Transforms and Statistics			
Course Code	**1BMATM301**	Scheme	**2025**
Type of Course	**ASC**	Semester	III
Teaching Hours/Week (L: T: P)	3:2:0	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42:0:28:25:25	SEE Marks	50
Credits	4	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set):

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

CO1: Apply Fourier series techniques to represent periodic functions and perform harmonic analysis relevant to engineering applications.

CO2: Utilize Fourier Transforms and Z-Transforms to analyze engineering systems and solve difference equations arising in mechanical and allied engineering problems.

CO3: Formulate and solve partial differential equations and apply numerical methods for the solution of heat, wave, and Laplace equations encountered in engineering practice.

CO4: Employ Laplace Transform techniques to solve ordinary differential equations and engineering problems involving dynamic systems.

CO5: Analyze and interpret engineering data using statistical tools, measures of central tendency, dispersion, and data visualization techniques for informed decision-making.

Module-1: Fourier Series

Definition, Periodic functions, Dirichlet's conditions, Fourier series of periodic functions of period 2π and arbitrary period, half range Fourier series. Complex form of Fourier Series. Practical harmonic analysis.

Number of Hours: 8

Module-2: Fourier Transform & Z-Transform

Infinite Fourier transform, Fourier sine and cosine transforms, properties, Inverse Fourier transform, integral equations and related problems.

Z-Transform: Definition, standard Z-transforms, damping rule, shifting rule, initial value and final value theorems (statements only). Inverse Z- transforms, Problems on difference equations.

Number of Hours: 9

Module-3: Partial differential equations

Partial Differential Equations: Definitions, Formation of PDE by eliminating arbitrary constants and arbitrary functions, Solution of non-homogeneous PDE by direct integration and Lagrange's multiplier method.

Numerical solution of PDE: Classification of second order PDE. Finite difference approximation to derivatives, Numerical solution of One-dimensional Heat and Wave equations. Numerical solution of two-dimensional Laplace equation.

Number of Hours: 9

Module-4: Statistics-1

Measures of central tendency: mean, median and mode for grouped and ungrouped data. Measures of dispersion: range, variance, standard deviation, quartile deviation, moments and coefficient of variation. Concept of Skewness and Kurtosis.

Number of Hours: 8

Module-5: Statistics-2

Statistical Methods: Principles of least squares, Curve fitting by the method of least squares in the form: $y = a + bx$, $y = a + bx + cx^2$, and $y = ax^b$.

Correlation and Regression: Karl Pearson's coefficient of correlation and rank correlation (with repetition and without repetition) -problems. Regression analysis- lines of regression –problems.

Number of Hours: 8

Suggested Learning Resources:

Textbooks:

1. S C Gupta and V K Kapoor, "Fundamentals of Mathematical Statistics", 12th Ed., S. Chand Publishing.
2. R K Jain and S R K Iyengar, "Advanced Engineering Mathematics", 5th Ed., Narosa Publishing House.
3. B S Grewal, "Higher Engineering Mathematics", 45th Ed., Khanna Publishers.

Reference books / Manuals:

1. B V Ramana, "Higher Engineering Mathematics", Mc Graw-Hill Education, 2017
2. M R Spiegel, J Schiller, and R A Srinivasan, "Schaum's Outline of Probability and Statistics", McGraw Hill.
3. S P Gupta," Statistical Methods", 46th Ed., Sultan Chand & Sons, 2023.
4. V K Rohatgi and A K Md. Ehsanes Saleh, "An Introduction to Probability and Statistics", 2nd Ed., Wiley.

Web links and e-Resources:

- https://nptel.ac.in/courses/111105160
- https://nptel.ac.in/courses/127106019
- https://ocw.mit.edu/courses/18-335j-introduction-to-numerical-methods-spring-2019/
- https://ocw.mit.edu/courses/18-330-introduction-to-numerical-analysis-spring-2012/pages/syllabus/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop students' theoretical and applied mathematical skills.
2. State the need for Mathematics with Engineering Studies and Provide real-life examples.
3. Support and guide the students for self–study.
4. You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress.
5. Encourage the students to learn groups to improve their creative and analytical skills.
6. Show short-related video lectures in the following ways:
   - As an introduction to new topics (pre-lecture activity).
   - As a revision of topics (post-lecture activity).
   - As additional examples (post-lecture activity).
   - As an additional material of challenging topics (pre-and post-lecture activity).
   - As a model solution of some exercises (post-lecture activity).

