arts of India, Abhinav Publications, 1987.
4. Jha V.N., Language, Thought and Reality.
5. Sharma D.S., The Upanishadas- An Anthology, Bharatiya Vidya Bhavan, 1989.
6. Capra F., Tao of Physics, Shambhala, 2010

Recommended NPTEL Lectures / Courses

1. Traditional Knowledge Systems and the indigenous materials; tools and techniques

NPTEL Course Lectures by Prof. Smriti Saraswat, IIT Roorkee
https://nptel.ac.in/courses/124/107/124107006/

2. Ayurvedic Inheritance of India NPTEL Course by IIT Madras
   https://nptel.ac.in/courses/121/106/121106003/
3. Indian Philosophy NPTEL Course by Dr. Satya Sundar Sethy, IIT Madras
   https://nptel.ac.in/courses/109/106/109106059/
4. Yog Satra Online Course by Vivekananda Kendra Kanyakumari
   https://www.vrmvk.yoga/mh2020

VA-BTM391 Introduction to Python Programming
Course Pre-requisites: - Higher Secondary Education or equivalent

Course Objectives:
The objective of this course is to:

- Learn capabilities of Python programming for numerical computations
- Prepare student to do engineering calculations using Python programming.
- Use Python for data analysis related to engineering applications.

Course Outcomes:
At the end of the course, the student will be able to

1. Write codes for commons algorithms to do engineering computations
2. Apply features of python language to produce efficient and modular computer code
3. Debug Python code
4. Implement open source numerical libraries to build engineering applications

Course contents:

Sr. No.	Description	Duration (hrs)
1	Practical 1: Introduction to Python, variable Types, Operators and Branching	4
2	Practical 2: Development of program, Bindings, Strings, Input/Output, IDEs, Control Flow, Iteration	4
3	Practical 3: Functions, Decomposition and Abstraction, Functions and Scope, Keyword Arguments, Recursion on non-numerics, File operations	4
4	Practical 4: Tuples and Lists: List Operations, Mutation, Aliasing, Cloning Dictionaries: Functions as Objects, Global Variables	4
5	Practical 5: Classes and Inheritance: Object Oriented Programming, Class Instances, Methods Debugging techniques	4
6	Practical 6: Use of open source libraries: NumPy and Matplotlib	4
7	Practical 7: Writing an engineering application for data analysis	4

Term work/Journal: e-Folder based on practical work.

Recommended Books:

1. Open source documentation at *https://docs.python.org/3/library/index.html*
2. John V. Guttag, Introduction to Computation and Programming Using Python – with Application to Understanding Data, The MIT Press, 2016.
3. Nagar Sandeep. *Introduction to Python: For Scientists and Engineers*, Independently published (2016).

BS-BTM401 Applied Mathematics -II

Course Pre-requisites: - X

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 Laplace Transform and its application to solve differential equations.

Course Outcomes:

Upon successful completion of the course, students should be able

1. Solve problem in basic statistics, probability, probability distribution.
2. Solve the problem based on testing of hypothesis.
3. Solve problems based on Laplace and Inverse Laplace Transform. Apply 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** 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, $L\{t^n f(t)\}, L\left\{\frac{f(t)}{t}\right\} L\left\{\frac{d^n f(t)}{dt^n}\right\} L\left\{\int_0^t f(u)du\right\}$ Convolution theorem, Evaluation of real integrals using Laplace Transform	**07**
7	**Inverse Laplace Transform**	**07**

	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.	

Term work 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.

