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ताळगांव पठार,
गोंय - ४०३ २०६
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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2026-27/200 Date: 08.07.2026

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2024/507 dated 12.09.2024
GU/Acad –PG/BoS -NEP/2025/257 dated 21.07.2025

In continuation to the above referred Circulars, the syllabus for Semester V & VI of the **Bachelor of Engineering in Mechanical Engineering** Programme as approved by the Academic Council in its meeting held on 20th February 2026 is attached.

The Dean, Faculty of Engineering and Principals of affiliated Colleges offering the **Bachelor of Engineering in Mechanical Engineering** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN V LAWANDE Digitally signed by ASHWIN V LAWANDE Date: 2026.07.08 12:29:04 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, Faculty of Engineering, Goa University.
2. The Principals of Affiliated Engineering Colleges.

Copy to:

1. Chairperson, BoS in Mechanical Engineering, Goa University.
2. Controller of Examinations, Goa University.
3. Assistant Registrar Examinations (Technical and Allied), Goa University
4. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

MECHANICAL ENGINEERING SEMESTER V & VI SCHEME AY 2024-25

SEMESTER - V

Sr. No.	Course Category	Course Code	Title of the Course	L	T	P	TCr
1	Major	**MEC-300**	Dynamics of Machines	3	0	0	3
		MEC-301	Dynamics of Machines Lab	0	0	1	1
2	Major	**MEC-302**	Material Science and Metallurgy	3	0	0	3
		MEC-303	Material Science and Metallurgy Lab	0	0	1	1
3	Major	**MEC-304**	Manufacturing Technology - II	3	0	0	3
		MEC-305	Manufacturing Technology - II Lab	0	0	1	1
4	Major	**MEC-306**	Engineering Statistics	2	0	0	2
		MEC-307	Engineering Statistics Lab	0	0	2	2
5	Prof. Elective	**MEC-321**	Composite Materials	3	0	0	3
		MEC-322	Composite Materials Lab	0	0	1	1
		OR					
		MEC-323	Mechatronics	3	0	0	3
		MEC-324	Mechatronics Lab	0	0	1	1
		OR					
		MEC-325	Power Plant Engineering	3	0	0	3
		MEC-326	Power Plant Engineering Lab.	0	0	1	1
			TOTAL	**14**	**0**	**6**	**20**

SEMESTER - VI

Sr. No.	Course Category	Course Code	Title of the Course	L	T	P	TCr
1	Major	**MEC-308**	Heat and Mass Transfer	3	0	0	3
		MEC-309	Heat and Mass Transfer Lab	0	0	1	1
2	Major	**MEC-310**	Machine Design	3	0	0	3
		MEC-311	Machine Design Lab	0	0	1	1
3	Major	**MEC-312**	Digital Manufacturing	2	0	0	2
		MEC-313	Digital Manufacturing Lab	0	0	2	2
4	Major	**MEC-314**	Industrial Engineering and Operations Management	3	0	0	3
		MEC-315	Industrial Engineering and Operations Management Lab	0	0	1	1
5	Prof. Elective	**MEC-327**	Automobile Engineering and Electric Vehicles	3	0	0	3
		MEC-328	Automobile Engineering and Electric Vehicles Lab	0	0	1	1
		OR					
		MEC-329	Mechanical Vibration & Control Systems	3	0	0	3
		MEC-330	Mechanical Vibration & Control Systems Lab	0	0	1	1
		OR					
		MEC-331	Fluid Power Control	3	0	0	3
		MEC-332	Fluid Power Control Lab	0	0	1	1
			TOTAL	**14**	**0**	**6**	**20**

SEMESTER V

Major Courses

Name of the Programme : B.E. Mechanical Engineering
Course Code : MEC-300
Title of the Course : Dynamics of Machines
Number of Credits : 3
Effective from AY : 2024-25

Pre-requisites for the course:	Knowledge of Fundamentals of Mechanical Engineering, Engineering Drawing & Design	
Course Objectives:	**The course will enable students to:** 1. Understand and analyze the static and dynamic forces in mechanisms using force and torque analysis methods. 2. Study the principles and methods of balancing rotating and reciprocating masses to minimize vibrations in machines. 3. Develop an understanding of gyroscopic effects in vehicles and the working principles of governors in speed control. 4. Gain knowledge on vibration analysis of single degree of freedom systems under undamped and damped conditions.	
Content	**Topics**	**No. of Hours**
Unit - 1	**Static Force Analysis:** Static force analysis of planar mechanisms using the equilibrium method, superposition method and virtual work method, numericals. **Inertia Force Analysis:** Inertia force and inertia torque, D'Alembert's principle, inertia force analysis of four bar mechanism and reciprocating engine mechanism, numericals, expression for engine output torque. **Flywheel:** Turning moment diagram, fluctuation of energy and speed, coefficient of fluctuation of speed, numericals, flywheel in an internal combustion engine and a punching press.	**11**
Unit – 2	**Balancing of Rotating Masses:** Static balancing, dynamic balancing - two plane balancing, numericals, **Balancing of Reciprocating Masses:** Balancing of reciprocating mass, balancing of locomotives and effects of partial balancing of locomotives (theory only), primary and secondary balancing, balancing of multi-cylinder inline engines, numericals, balancing of V engines (analytical approach), numericals, balancing of radial engines using the direct method, numericals.	**11**

Approved by: Academic Council on 20th February 2026

Unit - 3	**Gyroscopic Effect:** Gyroscopic effect, gyroscopic couple, gyroscopic effect on aeroplanes and naval ships, stability of a four wheeled and two wheeled vehicles while taking a turn, numericals. **Governors:** Types of governors, centrifugal governors - Watt governor, Porter governor, Proell governor and Hartnell governor. numericals. characteristics of centrifugal governors - controlling force, stability, sensitiveness, isochronism, hunting of centrifugal governors, inertia governors.	**11**
Unit - 4	**Undamped Free Vibrations of Single Degree of Freedom Systems:** Introduction, terminology, basic elements of a vibratory system, degrees of freedom, natural frequency, differential equation of motion and its solution for single degree of freedom systems using equilibrium method and energy method, equivalent springs, compound pendulum, , numericals. **Damped Free Vibrations of Single Degree of Freedom Systems:** Damping, differential equation of motion and its solution for viscously damped free vibration of single degree of freedom systems - underdamped, critically damped and over damped cases, damping ratio, logarithmic decrement, initial value problem, numericals.	**12**
Pedagogy:	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem, numerical-solving skills	
References/ Readings:	**Text Books** 1. S. S. Rattan, Theory of Machines, 5th Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2019. (ISBN-13: 978- 9353166281). 2. C.S. Sharma and Kamlesh Purohit. Theory of Mechanisms and Machines. PHI Learning Pvt. Ltd., 2006. (ISBN 8120329015). 3. G. K. Grover, Mechanical Vibrations, Nem Chand & Bros, 8th Edition, 2009. (ISBN 9788185240565). **Reference Books** 1. Ghosh, Amitabha, and Ashok Kumar Malik, Theory of Mechanisms and Machines. 3rd ed., Affiliated East-West Press, 1998. (ISBN 9788185938936). 2. Uicker, Joseph Edward Jr., Gordon R. Pennock, and Joseph E. Shigley, Theory of Machines and Mechanisms. 3rd ed., Oxford University Press, 2015. (9780198062325). 3. Rao, Singiresu S. Mechanical Vibrations. 5th ed., Pearson, 2011. (ISBN 0132128195).	
Course Outcomes:	**After going through this course, the students will be able to:** **CO1:**–Understand the concept of flywheels, rotating and reciprocating masses, gyroscopes, governors and vibrations	

	CO2: Apply appropriate methods to perform static and inertia force analysis of planar mechanisms, carry out balancing of flywheels, rotating and reciprocating masses, gyroscopes, governors and vibrations **CO3:** Analyze the results of static and inertia force analysis, assess the effects of unbalanced masses, and examine the effects of gyroscopic couple, governor mechanisms, and free vibration in SDOF systems. **CO4**: Evaluate the suitability and effectiveness of force analysis methods, balancing techniques, gyroscopic effects, governor mechanisms, and vibration parameters.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-301**
Title of the Course : **Dynamics of Machines Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Fundamentals of Mechanical Engineering, Engineering Drawing & Design	
Course Objectives:	**The course will enable students to:** 1. Understand the working principles of governors, gyroscopes, rotating mass balancing, and undamped free vibration in single-degree-of-freedom (SDOF) systems through hands-on experiments. 2. Perform experiments to determining the moment of inertia using compound pendulum, bifilar, and trifilar suspension setups. 3. Interpret, record, and analyze data related to dynamic forces, vibrations, and balancing in mechanical systems. 4. Develop the ability to perform static and inertia force analysis and balancing of rotating and reciprocating masses through engineering drawings and graphical methods	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. To perform static force analysis of planar mechanisms graphically using equilibrium method (drawing sheet) 2. To perform static force analysis of planar mechanisms graphically using virtual work method (drawing sheet). 3. To perform inertia force analysis of planar mechanisms graphically (drawing sheet). 4. To perform balancing of given systems of rotating masses (drawing sheet). 5. To perform balancing of a given system of rotating masses graphically (experiment). 6. To perform balancing of a multi-cylinder inline engine and a radial engine graphically (drawing sheet). 7. To verify the gyroscopic law using a motorised gyroscope (experiment). 8. To obtain the speed height characteristics of a gravity controlled centrifugal governor (experiment). 9. To obtain the natural frequency of a single degree of freedom system (experiment). 10. To determine the mass moment of inertia of a given rigid body by suspending it as compound pendulum or bifilar suspension or trifilar suspension (experiment)	**30**

Approved by: Academic Council on 20th February 2026

	Note- Students must be encouraged to use open source tools like Tool Kit Solver/ Microsoft Excel / VBA / SPSS / R / MATLAB/ or any other statistical software to simulate and compute	
Pedagogy:	The teaching-learning process shall combine instructional learning, constructive thinking, inquiry-based and collaborative learning, experiential learning, and problem, numerical-solving approaches.	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Understand the working principles of flywheels, rotating and reciprocating masses, gyroscopes, governors and vibrations **CO2:** Apply experimental techniques to determine characteristics of flywheels, rotating and reciprocating masses, gyroscopes, governors and vibrations and determine moment of inertia using compound pendulum, bifilar, and trifilar suspension methods. **CO3:** Analyze experimental data to interpret the behaviour of mechanical systems under dynamic conditions, including balancing systems, gyroscopic setups, and vibration responses. **CO4:** Evaluate the accuracy and effectiveness and performance of flywheels, rotating and reciprocating masses, gyroscopes, governors and vibrations	

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-302**
Title of the Course : **Materials Science and Metallurgy**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the course:	Basic Knowledge of Mathematics, Physics, Chemistry	
Course Objectives:	**The course will enable students to:** 1. Obtain a fundamental knowledge about common engineering materials - metals, ceramics, polymers and composites and the methods of observing, measuring and interpreting their properties, usage, which are important in engineering design and manufacture. 2. Gain familiarity with various characteristics and structure - property relationships and thermal processing of metals. 3. Provide proficiency and confidence in making judicious material choices for engineering applications. 4. Develop an understanding of crystal structures, defects, deformation mechanisms, phase diagrams, and testing techniques that govern the mechanical behaviour and performance of engineering materials	
Content	**Topics**	**No. of hours**
Unit – 1	**Engineering Materials:** Typical properties, classification, advantages & disadvantages, applications of metals, ceramics, polymers and composite materials. **Crystal Structure:** Unit cell, space lattices and crystal structures, packing efficiency, Miller indices for planes and directions, linear and planar density. X-ray diffraction **Crystal Defects:** Point defects - vacancy, impurities, Schottky and Frenkel defects. line defects - edge and screw dislocations, Burgers vector, dislocation motion, multiplication of dislocations. Surface defects - grain boundaries, twin boundaries, stacking faults. **Plastic Deformation:** Slip in a perfect lattice, deformation by slip, slip systems, critical resolved shear stress for slip, deformation by twinning.	**12**
Unit – 2	**Phase Diagrams:** Solid solutions, cooling curves, Binary phase diagrams, Gibb’s phase rule, interpretation of phase diagram, Lever rule. **Iron-Carbon Phase Diagrams:** Iron - Iron Carbide diagram, phases, Structures, invariant reactions in Fe-Fe3C diagram, critical temperature lines and development of microstructure during slow cooling, isothermal transformation diagram and Continuous	**12**