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

The CIE Theory component consists of average of TWO IA tests for 25 marks and Continuous Comprehensive Assessments (CCA) for 25 marks.

To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.

To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.

Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE is at least 40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA) + Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Assignment (at RBL3 or RBL4 levels) for Teamwork	10
2.	GATE-based Aptitude Test	15

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1.	Seminar on Fourier Series of periodic functions and harmonic analysis	5
2.	MATLAB/Python Simulation of Fourier and Z-Transform problems	5
3.	Mini Project on statistical Models in Engineering Applications	10
4.	Case Study on Signal Processing using Transform Techniques	5
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	MOOCs/NPTEL Courses	25

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):
1. Sample Rubrics - Mini-Project

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Problem definition & data	Clear, relevant engineering questions; data source and limitations documented.	Mostly clear; minor gaps in context or data description.	Vague questions or poorly documented data.	10%
Data processing & descriptive statistics	Correct cleaning, visualization, and computation of key measures; patterns clearly highlighted.	Mostly correct; minor computational errors.	Significant errors, missing key measures or plots.	25%
Probabilistic modelling (distributions, inference)	Appropriate distributions and tests used; assumptions stated; results interpreted in context.	Reasonable choice of models; some assumptions implicit; interpretation mostly sound.	Inappropriate or poorly justified models; limited interpretation.	30%
Engineering insight / risk framing	Clear link to design/assessment decisions, safety and uncertainty; limitations discussed.	Some discussion of implications; limited treatment of limitations.	Minimal engineering interpretation on beyond numbers.	20%
Report & communication	Well-structured report, clear figures/tables, reproducible calculations; effective brief presentation.	Acceptable structure; some clarity issues; presentation adequate.	Disorganized or incomplete report; weak presentation.	15%

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/ Self learning (TW/Sl-50 hours). Hence, students must complete minimum of two activities as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Manufacturing Processes			
Course Code	**1BMR302**	Scheme	**2025**
Type of course	**IPCC**	Semester	III
Teaching Hours/Week (L:T:P)	3:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42:0:28:20:30	SEE Marks	50
Credits	**4**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	3

Course Outcome (Course Skill Set):

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

1. Explain the concepts of metal casting, forming, welding and metal cutting.
2. Assess, compare and select appropriate manufacturing Processes.
3. Apply principles of casting, forming, welding, and metal cutting to specific applications.
4. Adapt the principles of manufacturing processes to develop the mechanical components.

Module-1

Casting Process: Sand casting: pattern and core making- materials, allowances, types, moulding process - sand properties, melting furnaces – pit furnace and electric furnaces. Melting and founding of cast iron, degasification, design of casting and risering, pouring and feeding of casting.

Special casting processes: Shell, investment, die casting – pressure and gravity types – squeeze casting - defects in casting.

Plastic moulding – injection and blow moulding.

Number of Hours: 9

Module-2

Welding Processes: Definition, Principles, classification, application, advantages & limitations of welding. Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW).

Special type of welding: Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and Electron beam welding. Gas welding: Principle, oxy-Acetylene welding, oxyhydrogen welding, air-acetylene welding, Gas cutting, Defects and Inspection of welded joints.

Number of Hours: 8

Module-3

Machining processes: Lathe: Review of- working principle, classification, specification, different operations on a lathe. Lathe accessories and tool holders, machining time and power required for cutting. Capstan lathe and Turret lathe, Introduction to CNC lathe, parts and functions. Drilling and boring - classification, specification and constructional features of drilling and boring machines, machining time calculation Milling - classification, principle, parts & specification of milling machines, milling process-cutters, indexing Shaping, Planing and Slotting machines- constructional features and machining operations

Number of Hours: 8

Module-4

Metal forming processes: Hot and cold working processes – Rolling, forging, drawing and extrusion processes, bending, hot spinning, shearing, tube and wire drawing, cold forming, shot peening. Sheet metal working – Blanking, Piercing, Punching, Trimming, Bending – types of dies – progressive, compound and combination dies. High-energy rate forming processes.

