Jharkhand University of Technology, Ranchi
NEP-2020 based Syllabus w.e.f – 2025-26 Batch
B.Tech in Mechanical Engineering

Semester-Vth

S.No.	Course Code	Course Title	L	T	P	J	Cr	FM	Overall Pass Marks	Internal	External	Categorization
			Contact Hours per week									
		PROGRAMME CORE COURSES (PCC)										
01	MECC501	PCC-I (Advanced Mechanics of Solid)	3	1	0		4	100	35	30	70	
02	MECC502	PCC-II (Applied Thermodynamics)	3	1	0		4	100	35	30	70	
		***PROGRAMME ELECTIVES I & II**										
03	MECPEI501, MECPEI502, MECPEI503, MECPEI504, MECPEI505, MECPEI506 MECPEI507 MECPEI508 MECPEI509 MECPEI510	PE-I (Any one from the given basket of PE-I)	3	0	0		3	100	35	30	70	
04	MECPEII501, MECPEII502, MECPEII503, MECPEII504, MECPEII505, MECPEII506, MECPEII507 MECPEII508	PE-II (any one from the given basket of PE-II)	3	0	0	6	3	100	35	30	70	
05	COM501	Entrepreneurship Management	2	1	0		3	100	35	30	70	
Total			**14**	**3**			**17**	**500**	**--**	**--**	**--**	

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Practical			L	T	P		Cr	FM	Overall Pass Marks	Internal	External	Categorization
06	COMP501	Seminar & Report Writing –I (UN Sustainable Development Goals)	0	0	3		1	50	25	30	20	
07	COMP502	Business Communications	0	1	2		2	50	25	30	20	
08	MECP501	**Lab-I** (Solid Mechanics Laboratory)	0	0	3		1	50	25	30	20	
09	MECP502	**Lab-II** (Applied Thermodynamics Laboratory)	0	0	3		1	50	25	30	20	
Total			**0**	**1**	**11**		**5**	**200**	**--**	**--**	**--**	
Audit Course			**L**	**T**	**P**		**Cr**	**FM**	**Overall Pass Marks**	**Internal**	**External**	**Categorization**
10	AUC501, AUC502, AUC503, AUC504	**REGIONAL LANGUAGE (ANY ONE THROUGH NPTEL / SWAYAM)** 1. MARATHI 2. KANNAD 3. TAMIL 4. TELUGU						100	35	30	70	
							Students will complete this Audit Paper of 12 weeks duration from NPTEL/SWAYAM. It is mandatory to pass this paper in order to pass this semester. Students may register on NPTEL/SWAYAM at any time from 1st to 5th semester also but the passing marks and credits will be reflected only in the 5th semester. The passing marks and certificate shall be forwarded by the institute to Controller of Examination (CoE), JUT, Ranchi timely.				
11	AUC505	Sports/NCC/NSS/YOGA/Painting/Music/ Classical Dance	6					50	25	30	20	
							Students shall participate actively in one of the activities and for Passing of the semester "Participation Certificate" in activity will be mandatory student participation shall be monitored and participation record shall be maintained at institute level. The marks obtained shall be forwarded to controller of Examination (CoE), JUT, Ranchi timely.					
Total			**6**				**-**	**150**				
Grand Total			**14**	**4**	**11**		**22**	**850**				

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Professional Elective-I

S. No.	Course Code	Subject
01	MECPEI501	Convective Heat Transfer
02	MECPEI502	Tool Design
03	MECPEI503	Industrial Robotics- A
04	MECPEI504	IC Engines and Emissions
05	MECPEI505	Renewable Energy Sources
06	MECPEI506	Computational Fluid Dynamics
07	MECPEI507	Alternative Refrigerants
08	MECPEI508	Mechanical Measurements
09	MECPEI509	Automobile Engineering
10	MECPEI510	Geometric Modelling for CAD

Professional Elective-II

S. No.	Course Code	Subject
01	MECPEII501	Vehicle Dynamics
02	MECPEII502	Mechanics of Composite Materials
03	MECPEII503	Quality Control & Reliability
04	MECPEII504	Computer Aided Design and Drafting
05	MECPEII505	Cryogenic Engineering
06	MECPEII506	Power Plant Engineering
07	MECPEII507	Fundamentals of Mechanobiology
08	MECPEII508	Mechatronics
09	MECPEII509	Industrial Robotics-B

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Abbreviations: - AU-Audit Course; L: Lecture, T: Tutorial, P: Practice.
J-Self learning hours shall not be reflected in the Time table. Self-learning includes micro projects/assignments/other activities as mentioned in earlier semesters.
***Passing in the Audit Course shall be mandatory.**
Note:- Students may choose their two Professional Electives (PE-1 & PE-II) from NPTEL/SWAYAM also on the approval of departmental academic council if that subject is not mentioned in the above basket.
Students will complete the Elective Papers (Professional) of 12 weeks duration from NPTEL/SWAYAM. Student may register on NPTEL/SWAYAM at any time from 1st to 5th semester also but the passing marks and credits will be reflected only in the 5th semester.
The secured percentage of marks and passing certificate of the subject shall be forwarded by the institute to Controller of Examination (CoE), JUT, Ranchi timely.
The institute will inform University Examination Session about selection of PE-1 and PE-2 subjects by the students also before 1" mid-semester examination of that semester.