	Cooling Transformation (CCT) diagram for eutectoid steel.	
Unit - 3	**Ferrous Alloys:** Classification, Properties and Typical Applications of Alloy steels, Tool steels & Stainless steels. Effect of alloying elements. **Cast Irons:** Gray, White, Malleable and Spheroidal Cast Irons. **Heat treatment of steels:** Annealing – Full Annealing, Process annealing and spheroidizing anneal, Normalizing, Hardening, Tempering, Hardenability, Jominy End Quench test. **Strengthening & Recovery:** Case hardening of steels - Carburizing, Nitriding, Induction and Flame hardening. Solid Solution Hardening, Precipitation Hardening, Strain hardening, Recovery-Recrystallization-Grain Growth	**11**
Unit - 4	**Non-ferrous Metals: Copper & Aluminum Alloys:** Classification, Properties and Typical Applications of Alloy **Metallography:** Sample preparation for micro-structural examination working of optical metallurgical microscope & Scanning electron microscope. **Mechanical Testing of Materials:** Hardness, ~~formability,~~ creep. **Non-Destructive Testing of Materials:** X - Ray and Gamma radiography, magnetic particle inspection, dye penetrant test, ultrasonic inspection, eddy current inspection.	**10**
Pedagogy:	Classroom Teaching, Inquiry-Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. V. Raghavan, Materials Science and Engineering: A First Course, 6th edition, Prentice Hall India Learning Private Limited, 2015, (ISBN-10: 9788120350922). 2. R Balasubramaniam, Callister's Materials Science and Engineering, 2nd edition, John Wiley & Sons, 2014, (ISBN-10: 8131518051). **Reference Books** 1. Sydney H. Avner; Introduction to Physical Metallurgy, 2nd edition, McGraw Hill, 2017, (ISBN-10: 0074630067). 2. George E. Dieter, Mechanical Metallurgy, 3rd edition, McGraw Hill, 2017, (ISBN-10: 1259064794). 3. R. A. Higgins, Engineering Metallurgy Part I: Applied Physical Metallurgy, 2nd edition, Edward Arnold, UK, 1991, (ISBN-10: 0340185066).	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Explain crystal structure in metals and alloys **CO2:** Co-relate structure, phase diagrams and resulting micro-structure for iron and aluminium alloys	

	CO3: Solve numericals related to crystal structure and phase diagrams. **CO4:** Analyze the structure-property relationship of engineering materials related to crystal defects, heat treatment processes and mechanical properties.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-303**
Title of the Course : **Materials Science and Metallurgy Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Basic Knowledge of Mathematics, Physics and Chemistry	
Course Objectives:	**The course will enable students to:** 1. Perform standard mechanical tests to evaluate hardness, creep, formability, and hardenability of materials. 2. Study the effect of heat treatment on the properties and microstructure of steels. 3. Examine material structure and crystallography using metallography and X-ray diffraction techniques. 4. Apply non-destructive testing methods to detect flaws in engineering materials	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. To measure the hardness of the given material using Brinell/Rockwell/Vicker's Hardness testing machine. (a) Steel Alloys (b) Aluminum Alloys (c) Copper Alloys 2. To study the creep behavior of solder wire. 3. To determine the formability of the given metal using cupping test. 4. To study the microstructure of the given material. 5. To detect the presence of cracks/flaws in the given metal piece by magnetic particle crack detection method. 6. To detect the presence of cracks/flaws in the given metal piece by dye penetrant test. 7. To determine the hardenability of the given specimen using Jominy end quench test. 8. To study the effect of hardening treatment on a steel specimen – oil quench, water quench, air-cooled 9. Determination of the inter-planar spacing and lattice structure of a given metal, from a given X-ray diffraction intensity vs diffraction angle plot and value of Miller indices at peaks. 10. Determination of the ASTM grain size number from a given	**30**

	micrograph, knowing the magnification or having a scale bar attached.	
Pedagogy:	The teaching-learning process shall combine instructional learning, constructive thinking, inquiry-based and collaborative learning, experiential learning, and problem, numerical-solving approaches.	
Course Outcomes:	After going through this course, the students will be able to: CO1: Analyze the crystal structure and microstructure of engineering materials using appropriate characterization techniques. CO2: Evaluate the formability and creep behaviour of materials under different loading and temperature conditions. CO3: Apply heat treatment processes to materials and assess their effects on mechanical properties CO4: Demonstrate the use of Non-Destructive Testing (NDT) techniques to inspect and interpret material integrity.	

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-304**
Title of the Course : **Manufacturing Technology - II**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Mathematics, Physics, Material Science, Manufacturing Technology - I	
Course Objectives:	**The course will enable students to:** 1. To introduce machining processes and operations – turning, drilling, boring, milling, grinding and related processes and also the non-traditional machining processes. 2. To understand how the different products are machined, their process details and process parameters. 3. To impart knowledge on machining processes, which will be essential to understand advanced courses being offered in the area of manufacturing. 4. To perform engineering analysis of machining processes.	
Content	**Topics**	**No. of Hours**
Unit-1	**Fundamentals of Machining:** Material removal processes and its classification, Overview of machining technology. **Chip Formation and Cutting Geometry**: Theory of chip formation – orthogonal cutting model, actual chip formation, Types of chip formation; Oblique cutting, **Mechanics of Metal Cutting:** Forces in metal cutting, Force diagram, Merchant equation, Velocity relationships, Modified Merchant equation. **Power and Thermal Aspects of Machining**: Power and energy in machining, Cutting temperature – Nathan Cook equation, Trigger equation.	**12**
Unit-2	**Turning and Lathe Operations:** Turning and related operations, Cutting conditions in turning, Engine lathe, Turret lathe. **Drilling, Boring, and Hole-Making Operations**: Drilling and related operations, Cutting conditions in drilling, Drill presses, Boring operations, Boring machines **Milling Operations and Machine Tools**: Milling, Types of milling operations, Cutting conditions in milling, Indexing – simple, compound, Knee and column milling machine – horizontal, vertical, Shaping and planning, Shaping time and power estimation, Broaching, Sawing. **Special and Advanced Machining Operations:** Machining operations for special geometries – screw threads, gears; High speed machining.	**11**

Unit-3	**Grinding and Abrasive Processes:** Grinding, Wheel and its specification, Cutting conditions in grinding, Wheel wear, Grinding ratio, Grinding machines – surface, cylindrical, centreless, creep feed; Related abrasive processes – honing, lapping, super finishing, polishing, buffing. **Tool Life and Tool Materials**: Tool life, Tool wear, Taylor tool life equation, Expanded version of Taylor tool life equation, Tool life criteria in production, Tool materials, Desirable properties, High speed steel, Cast cobalt alloys, Cemented carbides, Cermet's, Coated carbides, Ceramics, Synthetic diamonds, Cubic boron nitride. **Tool Geometry and Cutting Fluids:** Tool geometry, Single-point tool geometry, ASA and ISO system for tool nomenclature designation, Multiple cutting edge tools;Cutting fluids, Types, Application methods, Filtration, Dry machining.	**11**
Unit-4	**Machinability, Tolerances, and Surface Finish:** Machinability, Tolerances in machining, Surface finish in machining, Selection of cutting conditions, Optimizing cutting speed – maximizing production rate, minimizing cost per unit; Machining economics, Product design considerations in machining. **Non-traditional machining processes:** Mechanical energy processes – ultrasonic, water jet, abrasive water jet, abrasive jet; Electrochemical machining; Thermal energy processes – electric discharge machining and wire cutting, laser beam, plasma arc cutting; Chemical machining – steps, chemical milling, chemical engraving, photochemical machining; Application considerations of non-traditional machining.	**11**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	**Text Books** 1. Mikell P. Groover; Principles of Modern Manufacturing, Fifth Edition; Wiley Student Edition. (ISBN-10: 8126547375) 2. P. N. Rao; Manufacturing Technology: Metal Cutting and Machine Tools Welding, Volume - II; Fourth Edition; Tata McGraw-Hill Publishing Company Limited. (ISBN-13: 9789353160524) **Reference Books** 1. R. K. Rajput; Manufacturing Technology (Manufacturing Processes); Second Edition; Laxmi Publications (P) Ltd. (ISBN-13: 978-8131802441 2. Serope Kalpakjian, Steven R. Schmid; Manufacturing Engineering and Technology; Seventh Edition; Pearson India Education Services Pvt. Ltd. (ISBN: 9780133128741)	
Course Outcomes:	Upon successful completion of the course, the students will be able to: **CO1:** Understand the classification, scope, concepts and applications of machining used in industries.	

	CO2: Apply the knowledge, principles and techniques for selection of machining process for specific requirements. **CO3:** Analyze different aspects of machining processes to make inferences. **CO4:** Evaluate various criteria, parameters and facts of machining processes to interpret the results of engineering investigations.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-305**
Title of the Course : **Manufacturing Technology – II Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Concepts of manufacturing technology – I.	
Course Objectives:	**This course will enable students to:** 1. Develop a practical understanding of material removal processes and their role in manufacturing. 2. Gain hands-on experience in machining operations, including conventional and non-traditional processes. 3. Link machining theory with practical performance, such as surface finish, material removal rate, and tool behaviour. 4. Enhance problem, numerical-solving and analytical thinking through experimental investigation and evaluation of machining parameters.	
Contents	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. Experimental Study and Classification of Chip Formation in Machining under Orthogonal and Oblique Cutting Conditions 2. Experimental Measurement and Analysis of Cutting, Feed and Thrust Forces Using a Lathe Dynamometer. 3. Performance Evaluation of Turning Operations on Lathe with Respect to Surface Finish and Material Removal Rate 4. Design of Experiments (DOE) Based Study of Drilling Parameters on Material Removal Rate and Cutting Time. 5. Perform Milling Operations and Simple Indexing for Spur Gear Cutting on a Milling Machine 6. Design of Experiments (DOE) Based Analysis of Shaping Parameters on Surface Roughness 7. Experimental Investigation of Surface Grinding Parameters on Surface Finish. 8. Experimental Analysis of effect of geometry on tool wear of Single point cutting tools in Machining. 9. Experimental Study of Cutting Fluids and Their Effect on Cutting Temperature during Machining. 10. Comparative Analysis of Advanced / Non-Traditional Machining Processes.	**30**
Pedagogy:	Hands-on, Demonstration, Analysis, Collaborative Learning.	