Additive Manufacturing: Introduction to 3D-printing and rapid prototyping

Number of Hours: 8

Module-5

Advanced Machining Processes: Abrasive Jet Machining, Water Jet Machining, Ultrasonic Machining, Electrical Discharge Machining, Electrochemical Machining, Laser Beam Machining, Plasma Arc Machining, Electron Beam Machining.

Finishing Process: Surface finishing processes: Grinding, Lapping, honing and super finishing process – overview of machines used, grinding wheels and specification, selection of grinding wheels, ship hull finishing.

Number of Hours: 9

PRACTICAL COMPONENTS OF IPCC

PART – A: FIXED SET OF EXPERIMENTS

1. Study the effect of clay and moisture content on sand mould properties
2. Preparation of sand specimens and conduction of Compression, Shear, and Tensile tests using Universal Sand Testing Machine
3. Determine the permeability number of green sand, core sand, and raw sand
4. Determine AFS fineness number and distribution coefficient of the given sand sample
5. Demonstration: Operation on any one advanced machining process
6. Demonstration: Experimentation of simple programming of CNC machine operations
7. Design and develop a model of ship components using sand moulding and aluminium casting
8. Fabricate a ship component model using arc welding (L-Joint, T-Joint, Butt joint, V-Joint, Lap joint)
9. Develop a ship component using forging operations (upsetting, drawing, bending)
10. Manufacture ship components using Lathe, Shaping, Milling, Drilling, and Grinding processes
11. Design and demonstrate the use of Drill Jig & turning/grinding fixtures for a chosen component
12. Develop and execute a customized CNC program for machining a selected ship component

Suggested Learning Resources:

Textbooks:

1. P N Rao, "Manufacturing Technology", Vol. 1 – Foundry, Forming, and Welding, 5th Ed., McGraw Hill Education (India) Private Limited, 2018.
2. P N Rao, "Manufacturing Technology", Vol. 2 - Metal Cutting and Machine Tools, 4th Ed. McGraw Hill Education (India) Pvt. Limited, 2018.
3. Hajra Choudhary, S. K. and Hajra Choudhary, A. K., "Elements of Workshop Technology", Vol. I, 10th Ed., Media Promoters & Publishers, 2007.
4. Hajra Choudhary, S. K. and Hajra Choudhary, A. K., "Elements of Manufacturing Technology" Vol. II, 15th Ed., Media Promoters & Publishers, 2010.

<u>Reference Books / Manuals:</u>

1. H.M.T., "Production Technology", Tata McGraw-Hill, 2000.
2. Serope Kalpakjian , Steven,R Schmid, "Manufacturing Engineering and Technology," 4th Ed., Pearson, 2011.
3. Roy A Lindberg, "Process and Materials of Manufacturing", 4th Ed., Pearson, 2006.
4. Mikell P. Groover, "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", Wiley Publications, 2019.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112107219
2. https://nptel.ac.in/courses/112104301
3. https://nptel.ac.in/courses/112104028
4. https://nptel.ac.in/courses/112103248
5. https://nptel.ac.in/courses/112105127

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Simulation and Virtual Labs
- ICT-Enabled Teaching

Assessment Structure:
The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks**.

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

CIE Practical component:
The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.
The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

Continuous Internal Evaluation (CIE)
(i) Theory component
The CIE marks of 25 shall be earmarked for two tests.
The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.
Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component
Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.
The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.
(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

Passing requirement in SEE
For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

Table – ICs/IPCCs 1 Distribution of marks		
Component	**Description**	**Marks**
Allotment of marks for regular class work		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Rubrics for Practical CIE – Continuous Assessment:

Performance Indicator (COs/POs)	Superior	Good	Fair	Needs Improvement	Unacceptable
Ability in Conducting Experiments (CO3/PO2, PO3, PO4, PO8) **(10 Marks)**	Demonstrates excellent understanding of the experiment, independently prepares specimens, safely operates equipment, follows procedures accurately, records observations systematically, actively participates in the experiment and analyse the results effectively **(9 – 10 Marks)**	Performs the experiment correctly with minimal guidance, follows safety practices, and records observations with only minor errors. **(7 - 8 Marks)**	Performs the experiment satisfactorily with occasional guidance, follows procedures adequately, and records acceptable observations **(5 - 6 Marks)**	Requires frequent assistance in conducting the experiment, shows limited understanding of equipment/procedure, and records incomplete or inaccurate observations. **(3 – 4 Marks)**	Unable to perform the experiment independently, does not follow procedures or safety practices, and fails to obtain or record meaningful observations. **(1 - 2 Marks)**
Laboratory Record / Journal (PO9) **(20 Marks)**	Record book is complete, neat, and well-organized with objectives, theory, procedure, observations, calculations, graphs/microstructures, results, discussion, and precautions.	Record book is complete with good presentation; minor omissions or formatting errors; calculations and results are mostly accurate;	Record book contains all essential sections but lacks detail in presentation, analysis, or interpretation; few calculation or recording errors.	Record book is incomplete, poorly organized, contains several errors or missing sections, and/or delayed submission. **(5 - 8 Marks)**	Record book is largely incomplete, inaccurate, poorly maintained, or not submitted. **(2 - 4 Marks)**

