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College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Mechanical Engineering

Curriculum Structure & Detailed Syllabus (UG Program)

Second Year B.Tech.

(Revision: A.Y. 2015-16, Effective from: A.Y. 2016-17)

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Program Education Objectives (PEOs):

The Undergraduate students will demonstrate...

I. To prepare the students in order to cater the needs of automotive, design, thermal and manufacturing for Indian as well as multinational industries.

II. To develop competence in the students to understand technological concepts, analyze data in order to formulate and undertake industrial problems and obtain viable solutions.

III. To provide students with in depth knowledge in the core subjects such as mathematics and engineering sciences in order to prepare them for higher studies and inculcate research attitude.

IV. To make students aware of the importance of lifelong learning and provide opportunity to work on multidisciplinary projects.

V. To inculcate in student effective communication, management skills, professional ethics, codes of professional practice, induce societal awareness and indoctrinate team spirit.

Program Outcomes (POs):

The Undergraduate Students will demonstrate...

1. Proficiently use mathematical methods, basic sciences, engineering analysis, measurement and instrumentation techniques while attempting engineering problems and articulate viable solutions.
2. Graduates will demonstrate the ability to design, develop and analyze mechanical systems and manufacturing process that meets the required specifications.
3. Graduates will be familiar with modern engineering software tools and equipment to analyze mechanical engineering problems.
4. Graduates will demonstrate an aptitude to identify, formulate and solve problems associated with Mechanical Engineering.
5. Graduates will be able to understand the intricacies and impact of engineering solutions.
6. Graduates will be able to communicate effectively in both verbal and written forms.
7. Graduates will identify societal problems and provide viable engineering solution.
8. Graduates would be capable of self-education and clearly understand the value of lifelong learning.
9. Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.
10. Graduates will demonstrate professional and ethical responsibilities.
11. Graduates will adhere to the various important issues such as green house effect, carbon credit retrofit design concept; relevant norms laid down and exhibit maturity while providing engineering solutions.

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Correlation between the PEOs and the POs

PO→ PEO↓	1	2	3	4	5	6	7	8	9	10	11
I	✓	✓	✓	✓			✓				✓
II	✓	✓	✓	✓	✓				✓	✓	✓
III	✓	✓	✓	✓	✓	✓		✓			
IV			✓	✓			✓	✓		✓	✓
V				✓		✓	✓		✓	✓	✓

Note: The cells filled in with ✓ indicate the fulfilment/correlation of the concerned PEO with the PO.

List of Abbreviations

Abbreviation	Title
S.P. P.U.	Savitribai Phule Pune University
A.Y.	Academic Year
BSC	Basic Science Course
EFC	Engineering Foundation Course
MLC	Mandatory Learning Course
ILOE	Institute Level Open Elective Course
SLC	Self Learning Course
HSMC	Humanities/Social Sciences/Management Course
LLC	Liberal Learning Course
SBC	Skill Based Course
PCC	Program Core Course
DEC	Department Elective Course
LC	Laboratory Course

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Semester III [Odd Term]

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	BSC	Ordinary Differential Equations and Multivariate Calculus	2	1	-	**3**
2	BSC	Science of Living	3	-	-	**3**
3	PCC1	Engineering Thermodynamics	2	1	-	**3**
4	PCC2	Machine Drawing and Computer Graphics	2	-	-	**2**
5	PCC3	Manufacturing Engineering-I	3	-	-	**3**
6	PCC4	Strength of Materials	3	-	-	**3**
7	SBC	Machine Drawing and Computer Graphics Lab	-	-	4	**2**
8	SBC	Manufacturing Engineering - I Lab	-	-	2	**1**
9	LC1	Strength of Materials Lab	-	-	2	**1**
10						
			15	**2**	**8**	**21**
		Total Academic Engagement and Credits	**25**			**21**

Semester IV [Even Term]

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	BSC	Vector Calculus and Partial Differential Equations	2	1	-	**3**
2	MLC	Professional Ethics & Values	1	-	-	**0**
3	HSMC	Innovation	1	-	-	**1**
4	ILOE	1. Automobile Engineering **OR** 2. Smart Materials **OR** 3. Computer Aided 3 D Geometric Modelling [For Other Departments]	3	-	-	**3**
5	PCC1	Theory of Machines – I	3	-	-	**3**
6	PCC2	Fluid Mechanics	2	1	-	**3**
7	PCC3	Fundamentals of Metallurgy	3	-	-	**3**
8	PCC4	Manufacturing Engineering-II	3	-	-	**3**
9	LC1	Theory of Machines – I Lab	-	-	2	**1**
10	LC2	Fluid Mechanics Lab	-	-	2	**1**
11	LC3	Fundamentals of Metallurgy Lab	-	-	2	**1**
12	SBC	Manufacturing Engineering- II Lab	-	-	2	**1**
			18	**2**	**8**	**23**
		Total Academic Engagement and Credits	**28**			**23**

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Semester III (For Direct Second Year Admitted Diploma Students)

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	BSC	Linear Algebra and Univariate Calculus	4	1	-	5
2	BSC	Applied Biology	3	-	-	**3**
3	PCC1	Engineering Thermodynamics	2	1	-	**3**
4	PCC2	Machine Drawing and Computer Graphics	2	-	-	**2**
5	PCC3	Manufacturing Engineering-I	3	-	-	**3**
6	PCC4	Strength of Materials	3	-	-	**3**
7	SBC	Machine Drawing and Computer Graphics Lab	-	-	4	**2**
8	SBC	Manufacturing Engineering - I Lab	-	-	2	**1**
9	LC1	Strength of Materials Lab	-	-	2	**1**
			17	**02**	**8**	**23**
		Total Academic Engagement and Credits	**27**			**23**

Semester IV (For Direct Second Year Admitted Diploma Students)

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	BSC	Multivariate Calculus and Differential Equations	4	1	-	5
2	MLC	Professional Ethics & Values	1	-	-	**0**
3	HSMC	Innovation	1	-	-	**1**
4	ILOE	1. Automobile Engineering **OR** 2. Smart Materials **OR** 3. Computer Aided 3 D Geometric Modelling [For Other Departments]	3	-	-	**3**
5	PCC1	Theory of Machines – I	3	-	-	**3**
6	PCC2	Fluid Mechanics	2	1	-	**3**
7	PCC3	Fundamentals of Metallurgy	3	-	-	**3**
8	PCC4	Manufacturing Engineering-II	3	-	-	**3**
9	LC1	Theory of Machines – I Lab	-	-	2	**1**
10	LC2	Fluid Mechanics Lab	-	-	2	**1**
11	LC3	Fundamentals of Metallurgy Lab	-	-	2	**1**
12	SBC	Manufacturing Engineering- II Lab	-	-	2	**1**
			20	**2**	**8**	**25**
		Total Academic Engagement and Credits	**30**			**25**

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Semester-III

(MA) Ordinary Differential Equations and Multivariate Calculus

Teaching Scheme:
Lectures : 2 Hrs/week
Tutorial: 1Hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Students will be able to:

1. Know and recall core knowledge of the syllabus. (To measure this outcome, questions may be of the type- define, identify, state, match, list, name etc.)
2. Understand basic concepts. (To measure this outcome, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.)
3. Analyze the problem and apply the appropriate concept. (To measure this outcome, questions will be based on applications of core concepts)
4. Give reasoning. (To measure this outcome, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.)
5. Apply core concepts to new situations. (To measure this outcome, some questions will be based on self-study topics and also comprehension of unseen passages.)
6. Organize and present thoughts. (To measure this outcome, questions may asked to write summaries and short notes on a given topic.)
7. Analyze the problem and apply the appropriate concept. (To measure this outcome, questions will be based on applications of core concepts)

Unit I :
Review of first order differential equations, Reduction of order, linear differential equations, homogeneous higher order linear differential equations, non-homogeneous higher order linear differential equations with constant coefficients and reducible to differential equations with constant coefficients (method of undetermined coefficients and method of variation of parameters), systems of differential equations, applications to orthogonal trajectories, mass spring systems and electrical circuits. **[10 Hrs]**

Unit II :
Functions of several variables, level curves and level surfaces, partial and directional derivatives, differentiability, chain rule, local extreme values and saddle points, constrained optimization**.** **[05 Hrs]**

Unit III :

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Double integrals in Cartesian and polar co-ordinates, iterated integrals, change of variables, triple integrals in Cartesian, spherical and cylindrical co-ordinates, substitutions in multiple integrals, Applications to Area, Volume, Moments and Center of Mass. **[11 Hrs]**

Text Books:

- Maurice D. Weir, Joel Hass, Frank R. Giordano, "Thomas' Calculus", Pearson Education, 12th Edition.
- Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley eastern Ltd., 10th Edition

Reference Books: Author name, "Title of the book in double quotes", Publisher, Edition, Year
K.D Joshi, "Calculus for Scientists and Engineers", CRC Press.