Course Outcomes:	Upon successful completion of the course, the students will be able to: **CO1:** Perform conventional machining operations and measure machining performance, including surface finish, material removal rate, and cutting forces. **CO2:** Interpret chip formation, tool wear, and cutting temperature data to understand machining behaviour. **CO3:** Apply DOE and experimental techniques to optimize drilling, shaping, and grinding processes. **CO4:** Compare and assess conventional and non-traditional machining processes for practical manufacturing applications.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-306**
Title of the Course : **Engineering Statistics**
Number of Credits : **2**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Engineering Mathematics, Basic Probability.	
Course Objectives:	**The course will enable students to:** 1. Introduce the fundamental concepts of probability, random variables, and probability distributions used in engineering analysis. 2. Develop the ability to summarize and interpret data using descriptive and inferential statistical methods. 3. Enable students to apply sampling theory, estimation, and hypothesis testing for decision-making under uncertainty. 4. Familiarize students with statistical tools relevant to quality control, reliability, and experimental design in mechanical engineering.	
Content	**Topics**	**No. of Hours**
Unit – 1	**Basic Probability:** Introduction, conditional probability, theorem on total probability, Bayes' theorem. **Descriptive Statistics:** Measures of central tendency- mean, median, mode; measures of dispersion - range, interquartile range, variance, standard deviation, percentiles; statistical plots - frequency distributions, stem and leaf diagram, box plot, histogram. **Random Variables:** Types of variables – quantitative, qualitative, discrete, and continuous; characteristics - Mean, Variance, and distribution function	**7**
Unit – 2	**Standard Probability Distributions:** **Discrete:** Bernoulli trial, Binomial, Geometric, Pascal, Poisson. **Continuous:** Continuous uniform, Normal, Exponential. Mean, Variance, and Distribution functions, important properties, and applications (no derivations).	**8**
Unit – 3	**Statistics and Sampling Distributions:** Population and Sample, statistic, concepts of sampling distributions - Normal, Student's t-distribution, Chi-square, and F-distributions. **Point Estimation:** Definition, unbiased estimator, standard error. Method of Maximum Likelihood - derivation for Binomial and Exponential distribution. Expressions for estimated parameters of other distributions - Geometric, Pascal, Poisson, and Normal.	**8**

	Confidence Interval (CI) Estimation: Concept, CI on the mean of a single normal population, variance known and unknown, CI on the difference in means of two normal populations, variance known and equal unknown variances. CI on the variance of a normal population and on the ratio of variances of two normal populations.	
Unit – 4	**Concepts of Hypothesis Testing:** Null and alternative hypotheses, Type I and II errors, level of significance, and power of the test. Hypothesis tests on the mean with variance known and unknown. Hypothesis test on the variance of a single population. **Goodness of Fit Test:** Introduction, concept, and algorithm for testing discrete and continuous distributions discussed in Unit- 2. Test for independence. **Simple Linear Regression:** Concept of Simple Linear Regression, residual computation, and plotting.	**7**
Pedagogy:	Inquiry-based learning, integrative learning, Reflective Learning, Constructive learning, and Collaborative learning	
References/ Readings:	**Text Books** 1. D. C. Montgomery, C. G. Runger, Applied Statistics and Probability for Engineers, 6th Edition, Wiley India, 2016. (ISBN: 9788126562947) 2. J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010. (ISBN-13. 978-8126523504) 3. D. C. Montgomery, G. C. Runger, N. F. Hubele, Engineering Statistics, 5th Edition, Wiley India, 2013. (ISBN, 0470631473) **Reference Books** 1. T. Veerarajan; Probability, Statistics and Random Processes, 3rd Edition, Tata McGraw- Hill India, 2017. (ISBN-13: 978-0070669253)	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Understand the concepts of randomness, probability distributions, inferential statistics, and curve-fitting techniques **CO2:** Analyse the characteristics of random variables, standard probability distributions, inferential statistical methods, and curve-fitting techniques **CO3:** Compute probabilities associated with random variables and their probability distributions. **CO4:** Evaluate and interpret the results of probabilistic and inferential statistical techniques.	

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-307**
Title of the Course : **Engineering Statistics Lab**
Number of Credits : **2**
Effective from AY : **2024-25**

<table>
<tr><td>Pre-requisites for the course:</td><td colspan="2">Knowledge of Basic Engineering Mathematics and Statistics, Data Handling and Interpretation</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">The course will enable students to:
1. The objective of this laboratory course is to enable students to learn statistical tools
2. Apply statistical tools and methods for data analysis.
3. To understand the fundamental principles of probability and statistics
4. Practical exercises that connect theory with real-world engineering applications such as reliability analysis, quality control, and experimental design.</td></tr>
<tr><td>Content</td><td>LIST OF EXPERIMENTS</td><td>No. of Hours</td></tr>
<tr><td>List of Experiments</td><td>Perform the following experiments using analytical methods / Microsoft Excel / VBA / SPSS / R / MATLAB/Tool Kit Solver or any other statistical software.
1. To compute probabilities of simple events using basic probability concepts.
2. Evaluate conditional probabilities and apply Bayes' theorem to real-world problems
3. Obtain measures of central tendency and dispersion for given data.
4. Obtain quartiles and percentiles, and prepare a box-and-whisker diagram.
5. To represent data using frequency distribution, stem-and-leaf diagram, box plot, and histogram.
6. Understand the randomness of different random variables graphically and analyse their characteristics.
7. To perform an experiment demonstrating the Central Limit Theorem using repeated random sampling
8. To evaluate probabilities using the Binomial distribution.
9. evaluate probabilities using Geometric and Pascal distributions.
10. To evaluate probabilities using the Poisson distribution
11. To evaluate probabilities using the continuous uniform distribution.
12. To evaluate probabilities using the normal distribution.
13. To evaluate probabilities using the exponential distribution.
14. Calculate the confidence intervals on the mean and the</td><td>60</td></tr>
</table>

Approved by: Academic Council on 20th February 2026

	difference in means of single and two normal populations. 15. To perform hypothesis testing on the population mean with variance known and unknown. 16. To perform hypothesis testing on the variance of a single population. 17. Perform a goodness-of-fit test for standard discrete distributions. 18. Perform a goodness-of-fit test for standard continuous distributions. 19. Perform a test for independence of the given data. 20. Perform simple linear regression analysis and compute the residuals.	
Pedagogy:	Inquiry-based learning, Reflective Learning, Constructive learning, and Collaborative learning.	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Understand the concepts of randomness, probability distributions, inferential statistics, and curve fitting techniques **CO2:** Analyse and plot the characteristics of random variables for probabilistic and inferential statistical techniques. **CO3:** Compute probabilities associated with random variables analytically and using statistical software. **CO4:** Evaluate and interpret the results of probabilistic and inferential statistical techniques analytically and using statistical software.	

Professional Electives

Name of the Programme : B.E. Mechanical Engineering
Course Code : MEC-321
Title of the Course : Composite Materials
Number of Credits : 3
Effective from AY : 2024-25

Pre-requisites for the course:	Knowledge of Strength of Materials, Mathematics, Chemistry	
Course Objectives:	**The course will enable students to:** 1. Understand the fundamentals of composite materials, including their classification, characteristics, constituent materials, and applications of polymer matrix composites. 2. Gain knowledge of fibre and matrix materials used in composites, their properties, processing characteristics, and suitability for different engineering applications. 3. Learn composite manufacturing processes and terminology, and analyze the influence of fibre length, orientation, and loading on the mechanical behaviour of fibre-reinforced composites. 4. Analyze the mechanical behaviour and failure of composite laminas, including orthotropic material modelling, stiffness and compliance matrices, strength theories, testing methods, and damage identification techniques.	
Content	**Topics**	**No. of Hours**
Unit – 1	**Introduction to Composites:** Definition, general characteristics, classification, introduction to polymer-matrix composites, metal-matrix composites and ceramic-matrix composites. Applications of polymer matrix composites only. **Fibre Materials:** Natural fibres, Glass fibres synthesis and surface treatment, Carbon fibres and their production, Aramid fibres, Boron fibres. **Matrix materials:** Polymer matrices – Thermoplastic and thermosetting matrix materials, properties of importance to the composite, commonly used thermosets: polyester resins and epoxy resins.	**10**
Unit – 2	**Composite Manufacturing:** Terminology - Degree of cure, viscosity, resin flow, consolidation, Gel - time Test, shrinkage, voids. **Manufacturing Processes:** Hand Lay-up process, Spray-up process, Autoclave moulding (Bag), Resin Transfer Moulding,	**10**

	Filament Winding, Pultrusion, Compression Moulding. Prepregs and Sheet Moulding Compounds (SMC).	
Unit – 3	**Fibre-Reinforced Composites (FRC):** Influence of fibre length, Influence of fibre orientation, Tensile stress-strain behaviour of continuous fibre composites, Composite modulus: Longitudinal loading (iso-strain assumption) and Transverse loading (iso-stress assumption), longitudinal tensile strength of continuous and short fibre composites. **Analysis of an Orthotropic Lamina:** Stress-strain relations for specially orthotropic lamina, stress-strain relations for generally orthotropic lamina. **Hooke's law and stiffness and compliance matrices:** Specially orthotropic material, transversely isotropic material, isotropic material. Specially orthotropic material under plane stress, relation between engineering constants and elements of stiffness and compliance matrices, transformation of stiffness and compliance matrices. **Strength of an Orthotropic Lamina:** Maximum stress theory and maximum strain theory.	**15**
Unit – 4	**Damage Identification Techniques:** Ultrasonic, Acoustic emission, X-ray Radiography, Thermography. **Mechanical Properties and Testing of FRCs:** Tensile properties, compressive properties, flexural properties, impact properties, creep properties of FRCs. **Emerging composites:** Introduction to nanocomposites, carbon-carbon composites, biocomposites.	**10**
Pedagogy:	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem, numerical-solving skills.	
References/ Readings:	**Text Books** 1. Bhagwan D. Agarwal, Lawrence J. Broutman and K. Chandrashekhara, Analysis and Performance of Fiber Composites, 3rd edition, Wiley India, 2012, (ISBN-10: 0471268917). 2. R Balasubramaniam, Callister's Materials Science and Engineering, 2nd edition, John Wiley & Sons, 2014, (ISBN-10: 8131518051). 3. P. K. Mallick, Fiber Reinforced Composites, 3rd edition, CRC Press, 2007, (ISBN 10: 0367221233). **Reference Books** 1. M. Balasubramanian, Composite materials and processing, CRC Press, 1st edition, 2014. (ISBN-10 : 1138076872). 2. Sanjay K. Mazumdar, Composites Manufacturing - Materials, Product, and Process Engineering, CRC Press, 1st edition, 2001,	

	(ISBN-10: 0849305853). 3. Isaac M. Daniel and Ori Ishai, Engineering Mechanics of Composite Materials, 2nd Edition, Oxford University Press, 2013, ISBN-10: 9780198098386).
Course Outcomes:	After going through this course, the students will be able to: CO1: Explain the different types of fibres and matrices in composites, various manufacturing processes used for composites, damage identification and testing methods for Composites. CO2: Select the fibre and matrix material with manufacturing process for composite part for a given application with desired properties. CO3: Correlate the constituent characteristics with final composite product properties using mechanics. CO4: Design composite lamina, compute the stress/strain state in lamina and predict its failure.