	Results are accurate and submitted on time. **(17 – 20 Marks)**	submitted on time. **(13 – 16 Marks)**	**(9 - 12 Marks)**		

Term Work (TW) and Self Learning (SL) components in Number of hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Study an existing engineering component and identify the sequence of manufacturing processes used for its production with justification - Case Study Presentation	10
2.	Explore casting simulation, welding simulation, or forming simulation software and prepare a technical report.	10
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	MOOCs/NPTEL Courses/Video Lectures	30

Engineering Thermodynamics			
Course Code	**1BAU303**	Scheme	**2025**
Type of Course	**PCC**	Semester	III
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy per semester L:T:P:SL:TW	42:0:0:38:10	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course Outcome (Course Skill Set):

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

1. Explain fundamentals of thermodynamics and evaluate energy interactions across the boundary of thermodynamic systems.
2. Evaluate the feasibility of cyclic and non-cyclic processes using second law of thermodynamics
3. Apply the knowledge of entropy, reversibility and irreversibility to solve numerical problems and apply first law of thermodynamics to closed and open systems and determine quantity of energy transfers and change in properties.
4. Apply thermodynamic concepts to analyse the performance of gas and vapour power cycles.
5. Explain the principles, applications of refrigeration and air conditioning systems

Module-1

Thermodynamic System and Control Volume, Surroundings. Macroscopic and Microscopic Analysis. Definition of Substance, Properties of Substance, Intensive and Extensive Property, thermodynamic State, Thermodynamic Equilibrium, Concept of Quasi Equilibrium Process and Cycle. Fundamental Units, Units of Force, Energy, Specific Volume, Pressure etc. Equality of Temperature, The Zeroth Law of Thermodynamics, Temperature Scales. Numericals

Number of Hours: 9

Module-2

Heat and Work: Definition of Thermodynamic Work, Forms of Work. Definition of Heat, Inter Convertibility of Heat/work into Work/heat, Governing Principles, Sign Convention. Numericals

First Law of Thermodynamics: First Law for Cyclic Process, First Law for Change of State of a System. Internal Energy, A New Thermodynamic Property. Enthalpy, The Constant Volume and Constant Pressure. Numericals

Number of Hours: 9

Module-3

Second Law of Thermodynamics: Definition of Heat Engine, heat pump and Reservoirs, Kelvin-Planck and Clausius Statements of the Second Law, Reversible and Irreversible Engines and processes, Causes of Irreversibility, Numericals

Carnot Cycle: Efficiency of a Carnot Cycle, Thermodynamic Temperature Scale, Ideal Gas Temperature Scale. **Entropy:** Clausius Inequality, Entropy - A Property of a System, Entropy of a Pure Substance, Entropy Change in Reversible Process, Thermodynamic Property Relation, Calculation of Change in Entropy, Principle of Increase of Entropy. Numericals

Number of Hours: 8

Module-4

Analysis of Power Generation Cycles: Air-standard Power Cycles - Concept, Carnot Cycle, Otto Cycle, Diesel Cycle, Dual Cycle, Brayton Cycle. Efficiency and Mean Effective Pressure. Numericals

Number of Hours: 8

Module-5

Analysis of Refrigeration Cycles: Air-standard Cycles - Joule Cycle. Introduction to Refrigeration Systems, Vapor compression Refrigeration Cycle, Vapor-absorption Refrigeration Cycle. Numericals

Psychometrics and Air-conditioning Systems: Psychometric properties of Air, Psychometric Chart, Analysing Air conditioning Processes; Heating, Cooling, Dehumidification and Humidification. Numericals

Number of Hours: 8

Suggested Learning Resources:

Textbooks:

1. P K Nag, "Basic and Applied Thermodynamics", 2nd Ed., McGraw Hill Education, 2009.
2. Dr D S Kumar, "Engineering Thermodynamics", S. K. Kataria & Sons, 2012.
3. B K Venkanna and Swati B. V, "Basic Thermodynamics", PHI, New Delhi, 2010.