- Sudhir Ghorpade and Balmohan Limaye, "A Course in Multivariate Calculus and Analysis", Springer Science and Business Media.
- George Simmons, "Differential Equations with Applications and Historical notes", Tata Mc-Graw Hill publishing company Ltd, New Delhi.
- C.R. Wylie, " Advanced Engineering Mathematics" , McGraw Hill Publications, New Delhi
- Peter V. O' Neil, "Advanced Engineering Mathematics", Thomson Brooks / Cole, Singapore, 7th edition

(AS) Applied Biology

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Objectives: To make students conversant with basic Biology regarding the life processes. To impart knowledge about the common corridors of biology and engineering as biologically inspired technologies like designs in nature, bioenergetics, bioprocesses, biomaterials, biomechanics, bioimaging, bioinformatics, bioinstrumentation etc. To introduce recent trends in biology viz. genetic & tissue engineering, stem cell engineering, bio and nanotechnology etc. with the objective of appreciating engineering principles in biological systems.

Unit 1: Understanding Basics (6L)

1. Engineering perspectives of biological sciences: Where engineering meets biology and where biology meets engineering. Biology as an integrated Science; Case studies on integrating biology with engineering.
2. Biopolymers and macromolecules – Structure and Function: Organic and inorganic molecules; Unique Properties of Carbon; Carbohydrates, Amino Acids and proteins, Lipids, Nucleic Acids, Vitamins and Minerals; The Rise of Living Systems.

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3. Levels of organization of life : Cell as basic unit of life, prokaryotic and eukaryotic cells, microbes, plant and animal cells; Cell organelles – structure and function; Levels of organization of life - tissues, organs, systems and organism.

Unit 2: Biological Processes and Bioenergetics (6L)

1. **Energy Dynamics in Biology –**

a) Photosynthesis and energy assimilation: aerobic and anaerobic systems. Applications

b) Respiration and Electron Transport Chain: Mitochondria and respiration, ATP generation.

2. **Bioenergetics:** Thermodynamic principles applied to biology, negative entropy changes in biological systems, Free Energy, Chemical Equilibrium;

3. **Optimization of biological functions**: Metabolic networks; anabolism and catabolism; flux analysis (MATLAB).

Unit 3: Living Systems (6L)

1. **Transport Phenomena in Biological Systems:** Membrane channels and ion channels; Fluid flow and mass transfer

a. In plants: Xylem and Phloem

b. In animals: Blood and Lymph 2

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c. Transport of molecules and gases (Oxygen and Carbon dioxide); Heat Transport - Body temperature regulation.
2. **Communication:** Cell junctions, Cell-cell communications – cell signaling, Hormones, Pheromones; Chemotaxis. Communication in living systems by photo, bio, chemotactic methods.
3. **Defense mechanisms in plants and animals:**

a. In plants: Herbivory, secondary metabolites.
b. In animals: Innate and Adaptive immune systems.

Unit 4: Techniques and Devices (6L)

1. **Genetic Code** - Expression and Transmission of Genetic Information, The concept of DNA cloning; Mechanisms of Enzyme Action.
2. **Techniques for optimization:**

a. At molecular level: Genetic Code and protein synthesis, DNA replication, RDT, DNA hybridization, Colony Hybrids, PCR, DNA microarray,
b. At cell level: Hybridoma technology,
c. At tissue level: Plant Tissue Culture, Animal Tissue Culture and Microbial Culture techniques; Tissue Engineering.
3. **Instrumental Methods of analysis** – A case study of protein purification and characterization: Principles and types of microscopy and spectroscopy, Chromatography, electrophoresis, diffusion, centrifugation, light scattering.

Unit 5: Discovery and Innovation (6L)

1. **Current trends and advances** in cell and molecular biology
2. **Landmark Discoveries**: Landmark discoveries in the field of Molecular Biology, Cell Biology and Genetics.
3. **Nanobiotechnology:** Micro-/Nanotechnologies for Interfacing Live Cells; Nanotechnology in Medicine – Diagnostics and Therapy; Biosensors; Nanotechnology in Agriculture; Biomemetics.
4. **Biomemetics:** Nature inspired processes applicable to the field of Engineering.

Unit 6: Branch-wise

Branch: Electronics and Telecommunication Engineering
Biosensors – Introduction to Biosensors, transducers, amplifiers; **Bioimaging**-Introduction to medical imaging and different medical Imaging modalities; Review of Signals and system; Electro Physiological Signal Analysis. Bio-telemetry Communication in living systems by photo, bio, chemo, tactic methods; **Diagnostic Devices**- Radiography, X-ray Computed Tomography Nuclear Medical Imaging, Ultrasound Imaging, Magnetic Resonance Imaging. **Therapeutic Devices**-Cardiac Pacemakers, Cardiac defibrillators, Surgical Diathermy, Diagnostic application of LASERs, High frequency heat therapy, Hemodialysis, Ventilators, Anesthesia machines, Automatic Drug delivery Systems, Electro Surgical units and safety.

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Branch: Instrumentation and Control Engineering

Basic concepts of **Medical Instrumentation**: Generalized medical Instrumentation System, Medical Measurement constraints, Classification of Biomedical Instruments, Generalized static and dynamic characteristics, Design criteria, Commercial Medical Instrumentation 3

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Development process, Regulation of Medical Devices. **Biomedical transducers:** optical, photo-electric, electrochemical, electrical, mechanical, electromechanical and thermoelectric. **Specialty areas in Bioinstrumentation**—Confocal, Tunneling, Sequencing, FACS, PCR, MRI, CT,USG, Endoscopy, ECG; Introduction to biosensors and tissue engineering.

Branch: Mechanical Engineering

Biomechanics, Human body motion, Prosthetics; Introduction to Ergonomics; Elements of Anthropometry; Physiology, Anatomy; Mechanical Properties of Bone and Soft Tissues Rehabilitation engineering, Biomimetics; Bio Material Handling; Hand Tool Design; Human Information Processing; Applications of Principles of Biomechanics in two and three dimensional kinematics; Fundamentals of Fluid Mechanics; Introduction to bio sensors and tissue engineering.

Branch: Metallurgy and Material Science

Classification of biomaterials –Comparison of properties of some common biomaterials; Effects of physiological fluid on the properties of biomaterials; Biological responses (extra and intra vascular system) to Metallic, Ceramic and Polymeric implant materials; Introduction to bio sensors and tissue engineering. Metals & alloys, composites and their advantages used in bio-industries; Materials in bio-printing. **Tissue Engineering and cloning:** Engineering cells, tissues and organs; Stem cells and translational medicine; Introduction to Gene Therapy; Bioengineering at molecular, cell and systems level; 3D bio-printing; Engineering Materials for Biomedical Applications.

Branch: Production Engineering and Industrial Management

Bio chemical engineering; Fermentation Technology, Bioreactors; Bio process Engineering; Use of living organisms (mostly microbes) to produce useful products. Biomechanics and ergonomics–production innovations.

Branch: Electrical Engineering

Alternative energy sources; Electrical signaling in biological system; Bioluminescence, bioelectricity, ECG.

Branch: Civil Engineering

Environmental engineering, Understanding ancient engineering. Designs in Nature; Bio radars.

Branch: Computer and Information Technology –

Principles of Bioinformatics, Computational Biology: Role of Computational Biology in Bioengineering; Genomics, Proteomics, Bioinformatics. Computational solutions to Biological Problems, Virtual systems Artificial Intelligence in Biomedical Engineering: Basics of Artificial Neural Networks.

Reference books:

Unit-1 to 3:

1. Lodish H, Berk A, Zipursky SL, et al.Molecular Cell Biology. W. H. Freeman; 2000.

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2. Cooper GM. The Cell: A Molecular Approach. Sinauer Associates; 2000.

3. Alberts B, Johnson A, Lewis J, et al.Molecular Biology of the Cell. Garland Science; 2002.

4. Friefelder D., Molecular biology. Jones and Bartlett, 1987.

5. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2000). *Lehninger principles of biochemistry*. New York: Worth Publishers.

6. Voet D and Voet J. Biochemistry, Wiley. 2011.

7. Greenbrg D. Metabolic Pathways, Volume I Elsevier Science & Technology Books. 1967.

8. Stryer L. Biochemistry. W.H. Freeman and Co. 1998.

9. Guyton, A.C. and Hall, J.E. A Text Book of Medical Physiology. W.B. Saunders Company. 2000,

Unit-4:

1. Strickberger MW. Genetics. Prentice Hall, India. 2002.
2. Lewin B. Genes VII. Oxford University Press. 2000.
3. Kornberg A. DNA Replication. W.H. Freeman & Co. 1991.
4. Brown TA. Genetics: a molecular approach. Chapman & Hall, London. 1998.
5. Brown TA. Gene Cloning and DNA analysis. Blackwell Science. 2001.
6. Watson J, Baker T, et.al. Molecular Biology of the gene .2004.
7. Webster JG (Ed.). Medical Instrumentation: Application and Design. Houghton Mifflin Co., Boston. 1992.
8. Wilson K and Walker J. Practical Biochemistry: Principles & Techniques. Cambridge University Press. 2011.
9. Lanza RP, Langer R, Vacanti JP. Principles of Tissue Engineering, Academic Press. 2007.

Unit-5:

1. Wilson M, Kannagara K, et. al. Nanotechnology - Basic Science And Emerging Technologies, University Of New South Wales Press Ltd .2008.