Name of the Programme : B.E. Mechanical Engineering
Course Code : MEC-322
Title of the Course : Composite Materials Lab
Number of Credits : 1
Effective from AY : 2024-25

Pre-requisites for the course:	Knowledge of Strength of Materials, Mathematics, Chemistry	
Course Objectives:	**The course will enable students to:** 1. Fabricate fibre-reinforced composite laminates using hand lay-up techniques with synthetic and natural fibres. 2. Understand the influence of fibre and resin systems on composite preparation and product development. 3. Analyze elastic properties and plane stress behaviour of composite laminas using appropriate analytical and software tools. 4. Evaluate the physical performance of composites, including moisture absorption behaviour and practical applicability.	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. Laminate preparation by hand lay-up process using polyester resin and glass fibre chopped strand mat. 2. Laminate preparation by hand lay-up process using epoxy resin and glass fibre chopped strand mat. 3. Laminate preparation by hand lay-up process using woven fabrics. 4. Preparation of natural fibre composite using hand layup technique. 5. Calculation of elastic constants of a lamina using suitable software. 6. Determination of compliance and stiffness matrices for a composite lamina using suitable software. 7. Plane stress analysis of composite lamina for given loading using suitable software. 8. Water absorption test of glass fibre reinforced composite. 9. Water absorption test of natural fibre reinforced composite. 10. Preparation of a fibre reinforced composite product	**30**
Pedagogy:	The teaching-learning process shall combine instructional learning, constructive thinking, inquiry-based and collaborative learning, experiential learning, and problem, numerical-solving approaches.	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Demonstrate the hand-layup technique to fabricate composite	

	plate using various resins and fibres. **CO2:** Utilize computer software for mechanics of composite materials: Calculate the elastic constants, compliance and stiffness matrices and 2D stress analysis. **CO3:** Evaluate the water absorption characteristics of glass fibre and natural fibre reinforced composite material through experimental testing. **CO4:** Design and prepare a functional product using composite material fabrication technique.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-323**
Title of the Course : **Mechatronics**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Fundamentals of Electrical and Electronics Engineering	
Course Objectives:	**The course will enable students to:** 1. Understand the fundamental elements, structure, and functioning of mechatronic systems and control actions such as proportional, integral, and derivative control. 2. Select and integrate suitable sensors and transducers with controllers for measurement and automation applications. 3. Explain the working principles and applications of electrical, pneumatic, and hydraulic actuation systems in mechatronic control. 4. Explain the use of Programmable Logic Controllers (PLCs) and recognize the significance of Industry 4.0 concepts in modern automation systems.	
Content	**Topics**	**No. of Hours**
Unit – 1	**Introduction to Mechatronics:** Definition, open loop & closed loop control systems, Basic elements of closed loop control system, **Concepts of Control Engineering:** Review of Laplace transform, Transfer function, First order system with time response specifications subjected to unit step, ramp & impulse inputs, numerical problem, numericals on time response of first order systems, concept of second order system with time response specification and numericals, basics of proportional, integral, derivative, PI, PD, PID controllers	**11**
Unit – 2	**Sensors:** Performance terminology of sensors, thermocouple, Incremental and Absolute Encoder, proximity sensor, LVDT, Load Cell, Photoelectric sensor **System Models:** Mathematical models, Electrical system building blocks, Mechanical system building blocks, Electrical & Mechanical analogies, Fluid system building blocks, Thermal system building blocks. **Signal Conditioning:** Operational amplifier with pin diagram, Only Inverting & non inverting amplifier, Filtering-low pass, high pass, band pass, band stop, principle of Analog to digital conversion, principle of Digital to analog conversion.	**12**

Unit – 3	**Pneumatic & Hydraulic Actuation Systems:** Introduction, basic control valves (direction, pressure, flow), actuators (linear, rotary), basic hydraulic and pneumatic circuits, Process control valve. **Electrical Drives:** Relay, Solenoid, Working Principle of stepper and servo motor **Data acquisition:** Basics of PC based data acquisition.	**12**
Unit – 4	**Programmable Logic Controllers**: Introduction to PLC, block diagram of PLC, PLC architecture, I/O units & I/O processing, Introduction to simple ladder programming using logic gates, latching, timers, counters, selection of PLC. **Overview of Industry 4.0 (concepts only):** Technologies driving Industry 4.0, Characteristics of smart factory, Industrial internet of things.	**10**
Pedagogy:	Classroom Teaching, Inquiry-Based Learning, Reflective Learning, Integrative Learning.	
References/ Readings:	**Text Books** 1. W. Bolton; Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering; Pearson; 6e; (ISBN: 9789353065881, 9353065887) 2. D. Necsulescu; Mechatronics; Pearson; 2002; (ISBN: 9788177585407, 8177585401) 3. C. W. de Silva; Mechatronics: A Foundation Course; CRC Press (Indian edition); 2010; (ISBN: 9781138569553)	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Explain the fundamentals of mechatronic systems and interpret the time response of first- and second-order control systems. **CO2:** Apply principles of sensors, transducers, and signal conditioning circuits for measurement and control applications. **CO3:** Analyze the operation of pneumatic, hydraulic, and electrical actuation systems. **CO4:** Design and implement automation and control logic using Programmable Logic Controllers (PLCs) and integrate concepts of Industry 4.0.	

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-324**
Title of the Course : **Mechatronics Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Fundamentals of Electrical and Electronics Engineering	
Course Objectives:	**The course will enable students to:** 1. Familiarize with the simulation and analysis of control system time response using software tools. 2. Acquire, monitor, and control physical process parameters using hardware trainer kits and LabVIEW. 3. Develop practical understanding of fluid power circuits and their implementation for automation applications. 4. Design and implement basic automation using PLCs and Arduino platforms.	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. Determination of Time Response Specifications of a First-Order System Subjected to a Step/Ramp/Impulse Input using simulation software 2. Data Acquisition and Real-Time Display Using LabVIEW 3. Implementation of Water Level/ Temperature/Pressure Control Using Process Trainer Kit 4. Demonstration of Direction and Flow Control Valves to Control Cylinders on a Fluid Power Test Rig 5. Simulation and Implementation of Pneumatic Circuit for control of single and Double-Acting Cylinder using Directional control Valves 6. Determination of Flow Characteristics of a Process Control Valves. 7. Implementation of Boolean Logic using PLC Ladder Logic. 8. Implementation of one-way Traffic Light Control/ Electro-Pneumatic Cylinder Control using PLC Ladder Logic. 9. Calibration and Performance Evaluation of I/P and P/I Converters. 10. Implementation of DC Motor Speed Control Using Arduino	**30**
Pedagogy:	Demonstration Method, Experiential Learning, Problem, numerical-Based Learning, Collaborative Learning, Reflective Learning.	
Course	After going through this course, the students will be able to:	

Outcomes:	**CO1:** Determine the time response characteristics of first-order systems for various inputs using simulation tools. **CO2:** Interface sensors and transducers with LabVIEW or process control trainers for real-time data acquisition and control. **CO3:** Construct and analyze fluid power circuits for controlling actuators and valves. **CO4:** Apply PLC programming and Arduino interfacing techniques to develop simple industrial automation applications

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-325**
Title of the Course : **Power Plant Engineering**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Thermodynamics, Internal Combustion Engines	
Course Objectives:	**The course will enable students to:** 1. Gain basic knowledge of different types of power plants and site selection criteria. 2. Develop an ability to identify, formulate and solve engineering problem, numericals in the field of Power Plant Engineering. 3. Develop an ability to use the techniques, skills and modern engineering tools necessary for engineering practices used in power generation. 4. Understand Economics, Environmental and Safety aspects of power plant operations.	
Content	**Topics**	**No. of Hours**
Unit - 1	**Introduction:** Global Scenario, Present status of power generation in India, Role of private and governmental organizations, Carbon credits, Pitfalls in power reforms, concept of cascade efficiency, Introduction to the Sources of Energy – Resources and Development of Power in India. **Diesel/Hydroelectric Power Plants:** Plant Layout, working, application, advantages & disadvantages of diesel power plant. General arrangement & its operation, classification, advantages and disadvantages, technical data of hydro power plants in India.	**12**
Unit - 2	**Steam Power Plants:** Introduction, General layout of modern power plant with different circuits, working of thermal power plant, coal, ash and dust handling, types of boiler, supercritical boilers, FBC boilers, cogeneration power plant, Necessity of steam condenser, classification. **Nuclear Power Plants:** Principles of nuclear energy, basic nuclear reactions, nuclear reactors-PWR, BWR, CANDU, Sodium graphite, fast breeder homogeneous; gas cooled. Advantages and limitations, nuclear power station, waste disposal.	**11**
Unit - 3	**Gas Power Plant**: Brayton Cycle analysis, Thermal Efficiency, Work ratio, maximum & optimum pressure ratio, Actual cycle, effect of operating variables on thermal efficiency, inter-cooling reheating, & regeneration cycle.	**11**

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	Alternate Power Plants: Introduction, Solar Power Thermal Plants. Solar Photovoltaic Power System, Wind Power Plant, Tidal, Ocean Thermal Energy Conversion (OTEC), geothermal, magneto hydrodynamics, fuel cell. Nuclear Batteries.	
Unit - 4	**Environmental impact due to power plants:** Environmental aspects, different pollutants due to thermal power plants and their effects of human health, Environmental control of different pollutant such as particulate matter, Oxides of sulphur, nitrogen, global warming & greenhouse effect, thermal pollution of water & its control. **Economics of Power Generation:** Introduction, load curve and load duration curves and terminology. Cost of generation of electrical energy with numerical, Selection and Type of generation, Selection of generating equipment and electrical energy Tariff methods.	**11**
Pedagogy:	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem, numerical-solving skills.	
References/ Readings:	**Text Books** 1. E.I.Wakil, Power Plant Engineering , 1st Edition, McGraw Hill Publications New Delhi 2002. (ISBN: 978-0072871029). 2. P. K. Nag, Power Plant Engineering, 4th Edition, McGraw Hill Publications New Delhi 2017. (ISBN: 9789339204051). 3. K. K. Ramalingam, Power Plant Engineering, SCITECH Publications Pvt Ltd, India 2015. (ISBN: 9788183715256). **Reference Books** 1. Domkundwar & Arora, Power Plant Engineering, 8th Edition Dhanpat Rai & Co Pvt Ltd, New Delhi 2016. (ISBN: 9788177001952). 2. R. K. Rajput, Power Plant Engineering, 4th Edition, Laxmi Publications New Delhi 2007. (ISBN:9788131802557) 3. S. P. Sukhatme, Solar Energy, 4th Edition, Tata McGraw-Hill Publications, New Delhi 2017. (ISBN: 9789352607129)	
Course Outcome:	After going through this course, the students will be able to: **CO1:** Remember basics of Power Generation, solar, wind, tidal, Geothermal, Ocean, bio and new energy sources of power generation **CO2:** Understand working principles the various renewable energy sources like wind, solar, biomass, Ocean energy, Fuel cells and MHD systems. **CO3:** Apply principles of thermodynamics and energy conversion in different power plants. **CO4:** Analyze performance of various Power Plants	

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-326**
Title of the Course : **Power Plant Engineering Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Thermodynamics	
Course Objectives:	The course will enable students to: 1. Describe the sources of energy and types of power plants. 2. Analyse the performance of power plants. 3. Estimate different efficiencies associated with power plants. 4. Understand the economics of power generation.	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. Investigation & Analyse of cascade efficiency in Power Transmission 2. Analysis of Boiler Performance by Direct and Indirect Method 3. Analysis of Reheat Rankine Cycle (Steam Power Plant) 4. Case Study on Successful Cogeneration Plant 5. Analysis of Regenerative Rankine Cycle (Steam Power Plant) 6. Field Visit including submission of report to Steam Boiler from Industry 7. Field Visit including submission of report to Solar/Wind Power Plant 8. Experiment on diesel power generating set 9. Performing Carbon Accounting of Power Plant 10. Performing and Analysing Energy Auditing and Management/ Performing economic analysis of Power Generation Note- Students must be encouraged to use open source tools like Tool Kit Solver/ Microsoft Excel / VBA / SPSS / R / MATLAB/ or any other statistical software to simulate and compute	**30**
Pedagogy:	The teaching-learning process shall combine instructional learning, constructive thinking, inquiry-based and collaborative learning, experiential learning, and problem, numerical-solving approaches.	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Remember basics of Power Generation and new energy sources of power generation. **CO2:** Understand working principles Boilers, steam turbine, gas turbine, diesel and Cogeneration power plants. **CO3:** Apply principles of thermodynamics and energy conversion to	

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	analyse different power generating technologies. **CO4:** Analyze performance of various Power Plants.