Jharkhand University of Technology Ranchi, 834010

SCHEME OF INSTRUCTION AND SYLLABUS

For B.Tech. Program in Mechanical Engineering

(Effective from)

DEPARTMENT OF MECHANICAL ENGINEERING

B.Tech in Mechanical Engineering Semester- Vth

ADVANCED MECHANICS OF SOLIDS

Course code: MECC501 **L:3 T:1 P:0**

Rationale:

Course Outcomes:

After successful completion of the course, Students will be able to:

CO:1	Understand fundamentals of stress and strain at a point; Invariants and Traction vectors
CO:2	Apply principles of elasticity theory to estimate stresses and strains in isotropic materials using tensorial approach
CO:3	Formulate and solve boundary value problems in solid continua using stress and displacement-based solution Strategies
CO:4	Formulate and solve planar problems using Airy stress function in rectangular and polar co-ordinates
CO:5	Understand theories of failure, yielding and strain hardening rules of plastic flow

Course Contents

UNIT 1

Analysis of Stress: State of stress at a point; stress tensor; Geometrical representation of stress at a point; Traction vector and its components on a plane; Normal and shear stress components on a plane; Stress transformations; Principal stresses and principal planes; Invariants of a stress tensor; Octahedral stress; Decomposition of a stress tensor to hydrostatic and deviatoric components; Equations of equilibrium.**(8hrs)**

UNIT 2

Analysis of Strain: State of strain at a point; Principal strains; Strain-displacement relations for finite and infinitesimal strains; Strain compatibility conditions; Strain rosettes. **(8hrs)**

UNIT 3

Constitutive Equations: General theory; generalized Hooke's law for isotropic and anisotropic material; Material symmetry: Monoclinic materials, orthotropic materials, transversely isotropic materials, isotropic materials; Common equations of elasticity theory like Beltrami -Michell and Navier equations.**(10hrs)**

UNIT 4

Principle of Virtual work; Strain energy and Castigliano's theorem**;** Solution of Some Special Boundary Value Problems: Simplifications; Stress function; Airy's stress function in rectangular and polar coordinates; two-dimensional problems in Cartesian and polar coordinates; Axisymmetric problems. **(10hrs)**

UNIT 5

Principle of superposition; Torsion of bars; Membrane analogy; Criterion of yielding; Tresca and VonMises criterion of yielding; Yield surface; Representation of failure theories in stress space**(6hrs)**

Textbooks:

1. Timoshenko S. P. and Goodier J. N. - 'Theory of Elasticity'- McGraw Hill International Editions, 1970 - 3rd Edition
2. L. S. Srinath - 'Advance Mechanics of Solids' - McGraw Hill Education - 2009 - 3rd Edition

Reference Books:

1. M. H. Sadd, Elasticity: theory, applications, and numeric, 3rd edition, Academic Press, 2014.

2. R. G. Budynas, Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill, 1999

APPLIED THERMODYNAMICS

Course code: MECC502 **L:3 T:1 P:0**

Rationale:

Course Outcomes:

COUSE CONTENT

UNIT I

Steam Power Plant – Reheat, regenerative steam power cycles, low temperature power cycles, ideal working fluid and binary/multi-fluid cycles; Types of boilers and their attachments, Steam Turbine types and analysis using velocity triangles.

UNIT II

Properties of moist air: psychrometry and psychrometric charts, condensers and cooling towers;

UNIT III

IC Engines – SI, CI, two- and four-stroke engines, MEP, efficiency and specific fuel consumption, conventional and alternative fuels, pressure-crank angle diagram, carburetor and fuel injection systems;

UNIT IV

Gas Turbine Engines – Types of gas turbine engines, reheat, intercooling and regenerative cycles, combined cycles, introduction to jet propulsion;

UNIT V

Compressors and Turbines – Reciprocating air compressors: work transfer, volumetric efficiency, isothermal efficiency, multistage compression with intercooling, centrifugal compressor, axial flow compressors, axial flow turbines.

Texts:

1) G. F. C Rogers and Y. R. Mayhew, Engineering Thermodynamics Work and Heat Transfer, Pearson, 2003.
2) T. D. Eastop and A. McConkey, Applied Thermodynamics for Engineering Technologists, Pearson, 2003.

References:

1) M. M. El-Wakil, Power Plant Technology, McGraw Hill International, 1992.
2) P. K. Nag, Powerplant Engineering, Tata McGraw Hill, 2002.
3) W. W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, PHI, 2002.
4) H. I. H Saravanamuttoo, G. F. C. Rogers and H. Cohen, Gas Turbine Theory, Pearson, 2003

Solid Mechanics Laboratory

Course code: MECP501 **L:0 T:0 P:3**

List of Experiments conducted in this laboratory:

1. To determine 0.02% proof stress of Cast iron sample by Lindley's four-point method.
2. To determine the value of Young's Modulus (E) and Poisson's ratio (ν) for Brass/Aluminum using a Hounsfield Tensometer.
3. To perform the Ductility and Fatigue test of given materials.
4. To study the phenomena of Creep in a loaded specimen.
5. To study stress analysis by photo elasticity.
6. To perform the strain measurement using strain gauges under different loading conditions.

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Applied Thermodynamics Laboratory

Course code: MECP502 **L:0 T:0 P:3**

List of Experiments:

(1) To Study of Steam Power plant and its components.

(2) To study of different compounding methods, steam power cycle.

(3) To study of Two stroke and Four stroke Petrol Engine

(4) To study of Gas power cycle.

(5) Energy Auditing and performance Study on Diesel engine.

(6) Performance Study and exhaust analysis of Diesel engine with variable load.

(7) To study of performance improvement on Petrol engine & Diesel engine

(8) To study of two stage reciprocating air compressors.