2. Poole Jr, CP., et. Al. Introduction to Nanotechnolgy. John Wiley and Sons, Student Edition. 2008.

3. Rao CNR, et.al. Chemistry of Nanomaterials: Synthesis, Properties and Applications.

4. Schmidt G. Nanoparticles: From Theory to Applications. Wiley Weinheim. 2004.

5. Goodsell DS. Bionanotechnology: lessons from nature. Wiley-Liss Publication.

Unit-6:

1. Smith NB, Webb A. Introduction to Medical Imaging : Physics, Engineering & Clinical Applications. Cambridge University Press. 2010.

2. Wilson K and Walker J. Practical Biochemistry: Principles & Techniques. Cambridge University Press. 2011.

3. Lezza P. Biomechanics of Cells & Tissues. Springer.

4. Ethier CR, Simmons CA. Introductory Biomechanics. Cambridge University Press.

5. Eggins BR. Biosensors: An Introduction. John Wiley & Sons Publishers. 1996.

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6. Blum LJ, Coulet PR. Biosensors: Principles and Applications. Marcel Dekker, Inc. 1991.

7. Buerk DG. Biosensors: Theory and Applications. Technomic Publishing. Co, Inc. 1993.

(ME) Engineering Thermodynamics

Teaching Scheme:
Lectures : 2 Hrs/week
Tutorial: 1Hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Students will be able to

1. Apply basic laws of thermodynamics in analysis and design of thermodynamic cycles including vapor and gas power cycles, refrigeration cycles, and heat-pump.
2. Use thermodynamic relations in evaluation of thermodynamic properties.
3. Apply the fundamentals of conservation of mass and energy, and properties of ideal gas mixtures in design and analysis
4. Enhance problem solving skills.
5. Evaluate performance of air standard cycles
6. Gain design skills in thermal systems and enhance written communication.

Unit I : Basic concepts and properties:
Introduction, thermodynamic system, control volume, macroscopic and microscopic approaches, properties and state of a system, point and path functions, thermodynamic equilibrium, processes and cycles, quasi-static process, properties such as specific volume, pressure, temperature, zeroth law of thermodynamics, temperature scales. **[5hrs]**

Unit II : Ideal gases and vapors:
Difference between gases and vapors, ideal gases, gas laws, equation of state, gas constant, universal gas constant, work and heat, definition of work, thermodynamic work, work in compressible system, work-a path function, work done during various processes, p-v diagram, definition of heat, heat transfer a path function, comparison of heat and work, Phase change process of a pure substance: specific heats, sensible heat and latent heat, triple point, critical point, superheat and total heat of steam. **[6hrs]**

Unit III : First law of thermodynamics:
Energy of systems, classification of energy, law of conservation of energy, first law applied to closed system undergoing a cycle, Joule experiment, energy-a property of system, internal energy: a function of temperature, enthalpy, specific heat at constant volume and constant pressure, change in internal energy and heat transfer during various non-flow processes. First law applied to flow processes: steady-state steady flow process, mass balance and energy

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balance in steady flow process, steady flow energy equation and its application to nozzles and diffusers, throttling valve, turbines and compressors, pumps, heat exchangers etc. Work done and heat transfer during steady flow processes. **[6hrs]**

Unit IV : First law of thermodynamics:
Energy of systems, classification of energy, law of conservation of energy, first law applied to closed system undergoing a cycle, Joule experiment, energy-a property of system, internal energy: a function of temperature, enthalpy, specific heat at constant volume and constant pressure, change in internal energy and heat transfer during various non-flow processes. First law applied to flow processes: steady-state steady flow process, mass balance and energy balance in steady flow process, steady flow energy equation and its application to nozzles and diffusers, throttling valve, turbines and compressors, pumps, heat exchangers etc. Work done and heat transfer during steady flow processes. **[7hrs]**

Unit V : Entropy:
Inequality of Clausius, entropy: a property of system, entropy change for ideal gases, entropy change of a system during irreversible process, lost work, principle of increase of entropy. Availability and irreversibility: available energy referred to cycle, decrease in available energy with heat transfer through a finite temperature differences. Tds equations, Availability in a steady flow system, irreversibility and effectiveness. **[6hrs]**

Unit VI : Power cycles:
Gas power cycles: Otto cycle, Diesel cycle, semi-Diesel, Sterling cycles, their efficiency and mean effective pressure calculations.
Vapors power cycles: Properties of steam, specific volume and entropy of steam, dryness fraction of steam, throttling of steam, determination of dryness fraction, steam tables and their use, T-s and H-s diagram, Rankine and modified Rankine cycle, work done and efficiency, specific steam consumption, comparison of Rankine and Carnot cycle, representation on P-v, T-s and h-s diagram. **[8hrs]**

Text Books:

- Thermodynamics: An Engineering Approach, 3rd Edition, Yunus Çengel and Michael, Boles, Tata McGraw Hill.
- Basic and Applied Thermodynamics, 2nd Edition, Nag P. K., Tata McGraw-Hill.

Reference Books

- Fundamentals of Thermodynamics, 5th Edition, Richard E. Songtag, Claus Borgnakke and Gordon J. Van Wylen, John Wiley and Sons, Inc.
- Thermodynamics, 4th Edition, J.P. Holman, McGraw-Hill.
- Engineering Thermodynamics, 2nd Edition, Jones J.B. and Hawkins G.A., John Wyley and Sons.
- Fundamentals of Engineering Thermodynamics, Moran M.S. and Shapiro H.N., John Wyley and Sons, 1988.

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- Thermodynamics, 5th Edition, K. Wark, McGraw-Hill.

(ME) Machine Drawing and Computer Graphics

Teaching Scheme:
Lectures : 2 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Student will be able to

1. Learn the latest norms and standards about use of symbols and conventions abut Machine Drawing and get aware about standard codes and drawing practices.
2. Obtain the limits, fits and tolerances for various assemblies and learn to indicate various symbols on the machine drawing.
3. Develop the skills for drafting using CAD software and get the knowledge to enhance the CAD utilities.

Unit I : Introduction to Machine Drawing:
Dimensioning Techniques, Representation of standard components such as Screw Threads, Screw fasteners, keys, couplings, bearings, pulleys, brackets, gears, locking arrangements, Rivets and riveted joints, Welding symbols.
Symbols for Pipe Joints, Expansion joints, stuffing box and glands, piping layouts, conventional representation of pipe fittings, valves, joints, etc. **[8hrs]**

Unit II : Limits, Fits and Tolerances:
ISO system of tolerance, Tolerance charts, Hole - base and shaft -base system of tolerance, Types of fits, symbols and applications.
Geometric Tolerances : Introduction, Nomenclature, Rules, Symbols, values obtained from various manufacturing processes. **[8hrs]**

Unit III : Surface Roughness & Production Drawing :
Surface Textures, Roughness values and Roughness Grades, Machining symbols Conventional Representation on part drawings.
Production Drawing: Assembly and part drawings, Blue print reading, study and preparation of bill of materials. **[6hrs]**

Unit IV : Basic Drafting commands:
Drawing basic entities, Modify commands, Edit commands .. etc , Layers , Block attributes, Viewers, Design center utilities , Solid Modelling , Editing of solids, 3-D operations such as shading and rendering etc. **[6hrs]**

Unit V : Introduction to CAD programming :

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Concept of parametric programming, Need and importance of CAD programming. Data types: Integers, Real numbers, Strings, Symbols, Lists and File Descriptors. Data types conversions: Integer to real, string list, real to integer, string lists. Reading and writing to the screen by using visual lisp consoles. **[6hrs]**

Unit VI : Functions and Tools of CAD Programming :

Inputs in CAD Programming: Get functions for user input. Use of lists and the entities: Filtering from lists, editing/ modifying the lists, entity managing and modifying the entities. Arithmetic and Logical Functions: Additions, Subtraction, Multiplication, Division, sorting the data for deciding maximum and minimum numbers, remainders, exponential operation, trigonometric functions, AND, OR etc. Decision-making and looping, File handling functions (changing the properties of AutoCAD entities). Block attributes and extracting the attribute data. **[6hrs]**

Text Books:

- K. L. Narayana, P. Kanniah, & K.V. Reddy, " Machine Drawing ", SciTech Publications (India Pvt. Ltd.) Chennai
- Ajeet Sing, "Working with AutoCAD 2000", Tata McGraw Hill
- George Omura , "ABC of Autolisp", BPB Publications, New Delhi

Reference Books

- IS Code: SP 46 – 1988, Standard Drawing Practices for Engineering Institutes
- Auto CAD & Autolisp Manuals by AutoDesk Corp., USA
- "Design Data", Faculty of Mechanical Engineering, PSG College of Tech, Coimbatore
- "Machine Drawing", N.D.Bhatt and P.Kanniah, Charotar Pub. House, Anand, Gujrath
- "Computer Aided Engineering Drawing", S. Trymbaka Murthy, I.K. International Publishing House Pvt. Ltd, Pune

(ME) Manufacturing Engineering - I

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Student will be able to

1. Identify and explain the function of the basic components of machine tools and its accessories
2. Analyze various machining processes and select the particular manufacturing process for a given job.

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3. Have the knowledge of casting and forming process and solve the casting and forming problems.
4. Explain various surface treatment processes and its engineering applications.