PC-BTM403 Fluid Mechanics
Course Pre-requisites: BS-BT105, BS-BT106

Course Objectives:
The objective of the course is to make students familiar with the basic behavior of static and dynamic fluid 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
CO1: to define the fundamental principles of fluid mechanics,
CO2: to identify, describe and explain the basic principles with application,
CO3: to apply the knowledge of fluid mechanics, perform the related calculations and solve real-life flow problems,
CO4: 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:** Basic flow conservation equations and method of analysis- Integral and Differential approach. Reynolds Transport Equation and its application. Navier–Stokes equations (without proof) for rectangular and cylindrical co-ordinates. Cases of exact solutions of NS equations: Laminar flow through a pipe, Couette flow, Euler's equations; Bernoulli's equation and its applications.	06
5	**Turbulence and Boundary Layer:** Reynolds number and its significance in flow characterization. Turbulent flow and its characteristics, Boundary layer and its measurement, its	08

	development flat plate with zero pressure gradient Boundary layer equations its solution –Blasius solution (without derivation), Von-Karman momentum integral approach. Description of turbulent velocity profile in boundary layer- viscous, buffer and turbulent. Dimensional and Model Analysis: Fundamental concepts and its application	
6	**Internal and External Flows:** Laminar flow through pipes and ducts. Using velocity profile to compute - flow rate, pressure drop, shear stress, friction factor etc. Moody's diagram and calculation of head losses in different piping system. Flow over immersed bodies and the concept of drag and lift, flow separation and methods to control, Streamlined and bluff bodies.	06
7	**Compressible Flow:** 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 converging nozzle – critical pressure ratio and chocked flow. Case Study: Investigating a real life flow problem.	06

Recommended Books:

1. Fox and McDonald, "*Introduction to Fluid Mechanics*", John Wiley & Sons, 8ed.
2. Frank M. White, "*Fluid Mechanics*", McGraw Hill, 7ed.
3. Streeter V L and Wylie E B, "*Fluid Mechanics*", McGraw Hill, 8ed.
4. Munson B R and Huebsch W W, "*Fundamentals of Fluid Mechanics*", Wiley, 7ed.
5. Shaughnessy E J, "*Introduction to Fluid Mechanics*", Oxford University Press, 1ed.
6. Yunus Cengel and John Cimbala, "*Fluid Mechanics*", Tata McGraw Hill. 1ed.
7. Potter M C, "*Mechanics of Fluids*", Cengage Learning; 4 ed

PC-BTM404 Mechanical Engineering Measurements
Course Pre-requisites: - Applied Physics

Course Objectives:
The objective of the course is to impart fundamental knowledge of mechanical measurement techniques and data analysis with its application to the measurement of several mechanical engineering quantities.

Course Outcomes:
Upon successful completion of the course, students should be able
1. To describe overall methodology of measurement and fundamental concepts of experimental data analysis
2. To define different types or errors and to discuss uncertainty analysis
3. To examine common techniques used for measurement of mechanical quantities
4. To select measurement system for engineering applications

Course contents:

Module No.	Description	Duration (hrs.)
1	**Introduction:** Significance of Mechanical Measurements, Need of Inspection, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, Modifying and Interfering. **Static characteristics:** Static calibration, Linearity, Static Sensitivity, Accuracy, Precision, Threshold, Resolution, Reproducibility, Hysterisis, Drift, Range and Span etc. **Dynamic characteristics**: Order of instruments, dynamic behavior under standard inputs and key terminology	04
2	**Errors in measurement and data analysis:** Types of errors, factor influencing measurement, methods of elimination, Probable errors, Uncertainty and Uncertainty analysis **Statistical analysis of data:** arithmetic mean, deviation, average deviation, standard deviation, variance.	04
3	**Displacement measurement:** Transducers for displacement measurement – Potentiometers, LVDT, Capacitance type, Digital transducers (Optical Encoder), Nozzle Flapper transducer. **Measurement of Surface Characteristics:** Measurement of straightness, flatness, squareness, parallelism, roundness and cylindricity, non-contact profiling systems, Measurement of surface finish **Strain measurement:** Theory of strain gauges, gauge factor, Temperature compensation, Bridge circuit, Orientation of strain gauges for force and torque measurement, Strain gauge based load cells and torque sensors.	05