Professional Elective-I

Convective Heat Transfer

Course code: MECPEI501 **L:3 T:0 P:0**

Rationale:

- To familiarize governing equations of fluid flow and heat transfer.
- To exploit order of magnitude analysis to simplify complex mathematical equations using physical understanding of problems.
- To deeply analyze forced convection heat transfer in external and internal flows
- To study the boundary layer development with free convection phenomenon
- To understand the basics of heat transfer occurring with change of phase.

Course Outcomes:

CO1	To comprehend the governing equations involved in fluid flow and heat transfer problems.
CO2	To simplify complex mathematical equations using order of magnitude analysis.
CO3	To analyze forced and free convective heat transfer problems.
CO4	To understand the effect of different parameters on the heat transfer characteristics.
CO5	To conceptualize the similarity solution method for heat transfer analysis and study phase change effects

Course Content

UNIT I

Introduction: Convection definition and review of fluid mechanics. Derivation of governing equations of mass conservation, momentum balance and energy conservation. Order of magnitude analysis, Reynolds analogy.

UNIT II

Forced Convective Heat Transfer in External Flows: Derivation of hydrodynamic and thermal boundary layer equations, Similarity solution techniques, Momentum and energy integral methods and their applications in flow over flat plates with low and high Prandtl number approximations. Introduction to turbulence, Reynolds averaging, Eddy viscosity and eddy thermal diffusivity, Laws of the wall.

UNIT III

Forced Convective Heat Transfer in Internal Flows: Concept of developing and fully developed flows. Thermally developing flows: Graetz problem. Concept of thermally fully developed flow and its consequences under constant wall flux and constant wall temperature conditions. Steady forced convection in Hagen Poiseuille flow, Plane Poiseuille flow, and Couette flow and analytical evaluation of Nusselt numbers in limiting cases.

UNIT IV

Free Convective Heat Transfer: Free convection boundary layer equations: order of magnitude analysis, similarity, and series solutions. Concept of thermal stability and Rayleigh-Benard convection.

UNIT V

Convection with Phase Change: Concept of boiling heat transfer and regimes in pool boiling Condensation: Nusselt film condensation theory, dropwise condensation and condensation inside tubes, effects of non-condensable Deviations from continuum: wall slip and thermal creep.

References

1. A Bejan, Convection heat transfer. John wiley& sons, 2013.
2. L G Leal, Advanced transport phenomena: fluid mechanics and convective transport processes. Vol. 7. Cambridge University Press, 2007.
3. S K Som, Introduction to heat transfer. PHI Learning Pvt. Ltd., 2008.
4. F M White, Viscous fluid flow. Vol. 3. New York: McGraw-Hill, 2006.
5. T L Bergman, S L Adrienne, F P Incropera and D P DeWitt, Introduction to heat transfer. John Wiley & Sons, 2011.

Tool Design

Course code: MECPEI502 **L:3 T:0 P:0**

Rationale:

Course Outcomes:

CO1	Design Locating and Clamping systems for the given component based on geometrical and dimensional features.
CO2	Design progressive, compound or combination dies for producing a given component.
CO3	Design single point and multipoint cutting tools for conventional and CNC Machining.
CO4	Design jigs and fixtures for conventional and NC machining.
CO5	Design Locating and Clamping systems for the given component based on geometrical and dimensional features.

Course Content

UNIT I

Introduction: Tool design – An overview, Introduction to Jigs and fixtures.

Work holding devices: Basic principle of six-point location, Locating methods and devices, Principle of clamping and Types of clamps.

UNIT II

Design of jigs: Type of Drill bushes, Classification of drill jigs, Design of drill jigs.

Design of fixtures: Design of milling fixtures, Design of turning fixtures.

UNIT III

Introduction of press tool design: Introduction to Die cutting operations, Introduction to press and classifications, Die set assembly with components, Introduction to Centre of pressure, Examples of center of pressure, Design of piercing die, Design of blanking die, Progressive, Compound and Combination dies.

UNIT IV

Design of cutting tools: Introduction to cutting tools, Design of single point tool, Design of drill bit, Design of milling cutter.

UNIT V

Brief introduction of NC machines work holding devices: Tool design for NC machines- An introduction, Fixture design for NC Machine, cutting tools for NC Machine, Tool holding methods for NC Machine, ATC and APC for NC Machine, Tool presetting for NC Machine.

Text Books:

1. F. W. Wilson, Fundamentals of Tool Design, ASME, PHI, 2010
2. Donaldson C, G. H. Lecain and V. C. Goold, Tool Design, TMH, 2010

Reference Books:

1. Prakash Joshi, Jigs and Fixtures Design Manual, McGraw-Hill, 2002, 2nd Edition
2. K. Venkataraman, Design of Jigs, Fixtures and Press Tools, Wiley Athena Academic, 2015, 1st Edition

Industrial Robotics-A

Course code: MECPEI503 **L:3 T:0 P:0**

Rationale:

- To familiarize robot structures and their workspace and distinguish between different sensors and drives.
- To develop skills in performing spatial transformations and kinematic analysis of robot manipulator.
- To develop knowledge in the Industrial applications of robots using image processing concepts.

Course Outcomes:

CO1	Identify the components of a robot and distinguish the types of robot configurations
CO2	Compare, evaluate and choose sensors/drives for robots
CO3	Construct a kinematic model of a given manipulator and evaluate whether the inverse kinematic model is solvable
CO4	Choose and apply appropriate image processing techniques for object recognition in robotic systems
CO5	Familiarize with robot cell design and robot programming
CO6	Design and develop a robotic system for a given industrial application

Course Content

Unit I

Evolution of robotics. Robot anatomy- Co-ordinate Systems, Work envelope, types and classification – Specifications – Pitch, Yaw, Roll, Joint Notations, Speed of Motion: Accuracy, Resolution, Repeataility. Pay Load – Basic robot motions - Point to point control, Continuous path control. Robot Parts and Their Functions – Need for Robots Different Applications.