Unit I : Hot and cold working of metals:
Principles of rolling, forging, drop, press, upset, roll forging, extrusion, drawing, spinning, and effect of hot working. Cold working processes, Cold rolling, swaging, forging, extrusion-forward, backward and impact roll forming, tube drawing, wire drawing, spinning, shot penning, high energy rate forming, sheet metal working, types of presses, drives, different operations and types of dies. Forging design. **[6hrs]**

Unit II : Joining processes:
Arc welding- Theory, SMAW, GTAW, GMAW, FCAW, Submerged arc welding, Stud welding Resistance welding- Theory, spot and seam projection welding processes Gas welding Friction welding, Ultrasonic welding, Thermit welding, EBW and LASER welding Use of adhesive for joining, classification of adhesives, types of adhesive and their application, surface preparation and various joints welding defects and quality. **[7hrs]**

Unit III : Foundry- Pattern making, moulding and casting:
Sand casting, types of pattern material, pattern making allowances, core print moulding, sand properties and testing, hand and machine moulding, core boxes, core making, melting and pouring, melting furnaces- Cupola, fuel fired, electric arc and induction furnaces. Cleaning, finishing and heat treatment of casting, defects in casting lost foam processes, shell moulding and investment casting. Permanent mould dies casting- Die-casting, low-pressure permanent mould casting, hot and cold chamber processing, centrifugal casting, semi centrifugal casting and continuous casting. Gating system design, Risering Design, product design for sand casting. **[8hrs]**

Unit IV : Lathe and drilling Machine:
Turning and boring, lathe construction, accessories and operations. Thread cutting- single and multi start threading, concept of speed, feed and depth of cut. Introduction to boring Machines, Capstan and Turret lathe. Fundamentals of drilling processes, hoist, drill geometry, tool holder, types of drilling machines, operations performed on drilling machines, type of drill. Reaming processes and reamer types. **[8hrs]**

Unit V : Milling, shaping and planning:
Fundamental aspects, cutter types and geometry, Operations performed on milling machine, dividing head method of indexing. Construction, working and operations performed on shaper, planer, and broaching machines. **[5hrs]**

Unit VI : Grinding :
Wheels, wheel marking, wheel selection, wheel mounting, types of grinding machines. Honing, lapping, super finishing, buffing and burnishing processes. **[5hrs]**

Text Books:

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- K. L. Narayana, P. Kanniah, & K.V. Reddy, " Machine Drawing ", SciTech Publications (India Pvt. Ltd.) Chennai
- Ajeet Sing, "Working with AutoCAD 2000", Tata McGraw Hill
- George Omura , "ABC of Autolisp", BPB Publications, New Delhi

Reference Books

- IS Code: SP 46 – 1988, Standard Drawing Practices for Engineering Institutes
- Auto CAD & Autolisp Manuals by AutoDesk Corp., USA
- "Design Data", Faculty of Mechanical Engineering, PSG College of Tech, Coimbatore
- "Machine Drawing", N.D.Bhatt and P.Kanniah, Charotar Pub. House, Anand, Gujrath
- "Computer Aided Engineering Drawing", S. Trymbaka Murthy, I.K. International Publishing House Pvt. Ltd, Pune

(CE) Strength of Materials

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Student will be able to

1. Apply basic concepts in structural mechanics to solve simple problems.
2. Determine the types of stresses developed in statically determinate member due to
3. different actions.
4. Analyze and design simple problems in engineering applications subjected to various actions.
5. Explain various surface treatment processes and its engineering applications.

Unit I : **Simple stresses and strains:**
a) Concept of stress and strain (linear, lateral, shear and volumetric) Hooks law. Elastic constants and their relationship. Generalized Hook's law.
b) Axial force diagram, stresses, strains and deformation in determinate and indeterminate homogeneous and composite bars under concentrated loads, self weight and temperature changes. **[7hrs]**

Unit II :
a) Shear force and bending moment diagrams
Concept and definition of shear force and Bending Moment in beams due to concentrated load, UDL, uniformly varying loads and couples in determinate beams. Relation between SF, BM and intensity of loading, SF, and BM diagrams for cantilevers, simple compound beams and bend.

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b) Stresses due to bending

Theory of simple bending, concept and assumptions, Derivation of Flexure formula. Bending stress distribution diagram. Moment of resistance and section modules calculations. **[7hrs]**

Unit III :

a) Shear stress distribution in beams

Shear stresses concept, derivation of shear stress distribution formulae, shear stress distribution diagram for common symmetrical sections, maximum and average shear stress, shear connection between Flange and web.

b) Torsion of circular shaft

Theory of torsion of shafts of circular, cross section. Assumptions, Derivation of torsion formulae, stresses strains and deformation in determinate and indeterminate shafts of hollow, solid, homogeneous circular cross section subjected to twisting moments, stresses due to combine torsion, bending . **[6hrs]**

Unit IV :

a) Principal stresses and principal strain

Normal and shear stresses on any oblique planes and concept of principal planes and principal planes by analytical and graphical methods (Mohr's circle of stress 2-D).

b) Pressure Vessels.

Stresses, strains and deformation in thin walled seamless cylindrical and spherical vessels due to internal fluid pressure. Change in volume, effects of additional fluid injected under pressure. **[6hrs]**

Unit V : a) Axially loaded columns

Concept of critical load and buckling, derivation of Euler's formulae for buckling load with hinged ends, concept of equivalent length for various end conditions. Rankine's formulae, safe load on column, Limitations of Euler's formulae.

b) Strain energy and impact.

Concept of strain energy, derivation and use of expressions for deformation of axially loaded members under gradual sudden and impact loads. **[5hrs]**

Unit VI :**Slope and Deflection of Determinate Beams**

a) Concept and definition, relation between B.M., slope and deflection slope and deflection by double integration method (McCauley's method).

b) Slope and Deflection in determinate beams by Moment Area method **[5hrs]**

Text Book

- "Strength of Materials" By S. Ramamrutham & R Narayanan, Dhanpat Rai publication, New Delhi

Reference Books

- "Introduction to Mechanics of Solids" by J.B. Popov, Prentice – Hall publication

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- "Mechanics of Materials" by James M.Gere (5th Edition) Brooks/Cole Thomson Learning.
- "Strength of Material" by F. L. Singer and Pytel, Harper and Row publication.
- "Mechanics of Material" by Beer and Johnston, Mc Graw Hill publication.

(ME) Machine Drawing and Computer Graphics Laboratory

Teaching Scheme:	**Examination Scheme :**
Practical:4hrs/week	Term work – 50 marks
	Oral- 50 marks

Laboratory Outcomes:

At the end of the laboratory work, students will demonstrate the ability to:

Students will be able to

1. Utilize the knowledge of various ISO standards obtained in theory while attaining practical.
2. Use various standards, symbols, tolerances, limits and fits while drawing the sheets.
3. Communicate using software like AutoCAD and AutoLISP.

Term work:

Machine Drawing

1) One full imperial drawing sheet consisting the drawing/ sketches of representation of standard components, symbols of pipe joints, weld joints, rivet joint etc, surface finish symbols & grades, Limit, fit and tolerance related sketches.
2) One full imperial drawing sheet consisting of assembly and details of any one standard component such as valves, components of various machine tools, pumps etc.

CAD Drawing and Programmes

I] Assignment of CAD drawings : -

a) Simple Orthographic Views, Orthographic Projections with three views of any one simple machine component such as bracket, Bearing Housing or Cast component for Engines such as Connecting rod, Piston etc and its' 3-D model.
b) Isometric Views of machine components.
c) 3-D Models of machine components.

II] Assignments of CAD programming:

1) Introductory programmes (minimum two on each) such as

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a) Programmes to draw geometric figure or their combinations with changes in the type of input required, for those figures. Such programmes should have use of arithmetic functions, data conversions, filtering from lists.

b) Programmes to draw figures using Data type conversion involving users input data, blinking on the screen use of trigonometry for solving graphics problems etc.

2) Parametric Programming (minimum two on each) such as

a) Program to draw a standard machine component by using decision-making and looping statement of Autolisp.

b) Program to draw a profile, generated after getting data from user such as profile of cam, profile of gear tooth, profile of points present on moving links or mechanisms etc.

3) Programme to enhance the capacity of CAD drawing

a) Making the File handling programmes

b) Obtaining animation of moving parts or mechanisms

c) Changing the Front page / display by Menu Customization Programme.

4) Innovative programmes of any type, by using Autolisp environment.

(PE) Manufacturing Engineering – I Laboratory

Teaching Scheme:
Practical: Practical:2 hr/week

Examination Scheme :
Term work – 50 marks
Oral- 50 marks

Laboratory Outcomes:

At the end of the laboratory work, students will demonstrate the ability to:

Get the knowledge of working of machine tools, mechanisms and accessories used in various manufacturing processes

1. Perform the job of turning & taper turning operation using lathe
2. Perform Welding using gas/arc welding process
3. Solve the problems of Sand Casting and forming processes.
4. Explain CNC machines and their operations.

Termwork:

Each candidate shall be required to complete and submit the following term work:

- **Jobs:**

Plain and Taper turning – one job

Milling and Drilling – one Job

Forging and grinding of lathe tool with one knife and other end vee – one job

Welding (gas or arc) – one job

Sand Casting – one job

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CNC Lathe Machine- Demonstration and hands on.