4	**Angular velocity measurement:** Tachometers, Tachogenerators, Digital tachometers, Stroboscopic methods. **Acceleration measurement:** Theory of accelerometers and vibrometers, Practical accelerometers, strain gauge based and piezoelectric accelerometers.	05
5	**Pressure measurement:** Pressure standards, Elastic pressure transducers viz. Bourdon Tubes, Diaphragms, Bellows and Piezoelectric pressure sensors, **High pressure measurement:** Bridgman gauges. Calibration of pressure sensors. **Vacuum measurement:** Vacuum gauges viz. Mcleod gauge, Pirani gauge, Ionization gauge, Thermal conductivity gauge, Knudsen gauge etc.	06
6	**Temperature measurement:** Thermodynamic Temperature Scale and IPTS, Electrical methods of temperature measurement viz. Resistance Thermometers, Thermistors, Thermocouples, Pyrometers.	06
7	**Flow measurement:** Venturimeter, Orifice meter, flow nozzles, Pitot tube, Rotameter, Hot wire Anemometrs, Turbine flow meters, Laser Doppler Anemometer etc. Miscellaneous measurement: Measurement of liquid level, humidity etc. Digital Instrumentation, Data Acquisition System, Signal Conditioning systems, Op-Amplifier. Internet based measurement (Connecting Measurement systems to internet).	06

Text Books:

1. E.O.Dobelin, “Measurement Systems (Applications and Design)”, McGraw Hill.
2. A.K. Sawhney & Puneet Sawhney, “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.

PC-BTM406 Material Science
Pre-requisites: - **BS-BT105, BS-BT106**

Course Objectives:

The objective of this course is to

Make students familiar with of mechanical, physical and chemical properties of common engineering materials- metals, ceramics, polymers and composites with rationale behind these properties and to develop 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 micro as well as macro scale and to discuss economic, environmental and social issues of material usage.
2. Categorize different material imperfections and apply this knowledge to explain failures.
3. Demonstrate the concept of iron-carbon equilibrium diagram & phase diagrams and understand the basic terminologies associated with metallurgy. Construction and identification of phase diagrams and reactions.
4. Describe about different types of heat treatment methods to tailor the properties of Fe-C alloys and examine properties of nonferrous, ceramic and composite materials.

Course contents:

Module No.	Description	Hours
1	**Introduction:** Fundamentals of Metallurgy behind common engineering materials, Important Mechanical Materials and their characteristics, Classification of materials, Advanced materials andSmart materials and their examples, Materials for Additive Manufacturing	4
2	**Atomic Arrangements:** Lattice, Unit cells, Crystal Structure: Unit cells, Lattice Planes and Miller Indices Metallic crystal structures, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress. ASTM grain size.	6
3	**Phase diagrams:** Equilibrium phase diagrams, Alloys, substitutional and interstitial solid solutions- Phase diagrams, Kinetics of nucleation and growth, Gibbs-Phase rule, Phase transformations and TTT diagrams. **Iron-carbon equilibrium diagram:** Invariant Reactions, Microstructural aspects of ledeburite, austenite, ferrite and cementite, cast iron lever rule.	6
4	**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	6
4	**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,	8

	case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening **Ductile-Brittle transition:** Fatigue, crack initiation and propagation, Creep, generalized creep behavior, stress-strain curves of materials.	
6	**Ceramic, Composites & Nano materials:** Ceramic materials, application of ceramics, properties of ceramics, inorganic glasses. **Polymers:** classification of polymers, thermoplastics and mechanical properties, Elastomers, Thermosetting polymers **Composites:** types, characteristics and applications **Introduction to Nano materials:** Nano structured materials. Nano clusters & Nano crystals.	7
7	**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.	5

Text Books:

1. Callister, William D., and David G. Rethwisch. Materials science and engineering: an introduction. Vol. 7. New York: Wiley, 2007.
2. Kodgire, V. D., and S. V. Kodgire. "Material science and metallurgy." Everest Publication, 2009.
3. Balasubramaniam, R. Callister's Materials Science and Engineering: Indian Adaptation (W/Cd). John Wiley & Sons, 2009.
4. V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 1999.