Unit II

Robot drive systems: Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors – Salient Features, Applications. Harmonic drives. End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

Unit III

Coordinate frames. Mapping: Mapping between rotated frames - Mapping between translated framesMapping between rotated and translated frames-Description of objects in space-Transformation of vectors – Rotation translation combined with rotation-translation of

vectors-composite transformation - Inverting a homogenous transform- Fundamental rotational matrices.

Unit IV

Direct Kinematic Model – Mechanical structure and notations-Description of links and joints Kinematic modeling of manipulator-Denavit-Hartenberg Notation-Kinematic Relationship between adjacent links-Manipulator Transformation Matrix. Inverse Kinematic Model – Manipulator Workspace-Solvability-Solution techniques-Closed form solution.

Unit V

Imaging components-image representation-picture coding-object recognition and categorization visual inspection. Robot cell-design and control layouts. Robot programming Languages –VAL Programming – Motion Commands, Sensor Commands, End effecter commands, and Simple programs. Industrial Applications – Material Handling, Process, Assembly, Inspection. Non-Industrial Applications.

Textbooks:

1. Fu, K.S., Gonzalez, R.C. and Lee C.S.G. – 'Robotics: Control, Sensing, Vision, and Intelligence' – McGraw Hill, New York, NY – 1987

Reference Books:

1. R K Mittal and I J Nagrath, 'Robotics and Control', Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
2. J Craig, 'Introduction to Robotics: Mechanics and Control', Addison-Wesley, Reading, MA, 1989 (second edition).

IC Engines and Emission

Course code: MECPEI504 **L:3 T:0 P:0**

Rationale:

- To familiarize about actual cycle for SI and CI engines.
- To familiarize normal and abnormal combustion in SI and CI engines and interpret its effect on engine performance.
- To introduce the fuel supply system in SI and CI engines and to appraise the need for various alternate fuels.
- To familiarize about ignition, lubricating and cooling systems and its merit and demerits for engines.
- To familiarize about performance testing of the engine and appraise the methods to reduce emissions.

Course Outcomes:

CO1	Understand and analyse about actual cycle
CO2	Understand and analyse the combustion phenomenon of internal combustion engines
CO3	Understand various fuel-metering systems in SI and CI engines system and latest technology in fuel injection systems in SI and CI engines
CO4	Understand and analyse about various ignition systems and cooling system in IC Engines
CO5	Understand emission control techniques in engines, based on emission standards/norms and to recommend modification in engine for using alternate fuels

Course Content:

UNIT 1 Review of ideal cycles; Actual cycle, valve timing diagrams for two - stroke and four -stroke SI and CI engines, Details of fuel-air cycles, Effect of air-fuel ratio. **[08 Hrs]**

UNIT 2 Combustion in SI and CI engines, combustion stages, combustion chamber and abnormal combustion. Hybrid engines. **[08 Hrs]**

UNIT 3 Fuel supply systems in SI and CI engines, Alternate fuels. **[06 Hrs]**

UNIT 4 Ignition system, lubrication systems, cooling Systems and Supercharging.

[06 Hrs]

UNIT 5 Testing of IC Engines, Emission standards, Emission control devices.Additives for enhancing performance and pollution control.

[08 Hrs]

Textbook: Heywood, J. B., 'Internal Combustion Engine Fundamentals', McGraw-Hill, First Indian edition, 2017. BS VI emission norms (ARAI)

Reference: Ferguson, C.R, 'Internal Combustion Engines', John Wiley, 1989.
Degobert, P., 'Automobiles and Air Pollution', SAE, 2002
B. P. Pundir, 'IC Engines Combustion and Emissions', Narosa Publishing House, 2010

Renewable Energy Sources

Course code: MECPEI505 **L:3 T:0 P:0**

Rationale:

- To learn the present energy scenario and the need for energy conservation
- To understand the monitoring / targeting aspects of Energy
- To study the different measures for energy conservation of various thermal energy systems
- To learn economic analysis and project planning on energy conservation
- To understand the energy conservation principle with electrical equipment

Course Outcomes:

CO1	To estimate solar radiation and formulate heat transfer equations and analyze of modern energy conversion technologies
CO2	To describe various renewable energy resources and techniques to utilize them effectively.
CO3	Compute wind energy potential and predict the performance of wind turbines
CO4	Describe and analyze photovoltaic systems
CO5	Distinguish the various form of energies such as magneto hydrodynamic, thermionic and fuel cell.

Course Content

UNIT I

Renewable Energy Resources

Environmental consequences of fossil fuel use, Importance of renewable sources of energy. Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources

UNIT II

Wind Energy

Power in the Wind-Types of Wind Power Plants(WPPs)-Components of WPPs-Working of WPPs Siting of WPPs-Grid integration issues of WPPS

UNIT III

Solar Pv And Thermal Systems

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver

Power Plants, Solar Ponds. Thermal Energy storage system with PCM- Solar Photovoltaic systems: Basic Principle of SPV conversion Types of PV Systems- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array, PV Module IV Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking Applications.

UNIT IV

Biomass Energy

Introduction-Bio mass resources Energy from Bio mass: conversion processes-Biomass Cogeneration-Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydro power: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system.

UNIT V

Other Energy Sources

Tidal Energy Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)- Hydrogen Production and Storage-Fuel cell Principle of working- various types-construction and applications. Energy Storage System Hybrid Energy Systems.