Reference books / Manuals:

1. Yunus A. Cengel, Michael A. Boles, Mehmet Kanoglu, "Thermodynamics- An Engineering Approach", 10th Ed., McGraw Hill Education, 2019.
2. V Ganesan, "Thermodynamics: Basic and Applied", McGraw Hill Education (India), 2018.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/127106135
2. https://nptel.ac.in/courses/112106320
3. https://www.youtube.com/watch?v=9GMBpZZtjXM&list=PLD8E646BAB3366BC8

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Video demonstrations
- Simulations.
- Flipped Classroom
- Problem-Based Learning (PBL)
- Group Learning

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Internal Assessment Test (IA) + Continuous Comprehensive Assessments (CCA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.** It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Case Study Presentation on Thermodynamic Systems and Energy Interactions	15
2.	Psychometric chart and Problem-Solving: Activity	10

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Comprehensive Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Rubrics for Learning Activity 1
Case Study Presentation on Thermodynamic Systems and Energy Interactions

Performance Indicator (COs/POs)	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Identification and Classification of Thermodynamic System (CO1/PO1)	Correctly identifies and classifies the thermodynamic system with complete justification, including boundaries, surroundings, and system type.	Correctly identifies and classifies the system with minor omissions.	Classification is mostly correct but lacks adequate justification.	Classification contains significant errors and misconceptions.	Unable to identify or classify the thermodynamic system.
Analysis of Energy Interactions (CO1, CO2/PO2)	Accurately identifies all heat and work interactions and explains them using thermodynamic principles.	Identifies most energy interactions with minor errors in explanation.	Demonstrates basic understanding of energy interactions.	Limited understanding with several errors in analysis.	Unable to identify or explain energy interactions.
Application of Thermodynamic Concepts and Laws (CO2, CO3/PO2)	Applies thermodynamic laws and concepts correctly with logical reasoning and supporting analysis.	Applies concepts correctly with minor errors.	Partial application of thermodynamic concepts with limited analysis.	Inadequate application of thermodynamic principles.	No meaningful application of thermodynamic concepts.
Technical Report Preparation (CO1/PO10)	Comprehensive and professional report	Good report	Average report	Poor report	No report
Presentation and Team Participation (PO9, PO10)	Highly active and collaborative	Good participation	Moderate participation	Limited participation	No participation

Rubrics for Learning Activity 2: Psychometric chart and Problem-Solving Activity					
Performance Indicator (COs/POs)	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Identification of States and Properties (CO5, PO1)	Correctly identifies all steam states and accurately determines relevant properties from charts.	Correctly identifies most states with minor errors in property evaluation.	Identifies basic states with moderate accuracy.	Significant errors in identifying states and properties.	Unable to identify states or determine properties.
Use of Chart (CO5, PO1, PO2)	Uses chart accurately and efficiently to obtain required thermodynamic properties.	Uses charts correctly with minor calculation or reading errors.	Demonstrates basic ability to use charts.	Limited ability to extract accurate information.	Unable to use chart effectively.
Problem Solving and Analysis (CO5, PO2)	Applies principles correctly and obtains accurate solutions with clear methodology.	Mostly correct analysis	Partial analysis	Minimal analysis	No analysis
Interpretation of Results and Engineering Significance (CO5, PO2)	Provides excellent interpretation of results and relates findings to engineering applications.	Good interpretation with minor gaps.	Basic interpretation of obtained results.	Poor interpretation of obtained results.	No interpretation
Technical Report Preparation (CO5, PO10)	Comprehensive and professional report	Good report	Average report	Poor report	No report

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Case Study	23
2.	Psychometric chart and Problem-Solving Activity	15
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Video Lectures	10