SEMESTER VI

Major Courses

Name of the Programme : B.E. Mechanical Engineering
Course Code : MEC-308
Title of the Course : Heat and Mass Transfer
Number of Credits : 3
Effective from AY : 2024-25

Pre-requisites for the course:	Knowledge of Thermodynamics.	
Course Objectives:	**The course will enable students to:** 1. To study and understand the phenomena of heat and mass transfer. 2. To develop methodologies for solving a wide variety of heat and mass transfer problem, numericals. 3. To understand basic principles of heat exchanger analysis. 4. To understand heat Transfer rates and the consequent temperature distributions in different practical contexts.	
Content	**Topics**	**No. of Hours**
Unit - 1	**Introduction to Heat Transfer and Concepts:** Thermodynamics versus Heat Transfer, Modes of heat Transfer, Basic laws of Heat Transfer, Numerical. **Conduction:** Derivation of three-dimensional heat conduction equation in Cartesian coordinate system and its reduction to various forms. Initial and Boundary conditions. One-dimensional steady state conduction: plane walls & composite plane walls, hollow & composite cylinders. Critical radius of Insulation: cylinders. Plane wall with uniform heat generation, Cylinder with uniform heat generation. (Theoretical Concepts & Simple Numerical)	**11**
Unit - 2	**Heat Transfer from Extended Surfaces:** Generalized Fin Equation, Heat dissipation from fins: infinitely long fin, insulated fin, fin losing heat at the tip, Fin effectiveness & efficiency. (Theoretical Concepts & Simple Numerical) **Heat Exchangers:** Classification of Heat Exchangers, Overall heat transfer coefficient, The LMTD Method for Heat exchanger analysis, e – NTU method for heat exchanger analysis.	**11**
Unit - 3	**Forced Convection:** Physical Mechanism of forced Convection, Velocity boundary layer – laminar & turbulent flows, Reynolds number, Thermal Boundary layer, Flow over flat plates –	**11**

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	laminar flow, turbulent flow. Drag coefficient, the heat transfer coefficient. **Natural Convection:** Physical Mechanism of Natural Convection Empirical correlations. Natural Convection over surfaces – Natural Convection inside enclosures – effective thermal conductivity, Natural convection from finned surfaces. Introduction to boiling and condensation, Pool boiling regimes. (Theoretical Concepts).	
Unit - 4	**Radiation:** Thermal Radiation, Blackbody radiation, Radiation properties, Planck's law, Stefan Boltzman's Law, Wien's Displacement Law, Kirchhoff's law, Gray body & selective emitters. The view factor, View Factor Algebra, Radiation heat transfer – black surfaces, diffuse and gray surfaces, Radiation shields. **Mass Transfer:** Introduction to Mass transfer, Modes of Mass Transfer, Fick's law of diffusion, General mass diffusion equation in stationary media, Steady state diffusion through a plain membrane, Steady state equimolar counter diffusion. The mass transfer coefficient, Correlations for mass transfer.	**12**
Pedagogy:	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem, numerical-solving skills.	
References/ Readings:	**Text Books** 1. R.K. Rajput, Heat & Mass Transfer, 7th Edition S. Chand Publication, New Delhi 2019. (ISBN 13: 9789352837212). 2. Y. A. Cengel, Heat transfer – A Practical Approach, 3rd Edition, McGraw Hill. USA, 2007. (ISBN 13: 9780073129303). 3. A. V. Domkundwar, A course in Heat and Mass Transfer, Dhanpat Rai and Co. Pvt. Ltd, Delhi, 2007. (ISBN-13: 978-8177000290). 4. Dr. D. S. Kumar, Heat and Mass Transfer, S. K. Kataria & Sons. India 2013. (ISBN-13: 978-9350142691). **Reference Books** 1. Heat transfer-A basic approach, Ozisik N.M, McGraw-Hill. (ISBN: 978-0070479821). 2. P. K. Nag, Heat and Mass Transfer, 3rd Edition, Tata McGraw-Hill, India 2011. (ISBN: 978-0070702530). 3. C.P. Kothandaraman, S. Subramanyam, Heat and Mass Transfer Data Book, 11th Edition, New Age International Publishers, Mumbai 2025. (ISBN-13: 978-9360748487).	
Course Outcome:	After going through this course, the students will be able to: **CO1:** Understand the fundamental physical mechanisms of heat and mass transfer and explain the governing laws and properties for conduction, convection and radiation. **CO2:** Apply the principles of steady-state heat conduction to various	

	engineering systems. **CO3:** Analyse the performance of heat and mass transfer equipment's. **CO4:** Design simple heat transfer equipment, such as a finned surface to enhance heat dissipation or a shell-and-tube heat exchanger to meet specified thermal performance requirements or heat exchangers with LMTD and NTU procedures.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-309**
Title of the Course : **Heat and Mass Transfer Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Concepts of Heat Transfer	
Course Objectives:	The course will enable students to: 1. Provide a platform to understand advanced concepts involved in thermal energy transformation. 2. Provide students with the necessary skills to conduct experiments on conduction and convection of heat; collect data, perform analysis and interpret results to draw valid conclusions through standard test procedures. 3. To determine thermal properties and performance of heat exchangers. 4. Calculate the emissivity of surface which is required for radiation heat transfer analysis.	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. Derive and analyse the general heat conduction equation in cylindrical / spherical coordinates and its reduction to various forms. 2. Determination of thermal conductivity of insulating powder. 3. Derive the general heat conduction equation for fins under various boundary conditions and evaluate their performance parameters such as fin efficiency and fin effectiveness. 4. Determination of LMTD in a parallel / counter flow heat exchanger. 5. Determination of Effectiveness of parallel / counter flow heat exchanger. 6. Estimation of Forced Convection heat transfer coefficient. 7. Estimation of Natural Convection heat transfer coefficient. 8. Determination of Stefan Boltzmann Constant. 9. Determination of emissivity of a surface. 10. Determination of Time required to Heat/Cool a body. (Unsteady State Heat Conduction) Note- Students must be encouraged to use open source tools like Tool Kit Solver/ Microsoft Excel / VBA / SPSS / R / MATLAB/ or any other statistical software to simulate and compute	**30**
Pedagogy:	The teaching-learning process shall combine instructional learning, constructive thinking, inquiry-based and collaborative learning, experiential learning, and problem, numerical-solving approaches.	

Course Outcome:	After going through this course, the students will be able to: **CO1:** Understand the behaviour of heat transfer and determine conductivity / emissivity of the given material. **CO2:** Apply the knowledge of mathematics, science and engineering fundamentals to study heat transfer. **CO3:** Analyse the performance of heat transfer equipment's. **CO4:** Evaluate performance of heat transfer equipment's.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-310**
Title of the Course : **Machine Design**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Strength of Materials	
Course Objectives:	**The course will enable students to:** 1. Understand fundamentals of mechanical design 2. Analyse and design common machine elements such as shafts, springs, gears, and fasteners. 3. Apply failure theories to prevent mechanical failures. 4. Utilize engineering tools and standards to create effective mechanical designs for given application.	
Content	**Topics**	**No. of Hours**
Unit – 1	**Introduction to Design Process:** Process of Machine Design, Design considerations in machine parts, use of standard codes, factor of Safety, preferred numbers and preferred series. **Static Considerations in Design:** Design of simple parts subjected to direct and combined stresses. Design of Cotter joint (socket and spigot type) and Knuckle joint. Design of levers viz. Bell crank lever and lever for Safety valve. Design of curved members with rectangular, circular, trapezoidal and I - sections. **Design for Fatigue:** Stress concentration, stress concentration factors, reduction of stress concentration, fluctuating stresses, failure due to fatigue, S-N curve, endurance limit, endurance strength modifying factors, Design for finite and infinite life, Miner's equation, Soderberg, Goodman and Gerber criteria in designing for alternating stresses. Modified Goodman diagram.	**15**
Unit – 2	**Design of Threaded Joints:** Threaded connections: Screw fastener classification, Terminology of ISO metric threads, Bolted joint in tension, eccentrically loaded bolted joints. **Design of Welded Joints:** Stresses in fillet & Butt welds. Strength of Parallel & Transverse fillet weld, eccentrically loaded welded joints, Weld joints subjected to bending moment. **Springs:** Type, Terminology of helical spring, Styles of end, Deflection & Stress equations, Design of Helical Springs, Design against fluctuating loading.	**10**
Unit – 3	**Design of Shafts:** Shaft design on strength basis, Shaft design on torsional rigidity basis. Design of shaft based on ASME code.	**10**

	Keys & Couplings: Classification of keys, Design of Parallel, Taper Sunk keys. Classification and objectives of couplings, Design of rigid Flanged Coupling and Flexible Bushed Pin Coupling.	
Unit – 4	**Flexible Power Drives:** Classification and comparison of flexible drives. Belt Drives: Flat belt and V belt drives, open and crossed belt drives, length of open and crossed belt drive, stresses in flat and V-belts, selection of flat and V-belts for industrial applications using Data Book/manufacturer's catalogue. **Gears:** Design of Spur gears - Review of spur gear terminology and geometry, Gear Tooth failures: Types & causes, Force Analysis of a spur gear pair, Beam strength, and Wear Strength of Spur Gear Tooth. Estimation of module based on beam and wear strength, heat treatment of gears.	**10**
Pedagogy:	Emphasizes on problem, numerical-based and application-oriented learning approach that integrates theoretical concepts with practical design tasks, fostering critical thinking, creativity, and real world engineering decision making.	
References/ Readings:	**Text Books** 1. Design of Machine Elements, V B Bhandari, Tata McGraw Hill Education Pvt. Ltd., 2021, (ISBN-13: 978-9390177479). 2. Mechanical Engineering Design, Shigley J. E., McGraw-Hill Publication., 2024, (ISBN-13: 978-1266929892). **Reference Books** 1. Design Data - P.S.G. College of Technology, Coimbatore, 2022, (ISBN: 978-8192735504). 2. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers, 2020, (ISBN: 978-8123926971). 3. C. S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learning Pvt. Ltd. 2003, (ISBN: 978-8120319554). 4. D. K. Aggarwal & P. C. Sharma, Machine Design, S.K Kataria and Sons, 2012, (ISBN: 978-9350142813). 5. Design of Machine Elements, Spotts M. F., Shoup T. E., Prentice Hall International, 2003, (ISBN: 978-0130404470). 6. Peter Childs, Mechanical Engineering Design, Elsevier, 2021 (ISBN: 978-0128211021). 7. R. L. Norton, Machine Design, Pearson Education, 2018, (ISBN: 978-9353062408). **Note**: <u>**Only Reference Books**</u> at No. **1** and **2** to be used as data books in semester examination. These reference books **(Data Books**) at **1** and **2** above are to be provided by the College Examination Cell. Students should not be allowed to carry their own data books in the examination hall.	
Course	After going through this course, the students will be able to:	

Outcomes:	**CO1:** Understand the basic principles for designing machine elements. **CO2:** Comprehend and apply mathematical relations for designing machine elements **CO3:** Calculate the dimensions of machine elements. **CO4:** Analyse the problem, numericals related to static and fatigue loading and selection of drives for various applications.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-311**
Title of the Course : **Machine Design Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

<table>
<tr><td>Pre-requisites for the course:</td><td colspan="2">Knowledge of Machine Drawing, Strength of Materials</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">The course will enable students to:
1. Comprehend design principle used to model mechanical designs.
2. Apply theoretical design principle of basic machine components.
3. Evaluate material component strength.
4. Develop technical documentation and engineering drawings that comply with industry standards for manufacturing and assembly.</td></tr>
<tr><td rowspan="2">Content</td><td>LIST OF EXPERIMENTS</td><td>No. of Hours</td></tr>
<tr><td>1. Design and drafting of cotter joint for given loading, preparation of part & assembly drawings.
2. Study of stresses for various sections of curved beams.
3. Design of welded joint for a bracket under given loading.
4. Design and analysis of power transmission shaft using ASME code.
5. Design of bushed pin type coupling for given torque capacity.
6. Analysis and selection of belt for given power transmission application.
7. Study of fatigue failure criteria applied to machine element subjected to fluctuating stresses.
8. Design of bolted joint for given loading.
9. Design of spur gear drive for given application: check for bending and wear failure.
10. Design of helical compression spring subjected to fatigue loading.
Note- Students must be encouraged to use open source tools like Tool Kit Solver/ Microsoft Excel / VBA / SPSS / R / MATLAB/ or any other statistical software to simulate and compute</td><td>30</td></tr>
<tr><td>Pedagogy:</td><td colspan="2">The pedagogy of the Machine Design practical course shall emphasize on design thinking, problem, numerical-solving, and engineering judgment by allowing students to analyse through the integration of CAD tools which shall foster collaborative learning and iterative design approach to promote creativity, teamwork, and effective communication.</td></tr>
</table>

Course Outcomes:	After going through this course, the students will be able to: **CO1:** Comprehend design principles to analyse and solve real-world mechanical component problem, numericals such as shafts, gears & springs. **CO2:** Apply mathematical relations for designing machine elements and joints. **CO3:** Prepare technical drawings and reports in accordance with engineering standards and communicate design solutions effectively. **CO4:** Evaluate mechanical components based on design criteria to ensure functionality, safety & manufacturability.