Text Books:

1. Joshua Eamest, Tore Wizeliu, Wind Power Plants and Project Development, PHI LeamingPvt.Ltd, New Delhi, 2011.
2. D.P.Kothari, K.C Singal, Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", PHI Learning Pvt. Ltd, New Delhi, 2013.
3. Scott Grinnell, "Renewable Energy & Sustainable Design", CENGAGE Learning, USA, 2016.

References

4. A.K.Mukerjee and Nivedita Thakur, Photovoltaic Systems: Analysis and Design", PHI Learning Private Limited, New Delhi, 2011
5. Richard A. Dunlap, Sustainable Energy Cengage Learning India Private Limited, Delhi, 2015.
6. Chetan Singh Solanki, Solar Photovoltaics Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2011
7. Bradley A. Striebig, Adebayo A.Ogundipe and Maria Papadakis, Engineering Applications in Sustainable Design and Development, Cengage Learning India Private Limited, Delhi, 2016.
8. Godfrey Boyle, Renewable energy", Open University, Oxford University Press in association with the Open University, 2004.

9. ShobhNath Singh, "Non-conventional Energy resources Pearson Education 2015.

Computational Fluid Dynamics

Course code: MECPEI506 **L:3 T:0 P:0**

Rationale:

- To study the basic governing equations and understand the basic properties of CFD.
- To understand discretization techniques and solving methods for improving accuracy.
- To inculcate the knowledge required to solve real-time physical problems using simulation software.

Course Outcomes:

CO1	Understand the classification of PDEs, and governing equations.
CO2	Understand the basic principles of computational methods.
CO3	Apply finite volume method to solve steady and unsteady diffusion, advection-diffusion problems.
CO4	Select Solution algorithms and various discretization schemes.
CO5	Solve engineering problems using CFD software.

Course Content

Unit I

Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations,

Classification of Partial Differential Equations and Physical Behavior, Approximate Solutions of Differential Equations: Error Minimization Principles.

Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method, Consistency, Stability, and Convergence. 1-D Steady State Diffusion Problems- Source term linearization, Implementation of boundary conditions.

Unit II

1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme. Finite volume discretization of convection-diffusion problem. Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem. The concept of false diffusion, QUICK scheme, TVD schemes and flux limiter functions.

Unit III

Finite Volume Discretization of 2-D unsteady State Diffusion type Problems, Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods

Unit IV

Discretization of Navier Stokes Equations, primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation.

Unit V

Introduction to Turbulence Modeling, Important features of turbulent flow, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling and applications.

Textbooks:

1. Versteeg, H.K., and Malalasekara, W, "An Introduction to Computational Fluid Dynamics", The Finite Volume Method, 2007.
2. Moukalled, F., Mangani, L., &Darwish, M. "The finite volume method in computational fluid dynamics. An Advanced Introduction with OpenFOAM and Matlab", 2016

Reference Books:

1. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 1980.
2. Anderson, J. D., & Wendt, J., "Computational fluid dynamics" (Vol. 206). New York: McGraw-Hill, 1995.

Mechanical Measurements

Course code: MECPEI508 **L:3 T:0 P:0**

Rationale:

Course Outcomes:

CO1	Understand the measurement terminologies and the concept of a generalized measurement system.
CO2	Estimate errors and uncertainty in measurements using statistical analysis.
CO3	Analyze the zeroth, first and second order measurement systems.
CO4	Select sensors for measurement of specific parameters with required accuracy.
CO5	Calibrate measuring instruments with given standards.
CO6	Design experiments by combining measuring devices to obtain desired outputs.

Course Content

UNIT I

Basics of Measurements: Introduction, Generalized measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction, Dynamic response – zeroth, first and second order measuring systems.

Presentation of experimental data: Errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis.

UNIT II

Pressure measurement: Different pressure measurement instruments and their comparison, Transient response of pressure transducers **Thermometry:** Overview of thermometry, Thermo-electric temperature measurement, Resistance thermometry, Pyrometer, Other methods, issues in measurements.

Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, Other methods.

Thermal and transport property measurement: Measurement of thermal conductivity, diffusivity, viscosity, humidity and gas composition.

UNIT III

Nuclear, thermal radiation measurement: Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc.

Other measurements: Basics in measurement of torque, force, strain

UNIT IV

Advanced topics: Issues in measuring thermos-physical properties of micro and Nano fluidics

UNIT V

Design of Experiments: Basic ideas of designing experiments, Experimental design protocols with some examples.

Text Books:

1. Thomas G Beckwith, Mechanical Measurements, Pearson publications, 2006, 6th Edition
2. Ernest O Doebelin, Measurement systems, Tata McGraw Hill publications, 2019, 7th Edition
3. J P Holman, Experimental Methods for Engineers, Tata McGraw Hill publications, 2011, 7th Edition

Reference Books:

1. John R. Taylor, An Introduction to Error Analysis,University Science Books, 1997, 2nd Edition
2. S P Venkateshan, Mechanical Measurements, Ane Books Pvt. Ltd., 2015, 2nd Edition.

Other Suggested Readings:

1. Mechanical Measurements and Metrology by Prof. S P Venkateshan (IIT Madras), NPTEL Course (Link: https://nptel.ac.in/courses/112/106/112106138/).
2. Principles of Mechanical Measurement by Prof. Dipankar N Basu (IIT Guwahati), NPTEL Course (Link: https://nptel.ac.in/courses/112/103/112103261/).