Mechanics of Materials			
Course Code	**1BME304**	Scheme	**2025**
Type of Course	**PCC**	Semester	III
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy per semester L:T:P:SL:TW	42:0:0:38:10	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcome (Course Skill Set):
At the end of the course, the student will be able to:
1. Understand and analyse equilibrium of particles and rigid bodies
2. Determine stresses and strains in axially loaded members
3. Analyze torsional behavior of circular shafts
4. Analyze stresses and deformations in beams
5. Evaluate complex stress systems and pressure vessels

Module-1

Equilibrium of a Particle - Condition for the Equilibrium of a Particle, The Free-Body Diagram, Coplanar Force Systems. (Numericals)
Force System Resultants- Moment of a Force—Scalar Formulation, Principle of Moments, Moment of a Couple, Reduction of a Simple Distributed Loading. (Numericals)
Equilibrium of a Rigid Body-Conditions for Rigid-Body Equilibrium, Free-Body Diagrams, Equations of Equilibrium, Two- and Three-Force Members, Constraints and Statical Determinacy. (Numericals)

Number of Hours: 9

Module-2

Introduction: Normal Stress and Strain; Mechanical Properties of Materials; Elasticity, Plasticity, and Creep; Hooke's Law, and Poisson's Ratio; Shear Stress and Strain; Allowable Stresses and Allowable Loads (Numericals)
Axially Loaded Members: Changes in Lengths of Axially Loaded Members; Thermal Effects, Stresses on Inclined Sections; Strain Energy; Stress Concentration (Numericals).

Number of Hours: 8

Module-3

Torsion: Introduction; Torsional Deformations of a Circular Bar; Circular Bars of Linearly Elastic Materials; Stresses and Strains in Pure Shear; Relationship Between Moduli of Elasticity E and G; Transmission of Power by Circular Shafts; (Numericals).

Number of Hours: 8

Module-4

Stresses in Beams: Pure Bending and Nonuniform Bending; Curvature of a Beam; Longitudinal Strains in Beams; Normal Stresses in Beams; Design of Beams for Bending Stresses; Shear Stresses in Beams of Rectangular Cross Section; Shear Stresses in Beams of Circular Cross Section; Shear Stresses in the Webs of Beams with Flanges. (Numericals).
Shear Forces and Bending Moments: Introduction; Types of Beams, Loads, and Reactions; Shear Forces and Bending Moments; Relationships Among Loads, Shear Forces, and Bending Moments; Shear-Force and Bending-Moment Diagrams; (Numericals).

Number of Hours: 9

Module-5

Analysis of Stress and Strain: Introduction; Plane Stress; Principal Stresses and Maximum Shear Stresses; Mohr's Circle for Plane Stress; Hooke's Law for Plane Stress; Plane Strain; (Numericals).
Pressure Vessels, Beams, and Combined Loadings: Spherical Pressure Vessels; Cylindrical Pressure Vessels; Combined Loadings (Axial + Bending and Axial + Torsion only) (Numericals).

Number of Hours: 8

Suggested Learning Resources:

Textbooks:

1. Hibbeler R C, "Engineering Mechanics: Statics", 14th Ed., Pearson. ISBN: 978-0133918922, 2016
2. Goodno B J & Gere J M, "Mechanics of Materials", Enhanced Edition, 9th SI Ed., Cengage Learning. ISBN: 978-0357377857, 2020.

Reference books / Manuals:

1. Ferdinand P Beer, E. Russell Johnston, David Mazurek, Phillip J Cornwell and Brian Self, "Vector Mechanics for Engineers: Statics and Dynamics, 12th Ed., McGraw Hill, 2024.
2. Hibbeler R C, "Mechanics of Materials", 11th Ed., Pearson Education, 2024.
3. Meriam J L and Kraige L G, "Engineering Mechanics: Statics", 9th Ed., John Wiley & Sons, 2020.
4. Ferdinand P Beer, E Russell Johnston, John T DeWolf, David F Mazurek and Sanjeev Sanghi, "Mechanics of Materials", 8th Ed., McGraw Hill Education, 2020.
5. James M Gere and Barry J Goodno, "Mechanics of Materials", 9th Ed., Cengage Learning, 2018.
6. Timoshenko S P and Young D H, "Elements of Strength of Materials", 5th Ed., McGraw Hill Education, 2017 (Reprint).
7. Arthur P Boresi and Richard J Schmidt, "Advanced Mechanics of Materials", 6th Ed., John Wiley & Sons, 2003.