Name of the Programme : B.E. Mechanical Engineering
Course Code : MEC-312
Title of the Course : Digital Manufacturing
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the course:	Knowledge of Material Science, Machine Drawing and Machining Processes.	
Course Objectives:	**The course will enable students to:** 1. Understand fundamental concepts in Digital Manufacturing and explore the latest advancements in automation technologies. 2. Know the principles of Computer-Aided Manufacturing (CAM) and develop proficiency in NC part programming. 3. Understand fundamental concepts in Computer Integrated Manufacturing Systems (CIMS) and various Automated Production facilities. 4. Acquire foundational knowledge of Additive Manufacturing and its diverse processes.	
Content	**Topics**	**No. of Hours**
Unit - 1	**Introduction:** Introduction to Product Life cycle, Fundamentals of Computer Aided Design (CAD), Typical CAD process, CAD Standards, Introduction to Finite Element Method (FEM)- General steps of FEM, Engineering applications of FEM in various fields, Advantages of FEM, Software. **Introduction to Digital Manufacturing**- Definition, Operation Mode and Architecture, Various methods of digitalization in the manufacturing industries. **Industry 4.0 and Smart Manufacturing:** Industry 4.0, Current developments in Industry 5.0, Digital Twin, Smart factories, Role of IOT in Digital manufacturing, Integration of Augmented and Virtual Reality Technologies in Manufacturing.	**7**
Unit - 2	**Numerical Control and CNC Programming:** Introduction to Computer Aided Manufacturing, Numerical Control (NC), Computer Numerical Control, Numerical Control Modes, Numerical Control Element, Direct Numerical Control, Adaptive Control machining systems. CNC Part Programming, Machining Centre Programming, Canned cycles- Drilling.	**8**
Unit - 3	**CNC Turning and CIM Systems:** Turning Centre Programming, Canned cycles- Rough Turning and Finishing. **Introduction to Computer Integrated Manufacturing System**: Group Technology and Cellular manufacturing, Flexible	**8**

	Manufacturing System, Computer Aided Process Planning, Automated material handling systems.	
Unit - 4	**Additive Manufacturing:** Introduction to Additive Manufacturing Technology in product development, Materials for Additive Manufacturing Technology. Classification, Stereo lithography Apparatus, Selective Laser Sintering, Fused Deposition Modelling, 3D Printing, Laser Engineering Net shaping, Laminated Object Manufacturing. STL files, software for additive manufacturing, Reverse Engineering.	**7**
Pedagogy:	The teaching-learning process shall incorporate interactive and inquiry-driven approaches, with a strong focus on blended learning that seamlessly integrates traditional classroom instruction with digital platforms and advanced tools such as CAD software and simulation environments.	
References/ Readings:	**Text Books** 1. P. N. Rao; CAD/CAM: Principles and Applications; Tata McGraw-Hill Education Pvt. Ltd.;3e; 2013, (ISBN – 9780070681934). 2. M. P. Groover, E. W. Zimmers, Jr.; CAD/CAM: Computer-Aided Design and Manufacturing; Pearson Education, 2014, (ISBN – 9788177584165). 3. Ibhrahim Zeid, R. Sivasubramanium, CAD/CAM, Theory & Practice, Tata McGraw-Hill Education Pvt. Ltd.; 2e; 2013, (ISBN – 9780070151345). 4. M. P. Groover; Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall India Pvt. Ltd.; 3e; 2013, (ISBN – 9780133499612). **Reference Books** 1. Zude Zhou Shane (Shengquan) Xie, Dejun Chen; Fundamental of Digital Manufacturing Science; Springer Series in Advanced Manufacturing; DOI 10.1007/978-0-85729-564-4, (ISBN – 9780857295637). 2. F. W. liou; Rapid Prototyping and Engineering Applications: Toolbox for Prototype Development; 1e; CRC Press; 2018, (ISBN – 9781498798926). 3. T. Chang, R. A. Wysk, Hsu-Pin Wang; Computer Aided Manufacturing, Pearson Education Inc; 3e; 2013, (ISBN – 9780131429192).	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Understand the fundamental concepts in Digital Manufacturing and the transformative role of digitization across allied Manufacturing processes. **CO2:** Apply the knowledge and techniques to develop NC part programs for machining components using CNC systems. **CO3:** Analyze various dimensions of digitization in manufacturing to draw	

	meaningful insights and inform decision-making. **CO4:** Evaluate various criteria, parameters, and facts of Digital Manufacturing processes to interpret the results of engineering investigations.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-313**
Title of the Course : **Digital Manufacturing Lab**
Number of Credits : **2**
Effective from AY : **2024-25**

<table>
<tr><td>Pre-requisites for the course:</td><td>Knowledge of Machine Drawing & Machining Processes.</td></tr>
<tr><td>Course Objectives:</td><td>The course will enable students to:
1. To understand the fundamental principles of solid modelling and equip them with practical skills to create 3D models using standard CAD software.
2. To understand the fundamental principles of 1D structural analysis and equip them with the skills to perform simulations using standard Finite Element Analysis (FEA) software.
3. To acquire the concepts of CNC programming and enable them to develop CNC Programs using standard CAM software.
4. Fabricate simple mechanical components using additive manufacturing techniques.</td></tr>
<tr><td>Content</td><td>LIST OF EXPERIMENTS</td></tr>
<tr><td></td><td>
<table>
<tr><th>Domain</th><th>Description of Experiment</th><th>No. of Hours</th></tr>
<tr><td rowspan="3">CAD</td><td>Solid modelling of any six 3-D objects, Machine parts/ Components using standard CAD software.</td><td rowspan="3">24</td></tr>
<tr><td>3D Assembly modelling of any two Mechanical Systems using standard CAD software.</td></tr>
<tr><td>Creation of a Production drawing of any Two 3-D objects, machine parts/ components</td></tr>
<tr><td>FEA</td><td>Two exercises on 1D structural analysis using bar element using a standard FEA software.</td><td>6</td></tr>
<tr><td rowspan="3">CNC machining</td><td>CNC Part Programming manually and validating the Program using standard Simulation software.</td><td rowspan="3">24</td></tr>
<tr><td>Two exercises on CNC programming using any CAM Simulation software.</td></tr>
<tr><td>Implementation of CNC Program on machine.</td></tr>
<tr><td>Additive Manufacturing</td><td>Data preparation using 3D printing Slicing software</td><td>6</td></tr>
</table>
</td></tr>
</table>

		Manufacturing a mechanical component through 3D printing.	
		Total	**60**
Pedagogy:	The teaching-learning process shall incorporate hands-on, problem, numerical-based, and design-driven pedagogical approach that integrates experiential learning with digital tools for practical sessions.		
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Demonstrate the knowledge of solid modelling principles to create, modify, and analyze 3D Solid models in a CAD environment. **CO2:** Apply basic finite element techniques to analyze 1D structural analysis Problem, numericals using standard FEA software. **CO3:** Develop basic toolpaths and machining strategies for standard Manufacturing operations. **CO4:** Apply additive manufacturing techniques to fabricate simple mechanical components.		

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-314**
Title of the Course : **Industrial Engineering and Operation Management**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of basic Statistics and Manufacturing Systems.	
Course Objectives:	**The course will enable students to:** 1. To understand the concept of productivity and its significance in improving organizational performance. 2. To learn and apply methods for improving existing processes and work methods. 3. To study various techniques used for establishing work standards and understand the roles and responsibilities of an operations manager 4. To explore and apply techniques for effective operations management, enabling better decision-making and improved operational outcomes.	
Content	**Topics**	**No. of Hours**
Unit – 1	**Introduction:** Scope and Objectives of Industrial Engineering. Role of Industrial Engineer in the Manufacturing and Service Sectors. **Productivity:** Scope, measurement, partial and total productivity, means of increasing productivity. **Work Study:** Objectives, procedure, work content analysis, work study as a means of improving productivity, human factor in the application of work study. **Method Study:** Objectives, procedure, selection of a job, recording techniques – Charts (outline, flow process, two-handed, multiple activity and travel chart), diagrams (flow and string diagrams). **Principles of Motion Economy and Ergonomics:** Use of human body, arrangement of the work place, design of tools and equipment. **Learning Curve :** Crawford's model.	**12**
Unit – 2	**Work Measurement:** Objectives, procedure, techniques of work measurement. **Time Study:** Time study equipment, job selection, steps in time study, breaking jobs into elements, types of elements, qualified worker, average worker, standard rating, performance rating, allowances, calculation of standard time.	**11**

	Predetermined Motion time study (PMTS). **Work Sampling:** Procedure, determination of sample size. **Wages and Incentives:** Time wage system, piece wage system, characteristics, types of incentives plans - financial and non-financial, individual and group Incentives schemes. Value Analysis: Objectives, types, procedure.	
Unit – 3	**Forecasting:** Objectives, elements of a good forecast, steps, forecasting errors and accuracy, Qualitative forecasting methods, forecasting based on time series data - moving average, weighted moving average, exponential smoothing, trend - adjusted exponential smoothing, associative forecasting technique - linear regression. **Plant Location**: Need and nature of location decisions, factors affecting location decisions, global locations, evaluating location alternatives – cost-profit-volume analysis, factor rating, center of gravity method. **Facility Layout:** Objectives, factors influencing layout, types of facility layouts – product, process, fixed position, cellular. **Line Balancing:** Concept of work stations, cycle time, idle time, assigning task to work station using single rule or combination of rules - task times, following tasks, positional weight.	**11**
Unit – 4	**Sequencing and Scheduling:** Sequencing, priority rules, Johnson's rule for sequencing jobs through two work centres and Three work centres, scheduling, Gantt chart. **Project Management:** Project concept, AOA project network diagram, CPM and PERT analysis. **Linear Programming:** Mathematical formulation, graphical method, simplex method, Big- M Method.	**11**
Pedagogy:	Inquiry-based learning, Integrative learning, reflective learning, constructive learning, and collaborative learning	
References/ Readings:	**Text Books** 1. Nagoor Kani, A., Control Systems, Tata McGraw Hill, 3rd Edition, 2011 (ISBN-13: 9789389239003). 2. Anand Kumar, A., Control Systems, PHI Learning Pvt. Ltd., 2nd Edition, 2011 (ISBN-13: 9788120349391). 3. Nagarath and M.Gopal, — Control Systems Engineering, New Age International (P) Limited, Publishers, Fifth edition-2005 (ISBN-13: 9788122417005). **Reference Books** 1. R. M. Barnes, Motion and Time study - Design and Measurement of Work, Wiley & Sons, New York, 1980 (ISBN-10: 0471059056)	