Professional Elective-II

Vehicle Dynamics

Course code: MECPEII501 **L:3 T:0 P:0**

Rationale:

- To study the vibration of SDOF and MDOF vibrational systems.
- To understand various numerical techniques used to evaluate the natural frequencies and mode shapes of MDOF systems.
- To impart the knowledge of vehicle load distribution while acceleration, deceleration, and braking.
- To study the mechanical properties of tires and their rolling resistance.
- To understand the lateral and vertical dynamics of vehicle.

Course Outcomes:

CO1	To illustrate the fundamentals of vibration and formulate the differential equations of the given vibration models.
CO2	To evaluate the natural frequencies and mode shapes of MDOF systems by appropriate numerical techniques.
CO3	Analyze road vehicles for their longitudinal dynamic response during acceleration and braking.
CO4	To design tires which provide proper rolling resistance and contact pressure distribution.
CO5	To evaluate road vehicles for their lateral and vertical dynamic response while cornering and moving on a rough patch of the road.

Course Content

UNIT 1

Fundamentals of Vibration: Review of free, forced, and damped vibrations of Single Degree of Freedom Systems (SDOF). Multi Degree of Freedom Systems: Close-coupled system, Eigen valve problems, Far-coupled systems, Orthogonality of mode shapes, Modal analysis, Forced vibration by matrix inversion.

UNIT II

Numerical Methods: Approximate methods for fundamental frequency – Dunkerley's lower bound method, Rayleigh's upper bound method, Holzer method for close-coupled systems.

UNIT III

Longitudinal Dynamics: Vehicle load distribution – Acceleration and Braking, Brake force distribution, Braking efficiency and braking distance, Passenger car and Tractor-semi trailer models.

UNIT IV

Tire Mechanics: Mechanical properties of rubber – Slip, grip and rolling resistance, Tire construction and force development, contact patch and contact pressure distribution, Tire Brush Model, Lateral force generation – ply steer, conicity, and camber, Magic Formula Tire Models, Combined Slip.

UNIT V

Lateral dynamics: Bicycle Model, Stability and steering conditions, Understeer gradient, Handling response of a vehicle, Parameters affecting vehicle handling characteristics, Rollover prevention. **Vertical Dynamics:** Full car model, Half car model, Quarter car model.

References

1.Thomson, W.T., 2010. Theory of Vibration and its Applications, 5th Edition, Pearson Eduation, New Delhi.

2.Rao, J.S., 1999. Introductory Course on Theory and Practice of Mechanical Vibrations. New Age International.

3.Gillespie, T., 1992. Fundamentals of Vehicle Dynamics. SAE international.

4.Pacejka, H., 2006. Tire and Vehicle Dynamics. Elsevier.

5.Wong, J.Y., 2008. Theory of Ground Vehicles. John Wiley & Sons.

6.Karnopp, D., 2004. Vehicle Stability. CRC Press.

Mechanics of Composite Materials

Course code: MECPEII502 **L:3 T:0 P:0**

Rationale:

Course Outcomes:

CO1	Understand the industrial need for composite materials.
CO2	Identify suitable processes to develop fiber reinforced composite materials.
CO3	Apply the micro and macro mechanics for fiber reinforced composite materials.
CO4	Develop governing equation for Bending, Buckling, and Vibration of Laminated plates.
CO5	Design the composite structures with the help of computers.

Course Content

UNIT I

Introduction to composite materials: Introduction, What is a composite material, Current and potential advantages of fibre reinforced composites, Applications of composite materials, Military, civil, space, automotive and commercial applications

UNIT II

Macro and micro mechanical behaviour of a lamina: Stress strain relations for anisotropic materials, Restrictions on engineering constants, Strengths of an orthotropic lamina, biaxial strength criteria for orthotropic lamina

UNIT III

Micro mechanical behaviour of lamina and laminates: Mechanical of material approach to stiffness, Elasticity approach to stiffness, Classification lamination theory, Special cases, strength of laminates

UNIT IV

Bending, Buckling and Vibration of laminated plates: Governing equations for bending buckling and vibration of laminated plates, Deflection of simply supported laminated plates, Vibration of simply supported laminated plates

UNIT V

Design of composite structures: Introduction, design philosophy, Anisotropic analysis, Bending extension coupling, Micromechanics, Nonlinear behaviour, Inter-laminar stresses, transverse shearing, Laminate optimization

Text Books:

1. Ronald F. Gibson, Principles of composite material mechanics, CRC Press, 2011.
2. Robert M Jones, Mechanics of Composite Materials, Taylor & Francis, 2000.

Reference Books:

1. Lawrence E. Nielsen, Nielson, Paul Nielsen, Mechanical Properties of Polymers and Composites, Second Edition, CRC press, 2000

Quality Control and Reliability Engineering

Course code: MECPEII503 **L:3 T:0 P:0**

Rationale:

- To introduce the principles and techniques of statistical quality control and their applications
- To familiarize with basic concepts and techniques of reliability engineering

Course Outcomes:

CO1	Apply the knowledge of statistics and probability to attain the quality improvement in industries
CO2	Analyze the product quality using statistical tools
CO3	Determine the reliability and maintainability of systems

Course content

UNIT I

Basic concepts in Quality Engineering and Management: definitions, approaches and relevance to organizational excellence. Product quality control: Acceptance sampling methods- single, multiple and sequential sampling plans; Recent developments in inspection methods.

UNIT II

Statistical Process Control: Process evaluation and control by control charts: Various control charts including CUSUM charts and multivariate charts. Process capability studies: Various indices and approaches; use of Nomographs; Discussions on capabilities of Process, Machine and Gauge; Unit yields and rolled throughput yield.