Web links and Video Lectures (e-Resources):

Web Resources:

1. MIT OpenCourseWare – Solid Mechanics (Statics and Strength of Materials): https://ocw.mit.edu/courses/1-050-solid-mechanics-fall-2004/
2. MIT OpenCourseWare – Mechanics & Materials I: https://ocw.mit.edu/courses/2-001-mechanics-materials-i-fall-2006/
3. Virtual Labs (IITs) – Strength of Materials Laboratory: https://eerc01-iiith.vlabs.ac.in/

Video Lecture Resources:

1. NPTEL – Engineering Mechanics (IIT lectures) https://nptel.ac.in/courses/112106286
2. Jeff Hanson – Statics Lecture Series https://www.youtube.com/playlist?list=PLRqDfxcafc23LXGoItpkYMKtUdHaQwSDC
3. MIT OpenCourseWare – Mechanics of Materials https://ocw.mit.edu/courses/3-11-mechanics-of-materials-fall-1999/
4. Jeff Hanson – Mechanics of Materials Playlist https://www.youtube.com/playlist?list=PLRqDfxcafc21wlI3E56IkDmRJ-33apMjv

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Problem-Based Learning (PBL)
- Simulation and Virtual Labs
- ICT-Enabled Teaching

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Internal Assessment Test (IA) + Continuous Comprehensive Assessments (CCA) = Continuous Internal Evaluation CIE [25+25=50 marks]

i) A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.
ii) In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	To analyse and solve engineering problems involving any three or more of the following topics: equilibrium of particles and rigid bodies, stress analysis, axially loaded members, torsion, bending and shear in beams, pressure vessels, and combined loading, and interpret the results from an engineering perspective.. – Technical Report	15
2.	Structural Analysis of Engineering Components - Case Study Presentation	10

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Comprehensive Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Rubrics for Learning Activity 1:

To analyse and solve engineering problems involving any three or more of the following topics: equilibrium of particles and rigid bodies, stress analysis, axially loaded members, torsion, bending and shear in beams, pressure vessels, and combined loading, with appropriate engineering interpretation of the results. – Technical Report

Performance Indicator (COs/POs)	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Problem Formulation (PO1, PO2)	Correctly identifies engineering problem, assumptions and develops appropriate Free Body Diagrams/models.	Minor omissions in assumptions or modelling.	Adequate understanding with limited justification.	Incorrect assumptions or incomplete formulation.	Unable to formulate the problem.
Analytical Solution (PO1, PO2, PO3)	Accurate calculations with correct application of engineering principles and equations.	Minor computational errors.	Correct approach with moderate calculation errors.	Frequent conceptual and computational errors.	Unable to solve the problem.
Engineering Interpretation (PO2, PO4)	Critically analyses results, validates assumptions and provides meaningful engineering conclusions.	Good interpretation with minor omissions.	Basic interpretation of results.	Limited interpretation and discussion.	No meaningful interpretation.

Technical Documentation (PO9)	Well-organized, neat, complete and professionally documented.	Good documentation with minor deficiencies.	Acceptable documentation.	Poor organization and incomplete documentation.	Inadequate submission.

Rubrics for Learning Activity 2:

Structural Analysis of Engineering Components - Case Study Presentation

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Problem Identification (PO1, PO2)	Clearly identifies the engineering problem with complete justification.	Correctly identifies the problem with minor omissions in assumptions.	Identifies the problem with minor errors	Incomplete or incorrect problem formulation	Unable to identify or formulate the engineering problem.
Application of Mechanics Principles (PO1, PO2, PO3)	Correctly applies three or more mechanics concepts (equilibrium, stress analysis, torsion, bending, pressure vessels, combined loading, etc.) and sound engineering reasoning.	Applies the relevant concepts with minor conceptual errors.	Applies basic concepts with moderate errors.	Limited application of mechanics principles; frequent errors.	Unable to apply the relevant mechanics concepts.
Analysis, Interpretation and Design Recommendations (PO2, PO4)	Critically analyses results, validates assumptions, identifies failure/safety concerns, and proposes feasible engineering recommendations with justification.	Provides appropriate analysis and recommendations with minor omissions.	Performs basic analysis and provides limited recommendations.	Interpretation is incomplete or lacks engineering justification.	No meaningful analysis or recommendations.
Presentation and Technical Communication (PO9)	Presentation is well-organized, technically sound, visually effective, and delivered confidently with accurate responses to questions.	Good organization and communication with minor deficiencies.	Adequate presentation and communication.	Poor organization or ineffective communication.	Unable to communicate technical content effectively.