Journal:

Assignments on machine tools will be in the form of a journal based on demonstrations on machine tools. This should include sketches and relevant descriptions as given below:

1) **Block Diagrams (Any Two)**
   a) Lathe
   b) Universal milling machine
   c) Radial drilling machine
   d) Cylindrical grinder.
2) **Mechanisms (Any Two)**
   a) All geared headstock of a center lathe.
   b) Spindle arbor (assembly) drive of milling machine
   c) Crank and slotted lever quick return drive of shaping machine.
   d) Spindle assembly in a drilling machine.
3) **Accessories (Any Two)**
   a) Taper turning attachment for a centre lathe.
   b) Universal dividing head.
   c) Milling cutters.

CNC Lathe machine working and operations.

(CE) Strength of Materials Laboratory

Teaching Scheme:
Practical: Practical:2 hr/week

Examination Scheme :
Term work – 50 marks
Oral- 50 marks

Laboratory Outcomes:

Students will be able to

1. Utilize the knowledge obtained in theory in order to perform practical.
2. Analyze the effect of tensile, shearing force and can utilize the knowledge gained while tackling real life engineering problems.
3. Incorporate the important concepts learnt while designing components.

List of Experiments:

1. Tension test on Mild Steel and Aluminum
2. Shear test on Mild Steel and Aluminum
3. Torsion test on Mild Steel and Cast-Iron
4. Impact test on Mild Steel, Aluminum and Cast-Iron
5. Hardness test on Mild Steel, Aluminum and Cast iron
6. Bending test on Timber, Plywood and Mild Steel.

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7. Bend- rebend test on mild steel and Torsteel
8. Flexure test on Mild Steel.

Semester III (For Direct Second Year Admitted Diploma Students)

(MA-) Linear Algebra and Calculus

Teaching Scheme:	Examination Scheme:
Lectures : 4hrs / week	T1 and T2: 20 Marks each
Tutorial : 1 hr	End Sem. Exam: 60 marks

Course Outcomes:

Students will be able to

1. Know and recall the core knowledge of the syllabus. (To measure this outcome, questions may be of the type- define, identify, state, match, list, name etc.)
2. Understand the concept. (To measure this outcome, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.)
3. Analyze the problem and apply the appropriate concept. (To measure this outcome, questions will be based on applications of core concepts)
4. Apply core concepts to new situations. (To measure this outcome, some questions will be based on self-study topics and also comprehension of unseen passages.)
5. Give reasoning. (To measure this outcome, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.)

Unit I:

Matrices and linear equations: basic properties of matrices, row operations and Gauss elimination, Determinants and their basic properties. Basic concepts in linear algebra: vector spaces, subspaces, linear independence and dependence of vectors, bases, dimensions. Row and Column spaces, rank. Applications to systems of linear equations. **[14hrs]**

Unit II:

Linear mappings, representation by matrices, rank-nullity theorem, Eigen values, Eigen vectors and their basic properties, diagonalization. **[12hrs]**

Unit III:

Review of limits, continuity and differentiability, Mean value theorems, Taylor's theorem, local extrema, increasing and decreasing functions, concavity, points of inflection. **[10hrs]**

Unit IV:

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Integrals as limits of Riemann sums, fundamental theorem of calculus, surface area, integrals by special techniques: reduction formulae, arc length, solids of revolution, improper integrals, tests for convergence, Gamma and Beta functions. **[12hrs]**

Text Books :

- Advanced Engineering Mathematics (9^{th} edition) by Erwin Kreyszig, Wiley eastern Ltd &Bombay, 2006.
- Thomas' Calculus (12^{th} edition) by Maurice D. Weir, Joel Hass, Frank R. Giordano, Pearson Education, 2008.

Reference Books :

- Linear Algebra by Hoffman and Kunze, (2^{nd} edition) Prentice Hall Publication, New Delhi.
- Higher Engineering Mathematics by B. V. Ramana ,Tata McGraw Hill .
- Advanced Engineering Mathematics by C.R. Wylie, McGraw Hill Publications, New Delhi.
- Advanced Engineering Mathematics (7^{th} edition) by Peter V. O' Neil, Thomson.Brooks/ Cole, Singapore.
- Differential Calculus by Shanti Narayan, S. Chand and company, New Delhi.
- Engineering Mathematics (Volume-I) by S. S. Sastry, Prentice Hall Publication, New Delhi.
- Higher Engineering Mathematics by B.S.Grewal, Khanna Publications, New Delhi.

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Semester-IV

(MA) Vector Calculus and Partial Differential Equations

Teaching Scheme:
Lectures : 2 Hrs/week
Tutorial: 1Hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Students will be able to:

1. Know and recall core knowledge of the syllabus. (To measure this outcome, questions may be of the type- define, identify, state, match, list, name etc.)
2. Understand basic concepts. (To measure this outcome, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.)
3. Analyze the problem and apply the appropriate concept. (To measure this outcome, questions will be based on applications of core concepts)
4. Give reasoning. (To measure this outcome, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.)
5. Apply core concepts to new situations. (To measure this outcome, some questions will be based on self-study topics and also comprehension of unseen passages.)
6. Organize and present thoughts. (To measure this outcome, questions may asked to write summaries and short notes on a given topic.)

Unit I :
Vector differentiation, gradient, divergence and curl, line and surface integrals, path independence, statements and illustrations of theorems of Green, Stokes and Gauss, arc length parameterization, applications. **[9hrs]**

Unit II :
Partial differential equations with separation of variables, boundary value problems: vibrations of a string, heat equation, potential equation, vibrations of circular membranes. **[10hrs]**

Unit III :
Laplace Transforms, its properties, Unit step function, Dirac delta functions, Convolution Theorem, periodic functions, solving differential equations using Laplace transform. **[7hrs]**

Text Books:

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- Maurice D. Weir, Joel Hass, Frank R. Giordano, "Thomas' Calculus", Pearson Education, 12th Edition.
- Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley eastern Ltd., 10th Edition.

Reference Books:

- C.R. Wylie, "Advanced Engineering Mathematics" , McGraw Hill Publications, New Delhi.
- Peter V. O' Neil, "Advanced Engineering Mathematics", Thomson Brooks / Cole, Singapore, 7th edition.
- Wendell Fleming, "Functions of several variables", Springer-Verlag, New York.
- Fritz John, "Partial Differential Equations" (4th edition), Springer.
- Michael D. Greenberg, "Advanced Engineering Mathematics (2nd edition)", Pearson Education.

Professional Ethics & Values

Teaching Scheme:
Lectures : 1hr / week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem. Exam: 60 marks

Course Outcomes:

1. To create awareness about Professional Ethics and Human Values.
2. To enable future professional engineers to contribute to societal and human well-being.
3. To inculcate professional behaviour and sound work / workplace ethics in young minds.
4. To inculcate social responsibility at the personal, professional and corporate levels.
5. To appreciate the concept of gender diversity and related issues from an ethical viewpoint.
6. To appreciate and deal with ethical dilemmas while discharging duties in professional life.

Unit I :
Morals, Values and Ethics ,Integrity, Work Ethic, Honesty ,Commitment Courage ,Empathy ,Self-Confidence, Character, Caring and Sharing Empathy and Leadership. **[4hrs]**

Unit II :
Introduction to and history of Ethics,Profession and professionalism ,Professional roles played by an engineer,Engineering ethics (supported by case studies),Moral / ethical dilemma, moral autonomy, consensus and controversy, etc.Codes of conduct and codes of ethics, Gender diversity at the workplace, women's empowerment, sexual harassment. **[5hrs]**

Unit III :

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Types of technology and their ethical application, Transfer of technology, its benefits and drawbacks, Role of multinational corporations in technology transfer, Environmental ethics and need for sustainable development, Environmental hazards due to irresponsible technological development,Computer ethics and IPR, and computer crime ,Social problems resulting from. **[6hrs]**

Unit IV :

Meaning of experimentation in engineering, Engineers' role as responsible social experimenters to benefit society, R&D efforts towards ethically and environmentally sustainable design of products and systems, A balanced view towards legal, ethical and business aspects of technology use. **[5hrs]**

Unit V :

Knowledge of safety and risk and the ethical need to reduce it, Uncertainty of design, Need for testing product and system designs for safety, Concept of risk benefit analysis, Ethical issues in cost-benefit analysis, Protecting employee rights, human rights and human responsibilities, Case studies involving natural and manmade disasters, (e.g. Chernobyl, Bhopal Gas Tragedy, floods in Uttarakhand, Kashmir, etc. **[5hrs]**

Unit VI :

Meaning and brief history of whistle blowing, Internal and external whistle blowing,Ethical and legal issues involved in whistle blowing, Managing whistle blowing, Case studies involving whistle blowers like Manjunath, SatyendraDubey, etc. **[3hrs]**

(AS) Innovation

Teaching Scheme:
Lectures : 1hr / week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem. Exam: 60 marks

(ME) Automobile Engineering

Teaching Scheme:
Lectures : 3hrs / week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem. Exam: 60 marks

Course Outcomes:

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Student will be able to

1. Implement the knowledge obtained in theory towards design and analysis of various automobile systems.
2. Comprehend various aspects of automobile system for enhancement of comfort, safety and economics the various automobile
3. Repair and maintain the automobile

Unit I :

Introduction: Vehicle specifications, classifications, Engine cylinder arrangements, Power requirements, motion resistance and power loss; tractive efforts.