UNIT III

Total Quality Management perspective, methodologies and procedures; Roadmap to TQM, ISO 9000, KAIZEN, Quality Circles, Models for organizational excellence.

UNIT IV

Quality Function Deployment, Quality cost systems and Quality Policy Deployment Process evaluation and control by designs of experiment: Various basic designs; Special methods such as EVOP and ROBUST design (Taguchi Methods).

UNIT V

Six Sigma Management: Concepts, Steps and Tools ; Benchmarking and Balanced Score Cards Reliability engineering; statistical analysis of life time data and determination of reliability, availability and maintainability; TPM; FMECA, Fault Tree Analysis Quality and reliability perspectives of JIT. Application of Software tools and Case Studies.

References

1) A.J.Duncan, Quality Control and Industrial Statistics, Richard Darwin Inc., USA.1965
2) A.V.Feigenbaum, Total Quality Control, McGraw Hill International Editions, USA.1987
3) D.C.Montgomery, Design and Analysis of Experiments, John Wiley and Sons, USA.1984
4) J.M.Juran, Juran on Quality Control by Design, The Free Press.1992.
5) W.E.Deming, Out of Crisis: Quality, Productivity and Competitive Position, Productivity and Quality Publishing Private Limited, Madras.1992
6) A.Mitra, Fundamentals of Quality Control and Improvement, Pearson Education, 2nd ed. 2005.
7) J.R.Evans and W.M.Lindsay, The Management and Control of Quality, Thomson.2005.
8) H.M.Wadsworth, K.S.Stephens and A.B.Godfrey, Modern Methods for Quality Control and Improvement, John Wiley & Sons.2004.

Cryogenic Engineering

Course code: MECPEII505 **L:3 T:0 P:0**

Rationale: On successful completion of this course the student will be able to understand Concepts of cryogenic, cryogenic refrigeration and handling of the cryogens.

Course Outcomes:

After successful completion of the course, Students will be able to:

CO1	To give introductory knowledge of cryogenic Engineering
CO2	To impart knowledge in liquefaction, separation of cryogenics gases and working of cryocoolers.
CO3	To embark on a research career in Cryogenic Engineering

Course of Contents:

UNIT I INTRODUCTION

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics in Space Programs, Superconductivity, Cryo Metallurgy, Medical applications.

UNIT II LIQUEFACTION CYCLES

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve – Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Ortho-Para hydrogen conversion, Eollins cycle, Simpson cycle, Critical Components in Liquefaction Systems.

UNIT III SEPARATION OF CRYOGENEIC GASES

Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis – McCabe Thiele Method. Adsorption Systems for purification.

UNIT IV CRYOGENIC REFRIGERATORS

J. T. Cryocoolers, Stirling Cycle Refrigerators, G.M Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Dilution refrigerators, Magnetic Refrigerators.

UNIT V HANDLING OF CRYOGENS

Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature.

REFERENCES

1. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering ,Plenum Press ,New York, 1989.
2. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
3. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962.
4. Herald Weinstock, Cryogenic Technology, Boston Technical Publishers, inc., 1969.
5. Robert W. Vance, Cryogenic Technology, John wiley& Sons, Inc., New York, London.
6. G.Venkatarathnam, Cryogenic Mixed Refrigerant Processes, Springer Publication, 2010.
7. J.G. Weisend, Hand Book of Cryogenic Engineering —II, Taylor and Francis, 1998.

Fundamentals of Mechanobiology

Course code: MECPEII507 **L:3 T:0 P:0**

Rationale:

- To provide students with a comprehensive understanding of the basic biomechanical principles and their application in biological systems.
- To equip students with knowledge and skills in mechanics and dynamics as they relate to biological materials and systems at various scales.
- To explore the interplay between mechanical forces and biological responses, focusing on tissue mechanics and cellular behavior.
- To advance students understanding of biomechanics at the molecular and continuum levels, integrating advanced material properties and experimental techniques.

Course Outcomes:

CO1	Students will be able to analyze and solve static and dynamic problems in biomechanics
CO2	Students will demonstrate proficiency in evaluating linear and angular motion
CO3	Students will be adept at describing how mechanical forces influence biological processes at the cellular and tissue
CO4	To advance students understanding of biomechanics at the molecular and continuum levels, integrating advanced material properties and experimental techniques

Course Contents

UNIT 1

Introduction to Biomechanics: Force vectors, Coplanar, collinear and concurrent forces, Moment and torque, Statics: Analysis of systems in equilibrium, and Applications of statistics to Biomechanics.

UNIT 2

Mechanics and Dynamics: Introduction to dynamics, Linear kinematics and kinetics, Angular kinematics and kinetics, Work-energy methods, Stress and strain, Computational biomechanics, Multiaxial Deformations and stress analysis, Stress transformation, Principle stresses, Failure theories, Torsion and Bending.

UNIT 3

Mechanobiology and Tissue Mechanics: Skeletal tissues (bone, articular cartilage, tendons and ligaments) remodeling, Gait analysis, Cellular cytoskeleton, Intracellular signalling, Cell migration, Durotaxis, Mechanotaxis, Chemotaxis and Mechanics of biomembranes.

UNIT 4

Molecular Mechanics and Dynamics, Continuum mechanics, Microstructural models, Constitutive laws, Electromechanical and physicochemical properties of tissues, Viscoelasticity, Models of Viscoelasticity, Fracture and Fatigue, and Experimental measurements of mechanical behaviour Cells and tissues.