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.

PC-BTM412 Kinematics of Machinery
Course Pre-requisites: ES-BTM104, ES-BTM204

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 No.	Details	Hrs.
01	**Basic Kinematics:** **Structure, Machine, Link and its types** **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. **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).** Velocity analysis by instantaneous centre of rotation method (Graphical approach). 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

07	Two-three case studies on KOM related topic from Latest Journals	04

Term Work:

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 Science direct.

PC-BTM453 Fluid Mechanics Laboratory

Course Prerequisites: PC-BTM403

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 which involves 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.

Term Work:

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

PC-BTM454 Mechanical Engineering Measurements Lab.

Pre-requisites: - **PC-BT205**

Course Objectives:

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

Course Outcomes:

On successful completion of the course learner should be able to

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

List of Experiments: List of Experiments:

1. Characterization of dead weight pressure gauge tester and error analysis.
2. Investigating development of strain gauge based measurement systems.
3. Characterization of strain gauges and error analysis.
4. Investigating 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

Term Work:

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. Mini project on development of measurement system or characterization of sensor in group of 4 students.
4. Oral 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.

PC-BTM456 Material Science Laboratory
Course Pre-requisites: - PC-BT406

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/study

1. Study of Metallurgical Microscope.
2. Preparation of Specimen for microscopic examination.
3. Study of microstructure of plain carbon steels of various compositions.
4. Study of microstructure of various types of C.I.
5. Study of microstructure of various types of alloy steels.
6. Study of microstructure of non – ferrous metals and their alloys.
7. Comparative study of microstructures of different given specimens (mild steel, gray C.I., brass, copper etc.)
8. Surface hardening and study of microstructure
9. Study of I.S. codes of steels and selection procedure.
10. Study of Microstructures of Components developed by Additive Manufacturing Processes.

Term Work:

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. MCQ based on topics mentioned in latest GATE syllabus
4. Oral Examination

PC-BTM499 Assembly Shop Practice

Pre-requisites: - Workshop Practice – I & II (ES-BT199 & ES-BT299), Machine Shop Practice (PC-BTM399)

Course Objectives:

The objectives of this course are

1. to demonstrate different machines, its parts and functionality of these mechanical manufacturing machines,
2. to demonstrate 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 check list for the machines and equipment

Course Outcomes:

At the end of the course the students shall be able

1. to identify correct manufacturing machine for the given operation and demonstrate its construction and working,
2. to demonstrate 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 specific manufacturing process and maintenance check list for the machines and equipments,

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.	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

VA-BTM491 COBOTS – Collaborative Robots
Course Prerequisites: Manufacturing science

Course Objectives:
The objective of this course is to present introduction to collaborative robots (COBOTS)

Course Outcomes:
Upon successful completion of the course, students should be able to
1. Describe role of COBOTS in manufacturing
2. Explain safety aspects of COBOTS during interaction with humans
3. Discuss standards and guidelines for COBOTS
4. Explain future trends in collaborative robots technology

Course contents:

Sr.No.	Description	Duration (hrs)
1	History and development of collaborative robots, comparison with conventional robots	4
2	Safety aspects of COBOTS during its interaction with humans	4
3	Role of COBOTS in manufacturing processes and other areas of application	4
4	Study of different types of industrial collaborative robots – case studies	4
5	Programming, setup and flexible automation using COBOTS	4
6	Operational aspects of COBOTS – hand guiding, power and force limiting, safety monitored stops, speed and separation monitoring	4
7	Emerging trends in development of COBOTS	4

Term work:
- Assignment based on above topics and seminars.
- Case studies and presentations

Recommended Books:

1. Matthew Wilton, *Essential Guide To Risk Assessment for Collaborative Robots* (2018)
2. Michal Gurgul, *Industrial robots and COBOTS* (2018)
3. Research articles shared during coursework