Chassis layout, frame, main components of automobile and articulated vehicles. Design considerations, materials and their properties. **[6hrs]**

Unit II :

Transmission System : Clutches: need, types. Need of gearbox, types of gear transmission, shift mechanisms, over running clutch, fluid coupling, and torque converters. **[6hrs]**

Unit III :

Transmission universal joint, constant velocity joint, propeller shaft, Hotchkiss drive, torque tube drive, front and rear axles types, stub axles, need of differential and types, four wheel drive. **[6hrs]**

Unit IV :

Steering and Suspension Systems: Steering system, principle of steering, centre point steering, steering linkages, steering geometry and wheel alignment, power steering.

Suspension system: need, types, independent suspension, coil and leaf springs, suspension systems for multi, axle vehicles, trouble shooting and remedies. **[8hrs]**

Unit V : Brakes:

Need, types, mechanical, hydraulic and pneumatic brakes, disc and drum types, their relative merits, details of components, brake adjustments and defects, power brakes.

Wheels and Tyres: Types, tyre construction, specification, tyre wear and cause, wheel balancing. **[6hrs]**

Unit VI : Electrical Systems:

Electrical systems construction, operation and maintenance of lead acid batteries battery charging system principle and operation of cutout and regulators starter motor Bendix drive solenoid drive magneto coil and solid stage ignition systems, ignition timing, lighting, and electrical accessories, automobile air conditioning, panel board instruments. **[8hrs]**

Text Books:

- Automobile Engineering by Dr. Kirpal Singh (Vol. I & II) Standard Publishers 1999
- Automobile Engineering by G.B.S. Narang.1999

Reference Books:

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- Automotive Technology by H.M. Sethi.1990
- Automobile Engineering by Banga & Singh,1990
- Joseph Heitner„ Automotive Mechanics‟, 2nd Ed., Affiliated Eastern Law house, 1967.
- Dolan. J.A., „Motor Vehicle Technology and Practical Work‟, ELBS, 1978
- Motor Vehicles, Newton & Steed
- Motor Manuals (Vol I to VII), A.W. Judge.
- Automobile Mechanics, W.H. Crouse. McGraw Hill publishing Co 2005

(ME) Smart Materials

Teaching Scheme:
Lectures : 3hrs / week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem. Exam: 60 marks

Course Outcomes:

Student will be able to

1. Get introduce to the latest basic concepts and informations.
2. Know the applications of a range of smart materials.
3. Design and develop the smart system for the specific application.

Unit I : **Introduction to smart materials**
Various types of smart material and its need in advanced manufacturing processes, Smart material's properties, The development of smart materials and structures. **[8hrs]**

Unit II : Various Types and Manufacturing Methods
Manufacturing techniques for each smart material such as Deposition, Ion Implantation, Coatings for high temperature performance, Electrochemical and spark discharge and Plasma coating methods, Electron beam and laser surface processing, Organic and Powder coatings, Thermal barrier coating. **[10hrs]**

Unit III : Alloys
Shape memory alloys, Superalloys, creep resistance, Ultra high strength steels, Amorphous alloys, Zirconium alloys, Light metal alloys and synthesis by mechanical alloying. **[6hrs]**

Unit IV : Polymers and Composites
Polymers and their synthesis, polymer curing. Conductive polymers and elastomers. Electroactive polymers, electrostrictive materials and Piezoelectric materials, Ceramic materials.
Smart composites and Metal matrix composites (MMC). **[8hrs]**

Unit V : Bio-Materials

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Nano materials, Nanostructures, gels, coatings, LB films, electrochromic sol-gel coatings. Metallic glasses,

Magnetic materials. Magnetostrictive materials, magnetorheological fluids, electrorheological materials and their applications.

Design of smart systems and practical applications such as aerospace and automobiles. **[8hrs]**

Text Books :

- Engineering analysis of smart material systems , Donald J. Leo, John Wiley Sons.
- Smart material systems: model development, R.C. Smith, SIAM Edition

Reference Books:

- Addington, M. , Schodek, Daniel L.: Smart materials and new technologies, Architectural Press, 2005
- Polymer I.J., "Light Alloys & Metallurgy of light metals", Arnold Press,1995.
- Schwartz, M: Encyclopedia of Smart Materials, Volumes 1-2 ,Willey 2002
- Westbrook J.H & Fleischer R.L., "Intermetallic compounds VOL I & II", John Wiley, Chichester ,1995
- Smallman and Bishop, "Metals and Material Science, process, applications"
- Clyne T.W. & Withers P.J., "An Intro. to metal matrix composite", Cambridge University Press, 1993.
- Artz & L. Schulte (Ed), "New Materials by mechanical alloying techniques", DGM.

(ME) Computer Aided 3 D Geometric Modelling

Teaching Scheme:	**Examination Scheme:**
Lectures : 3hrs / week	T1 and T2: 20 Marks each End Sem. Exam: 60 marks

Course Outcomes:

Student will be able to

1. think logically & understand the basic concepts of solid modeling
2. to apply knowledge of mathematics, science, and engineering while creating parametric geometric model
3. create 3D model using any professional software
4. create assembly model using any professional software
5. generate 2D part and assembly drawings with BOM details using any professional software
6. interface 3D part model with program to automate design process

Unit I : **Geometric Modeling**:

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Introduction to CAD/CAM, 2D vs 3D Geometric model, Introduction to Wireframe, surface and solid modeling techniques. Geometry vs Topology, Requirements of Geometric Modeling, Geometric Modeling Methods: Constructive Solid Geometry (CSG), Boundary Representation (B-rep), Feature based Modeling, Direct (History less) Modeling, behavior modeling, 3D scan modeling. **[6hrs]**

Unit II : Parametric solid modeling:
Fundamentals, apply/modify constraints and dimensions, transform the parametric 2-D sketch into a 3D solid. Introduction to Graphical User Interface (GUI) of any commercially used solid modeling software. Create 3D model using Sketch features and Placed features. **[8hrs]**

Unit III : Advance Features:
3D modelling using Modifying and copying featurs. Use of datum featres: Datum points, axis, curve, planes etc. Parametric equation of various curves. **[8hrs]**

Unit IV : Assembly modeling
Defining relationship between various parts of machine, creation of constraints, generation of exploded view. **[6hrs]**

Unit V : Production drawing
Generation of 2-D sketches from parts and assembly 3-D model, appropriate dimensioning and tolerancing. Introduction to design automation by interfacing CAD software to Higher level languages. **[8hrs]**

Text books:

- Ibrahim Zeid, Mastering CADCAM, McGraw-Hill
- Help manuals and tutorials of professional CAD software

References books:

- N. D. Bhatt and V.M. Panchal, Machine Drawing, Charoter Publications
- ASME Y14.5 – 2009

(ME) Theory of Machines- I

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem. Exam: 60 marks

Course Outcomes:

Students will be able to;

1. Determine kinematic analysis (Velocity, acceleration, Inertia forces) for a given of a given mechanism using analytically and graphically method.

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2. Demonstrate the dynamics of cams and followers, governors, and their characteristics.
3. Draw inversions and determine velocity and acceleration of different mechanisms.
4. Construct different types of cam profile for a given data.
5. Solve and determine forces and dimensions of Spur and Helical Gear.
6. Calculate speeds and study performance of various types of Gyroscope.

Unit I: Fundamentals of kinematics and mechanisms:
Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom (Mobility), Kutzbach crieterion, Grubler's criterion, Inversion, Four bar chain and its inversions, Grashoff's law, Slider crank chain and its inversions, Double slider crank chain and its inversions, straight line mechanisms, pantograph, Geneva mechanism, steering gear mechanisms, Hooke's joint, Introduction to Compliant mechanism. **[8hrs]**

Unit II: Velocity and acceleration analysis:
Relative velocity acceleration methods, Corioli's component of acceleration, instantaneous center of Rotation method, Kennedy theorem of three center in line, body and space centrode, Klein's construction, Position analysis of links with vector and complex algebra methods, Loop closure equation, Chace solution, Velocity and acceleration analysis of mechanisms using vector and complex algebra methods. **[8hrs]**

Unit III: Static and dynamic force analysis of slider crank mechanism:
Analytical method for displacement, velocity and acceleration of slider crank mechanism, D'Alembert's principle, static and dynamic force analysis of slider crank mechanism, dynamically equivalent system, correction couple, graphical and analytical method for determination of torque on crankshaft. **[8hrs]**

Unit IV: Theory of Gears I:
Classification of gears, Types of gears, Spur gears - terminology, fundamental law of toothed gearing, involute and cycloidal profile, conjugate action, contact ratio, minimum number of teeth, interference and under cutting. Helical gears: Nomenclatures, center distance, force analysis. **[8hrs]**

Unit V: Cams and followers:
Types of cams and followers, types of follower motion, velocity and acceleration diagrams, profile of cam cams with specified contours. **[6hrs]**

Unit VI: Governor Mechanisms:
Introduction, Types, Governor Effort and governor power, Controlling force analysis, sensitivity, stability, isochronisms and hunting, friction, insensitiveness **[6hrs]**

Text Books:

- Ballaney, P., "Theory if Machines and Mechanisms", 2005, ISBN 9788174091222 / 817409122X Khanna Publications

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- John Hannah and Stephens, R. C., "Mechanics of Machines: Advanced Theory and Examples", 1970, Hodder; Student international edition, ISBN 0713132329 Edward Arnold London

Reference Books:

- Uicker Jr, J. J., Penock G. R. and Shigley, J. E., "Theory oif Machines and Mechanisms' 2003, Tata McGraw Hill.
- Ramamurthy V., "Mechanisms of Machines", 3rd edition, ISBN 978-1842654569, Narosa Publishing House.
- Bevan Thomas, "The Theory of Machines", 3rd edition, CBS publication.
- Bansal, R. K., "Theory of machines", Laxmi Publications Pvt. Ltd, New Delhi

(ME-) Fluid Mechanics

Teaching Scheme:
Lectures : 2 hrs/week
Tutorials: 1 hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem. Exam: 60 marks

Course Outcomes:

Student will be able to

1. Solve problems involving fluid properties and be able to calculate hydrostatic forces on various types of surfaces.
2. Obtain the solution of the problems dealing with dam gates, ship stability, buoy stability etc.
3. Apply and analyze fluid systems using the integral form of the continuity, momentum,
4. Apply Bernoulli's Equation for various fluid systems and flow measuring devices.
5. Apply and understand various dimensionless numbers for problems in fluid mechanics
6. Analyze and explain physical significance of flow through the pipes.
7. Derive governing equations and study various parameters for turbulent flows.

Unit I : Basics with fluid statics:
Definition of fluid, fluid properties such as viscosity, vapor pressure, compressibility, surface tension, capillarity, Mach number etc, pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, pressure measurement by simple and differential manometers using manometric expression.
Hydrostatic forces on the plane and curved surfaces, centre of pressure, Buoyancy, centre of buoyancy, stability of floating bodies, metacentre and metacentric height and its application in shipping. **[6hrs]**

Unit II : Fluid Kinematics:

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velocity of fluid particle, types of fluid flow, description of flow, continuity equation, Coordinate free form, acceleration of fluid particle, rotational & irrotational flow, Laplace's equation in velocity potential and Poison's equation in stream function, flow net. **[4hrs]**

Unit III : Governing equations in Fluid Dynamics:
Derivation of Momentum equations using integral
and deferential approach, dimensionless form of governing equations, special forms of governing equations, Integral quantities. **[4hrs]**

Unit IV : Applications of Bernoulli's Equation and Flow through pipes:
(a) Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem, Application of Bernoulli's theorem such as venture meter, orifice meter, pitot tube and orifices etc
(b) Reynolds's experiment, frictional loss in pipe flow, major and minor losses, HGL and TEL, flow through series and parallel pipes. **[4hrs]**

Unit V :
a) Dimensional homogeneity, Raleigh's method, Buckingham's theorem, Model analysis, similarity laws and dimensionless numbers.
(b) Introduction to boundary layer theory and its analysis.
(c) Forces on Submerged bodies: Drag, lift, Drag on cylinder, Development of lift in Cylinder.
[4hrs]

Unit VI :Turbulent Flow:
Characteristics of turbulent flow, laminar turbulent transition, time mean motion and fluctuations, derivation of governing equations for turbulent flow, shear stress models, universal velocity distribution. **[4hrs]**

Text Books :

- Fluid Mechanics, Vijay Gupta, Narosa Publications, 2014
- Advanced Fluid Engineering, Murlidhar and Biswas, Narosa Publications
- Mechanics of Fluids, Irwin Shames, McGraw Hill, 2003
- Hydraulics and Fluid Mechanics including Hydraulic Machines, Dr. P. N. Modi and Dr. S. M. Seth, Standard Book House

Reference Books:

- Fluid Mechanics, P. K. Kundu , I. M. Kohen and David Dowling Fifth Edition Elsevier Publication**.**

(MT) Fundamentals of Metallurgy

Teaching Scheme:
Lectures :3hrs/ week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem. Exam: 60 marks

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Course Outcomes:

1. Able to demonstrate an understanding of the structure-property-processing correlation engineering materials.
2. Able to select appropriate mechanical testing for various metallic materials.
3. Able to distinguish among various types of steels and cast irons for particular application.
4. Able to select appropriate heat treatment for metals and alloys for particular application.

Unit I :
Engineering Materials
Overview of Metallic Materials: Ferrous and Non Ferrous Metals, Ceramics- Traditional and Engineering Ceramics, Polymers: Traditional and Special Polymers, Composites: Ceramic-Metal- Polymer composites, Carbon nano tube composites. **[6 hrs]**

Unit II :
Plain Carbon and Alloy Steels
Type of equilibrium diagrams in metals and alloys, lever rule. Iron - Carbon equilibrium diagram, critical temperatures. Allotropy, cooling curve and volume changes of pure iron. Microstructures of slowly cooled steels, estimation of carbon from Microstructures, non-equilibrium cooling of steels, Effects of alloying elements and examples of alloy steels. Stainless steels. Tool steels and tool materials. Applications of plain carbon and alloy steels, specifications of some commonly used steels for engineering applications (e.g. En, DIN, IS etc with examples) **[8 hrs]**

Unit III : Heat Treatment of Steels
Transformation products of austenite, Time temperature Transformation diagrams, Critical cooling rate, continuous cooling transformation diagrams. Heat treatment of steels, Cooling media. Annealing, normalizing, hardening. Tempering, Carburising, Nitriding, carbonitriding, Flame and Induction hardening. Commercial heat treatment practice of gears of different sizes, tools, lathe beds, springs, etc. **[10 hrs]**

Unit IV : Cast Irons
Classification of Cast irons Gray cast irons, nodular cast irons, white cast irons, malleable cast irons, chilled. Effect of various parameters on structure and properties of cast irons. Applications of cast irons for different components of machine tools, automobiles, pumps, etc.
[6 hrs]

Unit V : Mechanical Testing
Tension test - Engineering and true stress strain curves, Compression test, Hardness Tests: Brinell, Rockwell, Vickers, Hardness conversions, Impact test, Non Destructive Testing: Magnetic Particle test, Dye penetrant, ultrasonic tests, radiography and eddy current testing.

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[6 hrs]

Unit VI : Powder Metallurgy

Sintered structural components, Advantages and Limitations of powder metallurgy, powder manufacture, testing and characterization, Manufacturing of typical P/M products : cemented carbides, cermets, sintered carbide cutting tools, diamond impregnated tools , sintered metal friction materials and self lubricating bearings. **[6 hrs]**

Text Books:

- D. R. Askland & P. P. Phule, "Material Science & Engineering of Materials", by Cengage Learning Center India Pvt Ltd. , Sixth Indian Edition, 2011
- R. A. Higgins, Engineering Metallurgy Part-I, Applied Physical Metallurgy, ELBS with Edward Arnold, Sixth Edition 1993.
- S.H. Avner, Introduction to Physical Metallurgy , Tata Mac Graw Hill, Second edition, 1997.

Reference Books:

- V. Raghvan, "Materials Science & Engineering", PHI 5th Edition, Prentice-Hall of India (P) Ltd.
- W. Callister, "Materials Science & Engineering", John Wiley & sons
- Clark D. S. and Varney W. R., "Physical Metallurgy for Engineers", Affiliated East-West Press, New Delhi.
- R. Balasubramaniam , Callister's Materials Science and Engineering, Wiley India Pvt Ltd., 2008.
- K. Bhargava , Mechanical Behaviour and Testing of Materials by and C. P. Sharma, Publication PHI 2011.

(PE) Manufacturing Engineering II

Teaching Scheme:
Lectures : 3hrs / week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem. Exam: 60 marks

Course outcome

Students will be able to

1. Demonstrate various non conventional manufacturing processes and select proper process for the purpose of manufacturing.
2. Develop competency for selecting appropriate machining process depending on desired output characteristics such as MRR, surface finish.

Unit I : **Sheet metal working**

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Introduction to sheet metal working, press-types and main parts of power press, die details and accessories, metal cutting in a punch and die set up, die details and accessories, types of dies, clearance, angular clearance, various press operations, strip layout, centre of pressure, cutting forces, methods of reducing cutting forces, Blanking die design, drawing- blank size calculations, number of draws, drawing force, Bending- Bend allowance, bending force calculations **[6 hrs]**

Unit II : Theory of metal cutting

Mechanics of chip formation, oblique and orthogonal cutting, single point tool geometry, types of chips, cutting ratio, shear plane angle, velocities in cutting, Merchant circle, shear strain, power in cutting, cutting tool materials, cutting fluid, machinability, evaluation of machinability, optimum cutting speed, tool life, factors affecting tool life, computation of tool life. **[7 hrs]**

Unit III : Non conventional methods of machining

Need of nonconventional methods of machining, classification of non conventional methods of machining, Operating principle, process parameters, advantages, disadvantages and applications of any four non conventional methods of machining which uses different forms of energy. **[6 hrs]**

Unit IV : Jigs and fixtures

Introduction to jigs and fixtures, need, 3-2-1 principle of location, various locating devices, cavity location, redundancy in location, fool proofing, clamping devices, general guidelines for design of jig/fixtures. Design of jig for simple component, design of milling fixture for simple component. **[7 hrs]**

Unit V : NC, CNC, DNC

Introduction to CAD/CAM, NC-Basic components, procedure, coordinate system, motion control, applications, merits and problems, CNC-types, functions and advantages, DNC- Types, functions and advantages. Introduction to adaptive control, FMS and machining centre.