	2. J. G. Monks, Operations Management: Theory and Problem, numericals; McGraw- Hill, New York, 1987 (ISBN-10. 0070427275) 3. A. P. Verma, Industrial Engineering & Management, S. K. Kataria & Sons, 2012 (ISBN-13: 978-9350143926) 4. M. Mahajan, Industrial Engineering and Production Management, Dhanpat Rai & Co., 2014 (ISBN-13: 978-9350143926)
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Understand the fundamental objectives and key techniques of Industrial Engineering and Operations Management. **CO2:** Apply the techniques of Industrial Engineering and Operations Management for improving work methods, establishing work standards, enhancing productivity, and ensuring effective management of operations **CO3:** Analyze work cycles for improving methods and establishing work standards aimed at enhancing productivity, and analyze operational situations using appropriate qualitative and quantitative techniques in Operations Management. **CO4:** Evaluate industrial situations and provide effective, data-driven solutions to operational and engineering problem, numericals.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-315**
Title of the Course : **Industrial Engineering and Operation Management Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Basic knowledge of Industrial Engineering and Operations Management.	
Course Objectives:	**The course will enable students to:** 1. Apply industrial engineering and operations management techniques to analyze productivity, work methods, forecasting, facility planning, scheduling, and optimization problem, numericals. 2. Develop analytical and computational skills using appropriate analytical methods and software tools for solving industrial engineering problem, numericals. 3. Interpret results to support effective decision-making in industrial and operational contexts. 4. Evaluate results to support effective decision-making in industrial and operational contexts.	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
List of Experiments	The experiments listed below shall be performed using analytical methods and/or appropriate computational tools and software, depending on the nature of the experiment and availability of resources. 1. Case study on the analysis of work content and productivity improvement using work study principles. 2. Case study on method improvement using appropriate method study charts and diagrams. 3. Case study on the determination of standard time using time study and work measurement techniques. 4. Case study on value engineering/value analysis applied to industrial engineering problem, numericals. 5. Demand forecasting analysis using moving average, weighted moving average, exponential smoothing, trend-adjusted exponential smoothing, and linear regression methods. 6. Plant location analysis and facility layout design using analytical techniques or software tools. 7. Line balancing analysis using task times, precedence relationships, and positional weight–based rules. 8. Job sequencing using Johnson's rule for two-machine flow shop problem, numericals. 9. Project management analysis by drawing an Activity-on-	**30**

Approved by: Academic Council on 20th February 2026

	Arrow (AOA) network and determining the critical path and project duration. 10. Linear programming problem, numerical formulation and solution using graphical and simplex methods. Note- Students must be encouraged to use open source tools like Tool Kit Solver/ Microsoft Excel / VBA / SPSS / R / MATLAB/ or any other statistical software to simulate and compute	
Pedagogy:	Experiential learning through case studies and problem, numerical-solving, supported by inquiry-based, reflective, and collaborative learning approaches.	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Understand the basic concepts and principles of industrial engineering and operations management. **CO2:** Analyse industrial engineering problem, numericals related to productivity improvement, method study, facility planning, and project management. **CO3:** Compute solutions to forecasting, sequencing, network analysis, and linear programming problem, numericals using analytical and computational tools. **CO4:** Evaluate and interpret the results of industrial engineering analyses for effective operational decision-making.	

Professional Electives

Name of the Programme	**: B.E. Mechanical Engineering**
Course Code	**: MEC-327**
Title of the Course	**: Automobile Engineering and Electric Vehicles**
Number of Credits	**: 3**
Effective from AY	**: 2024-25**

Pre-requisites for the course:	Basic knowledge of Mechanical Engineering, Thermodynamics, Electrical Machines, and Engineering Mechanics.	
Course Objectives:	**The course will enable students to:** 1. To understand the fundamentals of automobile construction and power transmission systems. 2. To analyze the vehicle performance in various scenarios and understand vehicle steering, suspension, braking system. 3. To illustrate the architecture and propulsion systems of electric and hybrid vehicles. 4. To describe EV batteries, charging technologies, and safety systems.	
Content	**Topics**	**No. of Hours**
Unit - 1	**Introduction:** Automobile History, development, Classification (Body shapes). Basic frames, sub-Frames, monocoque. Power flow and layout of Drive trains. **Clutches:** Operating principal of friction clutches. Single plate (Diaphragm), Multiplate, Centrifugal, fluid coupling & Torque Convertor. **Gearbox:** working of Sliding mesh, Constant mesh, Synchro mesh, epicyclic, Automatic Manual Transmission (AMT), Continuous variable Transmission (CVT) & Dual Clutch Transmission (DCT) gear box. Four-wheel drive with transfer case. **Drive Line:** Universal Joint, constant velocity (CV) joint, Transaxle, Propeller shaft, slip joint, Differential gear mechanism and rear axle.	**11**
Unit - 2	**Steering System:** General arrangements of steering system. Concept of true rolling condition. Under-steering and Over-steering. **Steering Gear Box:** Rack and Pinion, Recirculating ball type, Power steering (Hydraulic and electronic). **Steering Geometry:** Significance, Caster angle, Camber angle, Toe-in and Toe-out, king pin inclination. **Suspension System:** Coil Spring, Leaf Spring, torsion bar, Double wishbone and Macpherson strut suspension system.	**12**

	Brakes: Requirements. Disc brake, Hydraulic brake, Pneumatic brake, parking brakes. **Vehicle performance**: Power of Propulsion, Traction and tractive effort, Acceleration, Gradeability and Drawbar pull (Concept and Numerical). **Sensors for ICE Vehicle:** Position, Knock sensor (Piezoelectric), Hot wire and thin film flow sensor, oxygen sensor, Manifold Air Pressure Sensor (MAP).	
Unit - 3	**Introduction:** Benefits of electric vehicles (over ICE) ; Types of Electric Vehicles and layout: Battery Electric Vehicles (BEV), Hybrid Electric vehicles (HEV). **EV Architecture and components layout:** Centralized single motor and distributed multi-motor driven power trains, Transmission Systems in EVs – Fixed Gear vs Multi-speed. **Motors for EV propulsion:** Brushless DC Motor (BLDC), Permanent magnet Synchronous Motor (PMSM), Induction Motors – Operating Principles and Characteristics (Torque and Power). **Motor controllers:** Inverters and converters. **Regenerative braking:** working principle, components, energy recovery efficiency. National and Global EV Standards and policies (EMPS 2024, India EV Policy) Drive cycles and Range Estimation.	**11**
Unit - 4	**EV Batteries:** EV battery specifications, Construction and Working principle of: Lithium Ion (Li-ion), Aluminium-Air (Al-Air) and Solid-State batteries. **Ultra-capacitor technologies:** Introduction to ultra capacitors. Electrochemical double layer capacitor (EDLC); construction and working principle, Superconducting magnetic energy storage (SMES) systems; construction and working principle. Battery pack design and cell configuration, Battery Management System, State of Charge (SOC), State of Health (SOH), Thermal Management in Motors. **EV Charging:** On-board and Off-board Chargers: Types, AC & DC Fast Charging and Induction Charging. **EV Safety:** Electrical Isolation, Crashworthiness, Fire Safety in Battery Packs.	**11**
Pedagogy:	The teaching-learning process shall integrate Interactive lectures, multimedia presentations, demonstrations and practical examples to link theoretical concepts with real-world automobile and electric vehicle systems.	
References/	**Text Books**	

Readings:	1. K. Singh, Automobile Engineering, Vol I & II, Standard Publishers Distributors; 13e; 2012, (ISBN 978-8180141966). 2. K. K. Jain, R. B. Asthana; Automobile Engineering; Tata McGraw Hill; 2012, (ISBN 007044529X). 3. A. S. Rangwala; Trends in Automobile Engineering, New Age International Publishers, (ISBN 978-8122419948). 4. M. Ehsani, Y, Gao ; Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press ; 2018, (ISBN 978-1498761772). 5. I. Hussain ; Electric and Hybrid Vehicles Design and Fundamentals, CRC Press ; 2003 (ISBN 978-0849314667). **Reference Books** 1. W. H. Crouse, Donald L Anglin Author; Automotive Mechanics; Tata McGraw Hill; 2007. (ISBN 978-0070634350). 2. M. J. Nunney; Light and Heavy Vehicle Technology; Elsevier Ltd, 2009, (ISBN 978-0750680370). 3. J. Larmine, J. Lowry ; Electric Vehicle Technology Explained Second Edition, John Wiley & Sons Ltd, 2012 (ISBN 978-1119942733).
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Explain the main components of an automobile and illustrate the flow of power through clutches, gearboxes, and drivetrain systems. **CO2:** Apply the principles of vehicle steering, suspension, braking, and performance analysis to understand vehicle handling, control, and stability under different operating conditions. **CO3:** Discuss the layout and working of electric and hybrid vehicles, including propulsion systems, motors, and control units. **CO4:** Understand the working of EV batteries, charging systems, and safety features work together for efficient and safe vehicle operation.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-328**
Title of the Course : **Automobile Engineering and Electric Vehicles Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Basic knowledge of Mechanical Engineering, Thermodynamics, Electrical Machines, and Engineering Mechanics.	
Course Objectives:	**The course will enable students to:** 1. Study various components and working of internal combustion engines and their transmission systems. 2. Demonstrate vehicle steering, suspension, and tyre construction for understanding vehicle control and stability. 3. Study the layout, components, and transmission systems of electric vehicles. 4. Determine the performance characteristics of electric motors and evaluate EV battery capacity requirements.	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. Study of various I.C Engine components and their working. 2. Study of Transmission system in Internal Combustion Engine Vehicles. 3. Study of Ackermann steering mechanism and its analysis. 4. Study of vehicle suspension system. 5. Understand constructional features of tubed and tubeless tyres. 6. Study of components layout and transmission system in Electric Vehicles 7. Determine Torque and Power characteristics of permanent magnet synchronous motor. 8. Determine Torque and Power characteristics of BLDC motor. 9. Determine Torque and Power characteristics of induction motor. 10. Determining electric vehicle battery capacity requirements using suitable open source software.	**30**
Pedagogy:	Hands-on experiments, demonstrations, simulations, and practical exercises to develop skills in vehicle systems, electric motors, and EV battery performance evaluation.	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Remember the components and working of internal combustion engines and their transmission systems. **CO2:** Understand vehicle steering, suspension, and tyre systems to	

	understand vehicle control and stability. **CO3:** Discuss the layout, components, and transmission systems of electric vehicles. **CO4:** Analyze the performance characteristics of electric motors and evaluate EV battery capacity requirements.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-329**
Title of the Course : **Mechanical Vibration and Control Systems**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Mathematics, Physics, Dynamics	
Course Objectives:	**The course will enable students to:** 1. Introduce basic aspects of vibrational analysis of single and two-degree-of- freedom systems. 2. Discuss the use of analytical and numerical methods in vibration theory. 3. Analyze and implement active and passive vibration control theory. 4. Understand vibration control techniques and system stability	
Content	**Topics**	**No. of Hours**
Unit – 1	**Introduction:** Oscillatory motion, Harmonic motion, periodic motion, D'Alembert's principle Natural Frequency and stability, Free vibrations of Undamped and Damped single-degree-of-freedom system, Under damped, critically damped and over damped system. **Forced Vibrations:** Response of a single-degree-of-freedom system to Harmonic excitation, Resonance, frequency Response Function. System with rotating unbalanced mass, System with base excitation.	**10**
Unit – 2	**Vibration Isolation:** with rigid foundation, and flexible foundation. Energy Dissipation and Equivalent Damping. **Equation of motion** using Lagrange's method for single and two-degree-of-freedom systems only. **State space**: state space analysis of a two-DOF system, control of natural frequencies, Design of Undamped Vibration Absorber. Introduction to Negative stiffness: mono-stability and Bi-stability.	**11**
Unit – 3	**Classical control theory:** Transfer function and Block diagram, Transient Response, Bode Plots, Closed-Loop control systems, Routh-Hurwitz, Sylvester stability criterion, and Nyquist Stability criterion, PID and Lag-Lead controllers. **Transducers:** Modelling of Electromagnetic Inertial Actuator, Voice coil Transducer, and Electromagnetic velocity sensor. (The analysis in this section is restricted to 1st , 2nd , 3rd and 4th order systems only)	**12**
Unit – 4	**Modelling:** Modelling in the Time domain and the State Space Approach, Transfer function and Transfer function Matrix. Poles	**12**