Textbooks:

1. NihatOzkaya and Margareta Nordin, Fundamentals of biomechanics: Equilibrium, Motion and deformation, 2nd Edi. Springer
2. Y.C Fung, Biomechanics – Mechanical Properties of Living Tissues, Springer , 1993

References:

1. Roger Bartlett, Introduction to Sports Biomechanics: Analysing Human Movement Patterns, Taylor and Francis , 2007
2. Christopher R. Jacobs, Hayden Huang, Ronald Y. Kwon, Introduction to Cell Mechanics and Mechanobiology, Garland Science

Mechatronics

Course code: MECPEII508 **L:3 T:0 P:0**

Rationale:

Course Outcomes:

CO1	Model and analyze mechatronic systems for an engineering application
CO2	Identify sensors, transducers and actuators for monitoring and controlling the behavior of processes and products.
CO3	Develop PLC programs for an engineering application.
CO4	Evaluate the performance of mechatronic systems.

Course Content

UNIT I

Introduction: Overview of the course, Examination and Evaluation patterns, History of Mechatronics, Scope and Significance of Mechatronics systems, elements of mechatronic systems, needs and benefits of mechatronics in manufacturing.

UNIT II

Sensors & Actuators: Proximity Sensor, force sensors, sensors used in mechatronics systems.
Electrical Actuators: Solenoids, relays, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices – Power supplies, different control valves, cylinder sequencing. Design of Hydraulic & Pneumatic circuits. Piezoelectric actuators, Shape memory alloys actuators.

UNIT III

Basic System Models & Analysis: Modelling of one and two degrees of freedom Mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems.

Dynamic Responses of System: Transfer function, Modelling Dynamic systems, first order systems, second order systems, Time Domain Analysis, Stability analysis using Routh-Hurwitz criteria .

UNIT IV

Digital Electronics: Number systems, BCD codes and arithmetic, Gray codes, self-complimenting codes, Error detection and correction principles. Boolean functions using Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Designof Code converters, Encoders and decoders.

Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders.

Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion.

Controllers: Classification of control systems, Feedback, closed loop and open loop systems, Continuous and discrete processes, control modes, Two step Proportional, Derivative, Integral, PID controllers.

UNIT V

PLC Programming: PLC Principles of operation PLC sizes PLC hardware components I/O section Analog I/O section Analog I/O modules, digital I/O modules CPU Processor memory module Programming. Ladder Programming, ladder diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.

Case studies of Mechatronics systems: Pick and place robot, Bar code, Engine Management system, Washing machine etc.

Industry 4.0 Concepts & Principles: Introduction, AI, Cyber physical System, Cloud computing, machine learning

Text Books:

1. W. Bolton, Mechatronics, Addison Wesley Longman Ltd, 2010, 5thEdition
2. Devdas Shetty & Richard Kolk, Mechatronics System Design, PWS Publishing, 2009, 3rd Edition

Reference Books:

1. Alciatore David G and Histand Michael B, Introduction to Mechatronics and Measurement systems, Tata McGraw Hill, 2012, 4th Edition.
2. Clarence W. de Silva, Mechatronics : A foundation course, CRC Press, 2010.

Industrial Robotics-B

Course code: MECPEII509 **L:3 T:0 P:0**

Rationale:

- To familiarize robot structures and their workspace and distinguish between different sensors and drives.
- To develop skills in performing spatial transformations and kinematic analysis of robot manipulator.
- To develop knowledge in the Industrial applications of robots using image processing concepts.

Course Outcomes:

CO1	Identify the components of a robot and distinguish the types of robot configurations
CO2	Compare, evaluate and choose sensors/drives for robots
CO3	Construct a kinematic model of a given manipulator and evaluate whether the inverse kinematic model is solvable
CO4	Choose and apply appropriate image processing techniques for object recognition in robotic systems
CO5	Familiarize with robot cell design and robot programming
CO6	Design and develop a robotic system for a given industrial application

Course Content

Unit I

Evolution of robotics. Robot anatomy- Co-ordinate Systems, Work envelope, types and classification – Specifications – Pitch, Yaw, Roll, Joint Notations, Speed of Motion: Accuracy, Resolution, Repeataility. Pay Load – Basic robot motions - Point to point control, Continuous path control. Robot Parts and Their Functions – Need for Robots Different Applications.

Unit II

Robot drive systems: Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors – Salient Features, Applications. Harmonic drives. End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

Unit III

Coordinate frames. Mapping: Mapping between rotated frames - Mapping between translated framesMapping between rotated and translated frames-Description of objects in space-Transformation of vectors – Rotation translation combined with rotation-translation of vectors-composite transformation - Inverting a homogenous transform- Fundamental rotational matrices.

Unit IV

Direct Kinematic Model – Mechanical structure and notations-Description of links and jointsKinematic modeling of manipulator-Denavit-Hartenberg Notation-Kinematic Relationship between adjacent links-Manipulator Transformation Matrix. Inverse Kinematic Model – Manipulator Workspace-Solvability-Solution techniques-Closed form solution.

Unit V

Imaging components-image representation-picture coding-object recognition and categorizationvisual inspection. Robot cell-design and control layouts. Robot programming Languages –VAL Programming – Motion Commands, Sensor Commands, End effecter commands, and Simple programs. Industrial Applications – Material Handling, Process, Assembly, Inspection.Non-Industrial Applications.

Textbooks:

1. Fu, K.S., Gonzalez, R.C. and Lee C.S.G. – 'Robotics: Control, Sensing, Vision, and Intelligence' – McGraw Hill, New York, NY – 1987

Reference Books:

3. R K Mittal and I J Nagrath, 'Robotics and Control', Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
4. J Craig, 'Introduction to Robotics: Mechanics and Control', Addison-Wesley, Reading, MA, 1989 (second edition).