Surface treatment processes

Introduction to surface engineering, surface structure and properties, surface texture, need of surface treatment processes, various types of surface treatment processes, Introduction to any four surface treatment processes such as peening, burnishing, heat treatment etc. **[7 hrs]**

Unit VI : Broaching

Broach-geometry/elements, principle, Types of broaching machines, comparison of broaching with other processes, applications, broach design.

Gear manufacturing

Gear manufacturing by forming processes, gear generating processes such as gear shaping, hobbing, milling, hobbing, Gear finishing processes- shaving, roll finishing, grinding, lapping **[6 hrs]**

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Text Books

- Chapman, "Workshop technology" Vol. I, II & III; Edward Arnold Publications Ltd. London.
- Hajara Chaudhary S. K., "Workshop Technology" Vol. I & II, Media Prom & Publication, Mumbai.
- R. K. Jain, "Production Technology"; Khanna Publications
- Hoffman, "Introduction to Jigs and fixtures", Galgotia Publishers

Reference Books

- S. K. Basu, "Fundamentals of Tool design", Tata Mcgraw Hill Education Private limited.
- Serope Kalpakjian & Steven R. Schmid, "Manufacturing processes for engineering materials
- HMT Hand book "Production technology", Tata Mcgraw Hill Education Pvt. Ltd.
- S. E. Rusinoff, "Manufacturing processes", Times India Press.
- Doyle, "Manufacturing processes and materials for engineers", Prentice Hall of India Press

(ME) Theory of Machines– I Laboratory

Teaching Scheme:	**Examination Scheme:**
Lectures : 2hrs / week	Term Work: 50 marks
	Oral: 50 marks

Course Outcomes:

Students will be able to

1. Demonstrate knowledge of various mechanisms in order to design and analyze mechanisms essential in mechanical engineering.
2. Demonstrate ability towards graphically estimating velocity and acceleration.
3. Exhibit skills towards application of principles of static and dynamics force analysis.
4. Knowledge attained will comply towards successfully addressing issues relating to gears, governors, cams and followers in real life engineering problems.

List of Experiments:

1. Determination of moment of inertia of rigid bodies by bifilar/trifilar suspension methods.
2. Compound pendulum.
3. Experimental verification of displacement relation for different shaft angles for single Hooke's joint.
4. To generate gear tooth profile and to study the effect of under cutting and rack shift using model.

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5. To determine the characteristics curve of any two type of centrifugal governor and to find its coefficient of insensitiveness and stability.

List of Assignments:

1. Velocity and acceleration by vector and complex algebra method
2. Analytical determination of inertia forces in engine mechanisms.
3. Problem on steering gear mechanism.

List of Drawing Sheets:

1. Graphical solution to problems on velocity acceleration in mechanism by relative velocity and acceleration method including problem with Corioli's component of acceleration.
2. Velocity by instantaneous center method.
3. Klein's construction and inertia force analysis for slider cranks mechanisms.
4. To draw cam profile for various types of followers motion.

(ME-) Fluid Mechanics Laboratory

Teaching Scheme:
Lectures : 2hrs / week

Examination Scheme:
Term Work: 50 marks
Oral: 50 marks

Course Outcomes:

Student will be able to

1. Do the pressure measurement using manometers
2. Calculate viscosity of a fluid.
3. Determine the forces experienced by the body when flow occurs around it
4. Carry out the velocity measurement using pitot tube
5. Determine the coefficient of discharge using Bernoulli's equation
6. Determine the friction factor for flow

List of Experiments:

1. Measurement of viscosity using Red Wood viscometer
2. Study and demonstration of pressure measurement using manometers
3. Determination of the metacentric height of a floating body and its stability
4. Demonstration of electrical analogy method for flow measurement
5. Determination of coefficient of discharge for Venturi meter
6. Determination of coefficient of discharge for orifice meter
7. Determination of coefficient of discharge for rectangular notch
8. Demonstration of Pitot tube for velocity measurement

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9. Determination of the friction factor for flow through a long circular pipe
10. Determination of pressure variation around a circular body when it is submerged in a flow

(MT) Fundamentals of Metallurgy Laboratory

Teaching Scheme:
Lectures : 2hrs / week

Examination Scheme:
Term Work: 50 marks
Oral: 50 marks

Course Outcomes:

Students will be able to

1. Perform mechanical tests on metallic materials.
2. Perform heat treatment on steels.
3. Distinguish between microstructures of various metallic materials.

List of Experiments:

1. To perform hardness test on different metallic samples.
2. To perform tensile test on different metallic samples.
3. To perform Impact test on different metallic samples.
4. Non-Destructive tests: Magnaflux testing, Dye penetrant testing.
5. Study and drawing of microstructures of various types' plain carbon steel.
6. To perform various types of heat treatment on plain carbon steels.
7. To study effect of heat treatment on microstructure and hardness of plain carbon steel.
8. Study and drawing of microstructures of various types cast irons.

(ME) Manufacturing Engineering- II Laboratory

Teaching Scheme:
Lectures : 2hrs / week

Examination Scheme:
Term Work: 50 marks
Practical Exam with oral: 50 marks

Course Outcomes:

At the end of the course, students should be able to:

1. Use different Non-Conventional processes for the given applications.
2. Perform job on CNC machine by using CNC programming.
3. Use manufacturing machine tools and make the given jobs.
4. Design the Jigs and Fixture for the given jobs.

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Termwork:

Each candidate shall be required to complete and submit the following term work.

Part A

1. One composite job consisting of at least one spur gear to be made by each student.
2. One composite Job on CNC Lathe/Milling which includes operations like Turning, Facing, Taper Turning, Drilling etc.

Part B

1. Demonstration on different non-conventional machining set-ups to manufacture simple components.
2. Demonstrations on different surface treatment processes.

Part C

A journal consisting of:

1. Design of a jig or fixture. (No fabrication).
2. A report of visit to any surface treatment industry.
3. Assignments on NC/CNC Machines, Press working, Non conventional processes, Advanced manufacturing Processes etc.

Semester IV (For Direct Second Year Admitted Diploma Students)

(MA) Multivariate Calculus and Differential Equations

Teaching Scheme:	**Examination Scheme:**
Lectures : 4hrs / week	T1 and T2: 20 Marks each
Tutorial: 1Hr/week	End Sem. Exam: 60 marks

Course Outcomes:

Students will be able to:

1. Know and recall core knowledge of the syllabus. (To measure this outcome, questions may be of the type- define, identify, state, match, list, name etc.)
2. Understand basic concepts. (To measure this outcome, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.)
3. Analyze the problem and apply the appropriate concept. (To measure this outcome, questions will be based on applications of core concepts)
4. Give reasoning. (To measure this outcome, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.)

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5. Apply core concepts to new situations. (To measure this outcome, some questions will be based on self-study topics and also comprehension of unseen passages.)

Unit I: Functions of several variables, level curves and level surfaces, partial and directional derivatives, differentiability, chain rule, local extreme values and saddle points. **[06 Hrs]**

Unit II: Double integrals in Cartesian and polar co-ordinates, iterated integrals, change of variables, triple integrals in Cartesian, spherical and cylindrical co-ordinates. **[11 Hrs]**

Unit III: Vector differentiation, gradient, divergence and curl, line and surface integrals, path independence, statements and illustrations of theorems of Green, Stokes and Gauss. **[10 Hrs]**

Unit IV: Review of first order differential equations, linear differential equations, homogeneous higher order linear differential equations, non-homogeneous higher order linear differential equations with constant coefficients (method of undetermined coefficients and method of variation of parameters). **[09 Hrs]**

Unit V: Laplace Transforms, its properties, Unit step function, Dirac delta functions, Convolution Theorem, periodic functions, solving differential equations using Laplace transform. **[07 Hrs]**

Unit VI: Partial differential equations with separation of variables, boundary value problems: vibrations of a string, one dimensional heat equation. **[07 Hrs]**

Text Books:

- Maurice D. Weir, Joel Hass, Frank R. Giordano, "Thomas' Calculus", Pearson Education, 12th Edition.
- Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley eastern Ltd., 10th Edition.

Reference Books:

- K.D. Joshi, "Calculus for Scientists and Engineers", CRC Press.
- Sudhir Ghorpade and Balmohan Limaye, "A Course in Multivariate Calculus and Analysis", Springer Science and Business Media.
- George Simmons, "Differential Equations with Applications and Historical notes", Tata Mc-Graw Hill publishing company Ltd, New Delhi.
- Wendell Fleming, "Functions of several variables", Springer-Verlag, New York.
- Fritz John, ""Partial Differential Equations (4th edition), Springer.
- C.R. Wylie, "Advanced Engineering Mathematics" , McGraw Hill Publications, New Delhi.
- Peter V. O' Neil, "Advanced Engineering Mathematics", Thomson Brooks / Cole, Singapore, 7th edition.
- Michael D. Greenberg, "Advanced Engineering Mathematics (2nd edition)", Pearson Education.

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