	and Zeros in State Space model, Stability in State Space model, Controllability and observability, State Feedback Control, Pole placement Design. Stability of second-order system using Lyapunov stability criterion. **PID Control:** Displacement, Velocity, and acceleration feedback control, Force Feedback control, and Active Force Isolation System. (The analysis in this section is restricted to 1st , 2nd , 3rd and 4th order systems only)	
Pedagogy:	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem, numerical-solving skills.	
References/ Readings:	**Text Books** 1. W.T. Thomson, Marie Dillon Dahleh and Chandamouli Padmanabhan, Mechanical Vibrations, Prentice Hall of India, 5e, 2007. (ISBN: 978-81-317-0482-0) 2. D. J. Inman, Engineering Vibration, 4th ed. Prentice Hall, Upper Saddle River, New Jersey, 2013. (ISBN: 978-9332518483) 3. Asok kumar Mallik, Shymal Chatterjee, Principles of Passive and Active Vibration Control, East west Press Private ltd, 2014. (ISBN: 978-81-7671-098-5) 4. S. S. Rao, Mechanical Vibrations, 5th ed., Prentice Hall, Upper Saddle River, New Jersey, 2011. (ISBN: 978-0132128193) **Reference Books** 1. J. P. Den Hartog, Mechanical Vibrations, Dover Civil and Mechanical Engineering, January 1985. (ISBN: 978-0486647852) 2. Golnaraghi, F., & Kuo, B. C., Automatic Control Systems, 9th ed. Wiley, 2010, (ISBN: 978-8126552337) 3. Francis H. Raven, Automatic Control Engineering, 5th Edition, McGraw-Hill, (ISBN: 9780071136396) 4. Franklin, G. F., Powell, J. D., & Emami-Naeini, A., Feedback Control of Dynamic Systems (8th ed.), 2024, Pearson Education. (ISBN: 978-0134685717) 5. Rudra Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford; (ISBN: 978-0199731244)	
Course Outcomes:	After going through this course, the students will be able to: **CO1:** Understand simple harmonic response in structures and machinery, means for control of vibratory systems, and transducers. **CO2:** Apply the Lagrangian method for single and two-degrees-of-freedom-system and apply the stability criteria. **CO3:** Analyse the frequency response function of vibrating systems and state space system analysis. **CO4:** Design of vibration isolation, absorbers and control systems.	

Name of the Programme : B.E. Mechanical Engineering
Course Code : MEC-330
Title of the Course : Mechanical Vibration and Control Systems Lab
Number of Credits : 1
Effective from AY : 2024-25

Pre-requisites for the course:	Knowledge of Mathematics, Physics, Dynamics	
Course Objectives:	**The course will enable students to:** 1. Understand the concept of numerical analysis in the field of mechanical vibrations and control systems 2. To develop skills in performing experiments and interpreting the results by using suitable software 3. To enable students to correlate theoretical concepts with practical observations by conducting experiments on a spring mass damper/cantilever/rotor/viscoelastic system 4. To evaluate stability and vibration control behaviour using numerical/simulation tools	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. Introduction to Numerical Methods: Ordinary Differential Equation numerical solution using the 4th order Runge-Kutta method and Newton-Raphson Method to find roots of an equation using either MATLAB/Python/C or C++. 2. To find the amplitude, displacement and natural frequency of a single-degree-of-freedom system. 3. To find damping in a system using the Logarithmic decrement. 4. To find the response of a spring mass damper or a cantilever system under a forcing function 5. Study of a single or two-degrees-of-freedom Torsional vibration system 6. Condition monitoring of any mechanical systems/devices 7. Design and Simulation of vibration absorber using either MATLAB/Python/C or C++. 8. To find the Vibration Isolation capacity of the Viscoelastic material. 9. To find the Moment of Inertia of any Mechanical System 10. Stability analysis of an oscillatory system using Bode/Nyquist plots	**30**
Pedagogy:	The teaching-learning process shall combine instructional learning, constructive thinking, inquiry-based and collaborative learning, experiential learning, and problem, numerical-solving approaches.	

Course Outcomes:	After going through this course, the students will be able to: **CO1:** Understand the concept of Vibrations and Control systems and estimate the parameters using an appropriate experimental technique **CO2:** Apply Analytical/Numerical Methods to analyze the results obtained by experimental methods **CO3:** Interpret the results obtained from the Experimental method using Numerical or machine learning techniques **CO4:** Analyse the performance of the Vibration isolation/control system

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-331**
Title of the Course : **Fluid Power Control**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Fundamentals of Fluid Mechanics, Engineering Physics, Basic Thermodynamics	
Course Objectives:	**The course will enable students to:** 1. Introduce the fundamental principles and advantages of fluid power systems. 2. Familiarize students with the construction, working, and characteristics of hydraulic and pneumatic components. 3. Develop understanding of energy transmission, losses, and control in hydraulic systems. 4. Enable students to design and analyze fluid power circuits used in automation and control applications.	
Content	**Topics**	**No. of Hours**
Unit - 1	**Introduction to Fluid Power:** advantages & application of fluid Power systems, Components of fluid power system, Types of fluid power control system, Environmental Issues. **Physical Properties of Hydraulic Fluids:** Pascal's law, Bulk Modulus, Viscosity & Viscosity Index. **Energy and Power in Hydraulic Systems:** Application of Pascal's Law, Conservation of Energy, The Continuity Equation, Bernoulli's Equation. **Basics of Hydraulic Flow in Pipelines:** Frictional losses in Laminar and Turbulent Flow, Losses in Valves and Fittings, Equivalent Length technique, Hydraulic Circuit Analysis. **Hydraulic Conductors and Fittings:** Conductor Sizing for Flow Rate Requirements, Pressure Rating of Conductors, Steel Pipes, Steel Tubing, Plastic Tubing, Flexible Hoses, Metric Steel Tubing.	**10**
Unit - 2	**Hydraulic Pumps:** Pumping theory, Classification of pumps, Gear pumps, Vane pumps, Piston pumps, Pump Performance, Pump Selection, Pump Noise. **Hydraulic Actuators and Motors:** Linear Hydraulic Actuators, Mechanics of Hydraulic Cylinders loadings, Limited Rotation Hydraulic Actuators, Gear Motors, Vane Motors, Piston Motors, Hydraulic Motor Performance.	**12**

	Hydraulic Direction Control: Check Valves, Shuttle Valves, 2-Way, 3-Way and 4-Way Direction Control Valves, Direction Control Valve Actuation, Hydraulic Circuits, Specifications.	
Unit - 3	**Hydraulic Pressure Control:** Pressure Relief Valves, Unloading Valves, Pressure Reducing Valves, Sequence Valves, Counterbalance Valves, Brake Valves, Pressure Compensated Pumps, Specifications. **Hydraulic Flow Control:** Flow Valve Control Valve types, Flow Coefficient, Circuits, Cushioned Cylinders, Flow Dividers. **Ancillary Hydraulic Components:** Accumulators, Intensifiers, Reservoirs, Filters, Seals and Bearing	**11**
Unit - 4	**Pneumatics:** Introduction, Types of Compressor, Air Preparations – Filtering, Regulation, Lubrication, Air Distribution. **Pneumatic Components and circuits:** Pneumatic Cylinders, Pneumatic Motors, Pneumatic Direction Control Valves, Pneumatic Flow Control Valves. Circuits for shuttle valve, AND valve, Quick exhaust valve, Meter-in & Meter-out, Pressure sequence valves. Displacement diagrams. **Electro Pneumatics:** Introduction, Solenoids, Switches, Relays, PE Convertor, Concept of Latching, Circuits of Electro-pneumatics (control of single and two cylinders only)	**12**
Pedagogy:	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem, numerical-solving skills.	
References/ Readings:	**Text Books** 1. Esposito, A., Fluid power with applications, 7th edition, Pearson, 2013 (ISBN: 978-9332518544). 2. Johnson, J. Introduction to fluid power, Delmar-Thomson Learning,2013, (ISBN: 978-0766823655). 3. Ilango, S., & Soundararajan, V, Introduction to hydraulics and pneumatics,3rd edition, Prentice Hall of India, 2017, (ISBN: 978-8120353213). 4. Jagadeesha, T., & Gowda, T, Fluid power: Generation, transmission, and control, 1st edition, Wiley,2013 (ISBN: 978-8126539543). **Reference Books** 1. Rohner, P., Fluid power and logic circuit design. Macmillan,1979 (ISBN: 978-0333256473). 2. Pippenger, J., & Hicks, T, Industrial hydraulics, McGraw-Hill International Edition.1980, (ISBN: 978-0070664777). 3. Majumdar, S. R. Oil hydraulic systems: Principles and maintenance. Tata McGraw-Hill Education. (ISBN: 978-0074637487). 4. Majumdar, S. R. Pneumatic systems: Principles and maintenance. Tata	

	McGraw-Hill Education. (ISBN: 978-0074602317).
Course Outcomes:	**CO1:** Explain the working principles and characteristics of fluid power systems and their components. **CO2:** Describe the working and functions of major hydraulic and pneumatic components such as pumps, compressors, valves, and actuators. **CO3:** Apply fluid mechanics principles to analyse flow, losses, and performance of hydraulic and pneumatic systems. **CO4:** Illustrate and analyse hydraulic and pneumatic circuits for automation and control applications.

Name of the Programme : **B.E. Mechanical Engineering**
Course Code : **MEC-332**
Title of the Course : **Fluid Power Control Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course:	Knowledge of Fundamentals of Fluid Mechanics	
Course Objectives:	**The course will enable students to:** 1. Expose students to real hydraulic and pneumatic systems and their components. 2. Develop skills in designing and simulating hydraulic and pneumatic circuits using software tools. 3. Provide hands-on experience in assembling and testing basic fluid power circuits on training kits. 4. Enable students to analyze and troubleshoot hydraulic and pneumatic circuits	
Content	**LIST OF EXPERIMENTS**	**No. of Hours**
	1. Study of a hydraulic system and identification of its components. 2. Study of a pneumatic system and identification of its components. 3. Actuation and control of a Double Acting Cylinder. 4. Actuation and control of Rotary Actuators. 5. Actuation and parametric study for regenerative circuit. 6. Sequential Operations using Pressure Sequencing Valves 7. Sequential Operation of Multiple Cylinders using displacement Diagram. 8. Speed Control of Actuators using Flow Control Valves and Flow Dividers. 9. Electro-pneumatic control of Single Cylinder. 10. Electro-pneumatic control of Multiple Cylinders.	**30**
Pedagogy:	The teaching-learning process shall combine instructional learning, constructive thinking, inquiry-based and collaborative learning, experiential learning, and problem, numerical-solving approaches.	
Course Outcomes:	**CO1:** Understand working principle of fluid power systems. **CO2:** Identify and describe major hydraulic and pneumatic components used in fluid power systems. **CO3:** Apply appropriate tools to demonstrate hydraulic and pneumatic	

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	circuits. **CO4:** Analyze the operation of fluid power circuits for automation applications.

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