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Technical Report	23
2.	Case Study	15
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	MOOCs/NPTEL Courses	10

Material Science and Measurement Systems			
Course Code	**1BMR305**	Scheme	**2025**
Type of Course	**PCC**	Semester	III
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy per semester L:T:P:SL:TW	42:0:0:28:20	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcome (Course Skill Set)

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

1. Explain behaviour of various materials with respect to crystal structure, mechanical behaviour, phase transformation and corrosion.
2. Identify suitable materials for specific engineering application
3. Explain the objectives of measurement, methods of measurement, standards of measurement & various measurement parameters.
4. Analyze measurement systems, transducers and describe functioning of force, torque, pressure, strain measuring devices

Module-1

Crystal Structure and Failure of Materials:

Crystal Structure: Crystal Lattice, Unit Cell, space lattice and Atomic packing factor of BCC and FCC, simple numerical.
Imperfections in Solids: Types of imperfections, Point defects, line defects, and 3D-defects.
Failure of Materials: Fracture – Definition of fracture, ductile & brittle fracture, fracture mechanism
Fatigue: Definition of fatigue, Types of fatigue loading with examples, Mechanism of fatigue.
Creep: Definition of creep, mechanism of creep, creep curve, factors affecting creep.

Number of Hours: 9

Module-2

Solidification and Ferrous and Non-ferrous Materials:

Solidification: Mechanism of solidification, Homogeneous and Heterogeneous nucleation, Crystal growth, cast metal structures, Solidification of Steels and Cast irons. Gibbs phase rule, Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel.

Ferrous and non-ferrous materials: Properties, Composition and uses of Grey cast iron, malleable iron, SG iron , Copper alloy and Aluminium alloys.

Number of Hours: 8

Module-3

Heat Treatment and Surface Hardening Methods:

Heat Treatment: Time-Temperature Transformation (TTT) curve, Heat treatment: Annealing- Types of annealing, Normalizing, Hardening, Tempering, Concept of hardenability, Factors affecting hardenability.
Surface hardening methods: Carburizing, Cyaniding, Nitriding, Flame hardening and Induction hardening

Number of Hours: 8

Module-4

Measurement System and Basic Concepts of Measurement Methods:

Definition, Significance of measurement, Generalized measurement system, Static characteristics-Accuracy, Precision, Calibration, Threshold, Sensitivity, Hysteresis, Repeatability, Linearity, Loading effect, Dynamic characteristics- System response, Time delay. Errors in measurement, Classification of errors.
Transducers:
Transfer efficiency, Primary and Secondary transducers, Electrical transducers, Mechanical, Electronic transducers, Relative comparison of each type of transducers.

Number of Hours: 8

Module-5

Applied Mechanical Measurement:

Linear measurement and angular measurements: Slip gauges-Indian standards on slip gauges, Adjustable slip gauges, Wringing of slip gauges, Measurement of angle-sine bar, Sine centre, Angle gauges, Optical instruments for angular measurements. Autocollimator-Applications for measuring straightness and squareness.

Applied mechanical measurement: Measurement of force, Torque, Pressure, Types of Dynamometers, Absorption dynamometer, Prony brake and Rope brake dynamometer, and Power Measuring Instruments. Use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge.

Number of Hours: 9

Suggested Learning Resources:

Textbooks:

1. Beckwith Marangoni and Lienhard, "Mechanical Measurements", 6th Ed., Pearson Education, 2006.
2. R K Jain, "Engineering Metrology", Khanna Publishers, 2009.
3. William D Callister, "Material Science and Engineering", 6th Ed., John Wiley and Sons, 1997.
4. Raghavan V, "Materials Science and Engineering: A First Course", 6th Ed., PHI Learning, 2015.

Reference books / Manuals:

1. Richard S Figliola and Donald E Beasley, "Theory and Design for Mechanical Measurements", 3rd Ed., WILEY India Publishers, 2015.
2. O P Khanna, "A text book of Material Science and Metallurgy", Dhanpat Rai Publishers, 2010.
3. Avner S H, "Introduction to Physical Metallurgy", 2nd Ed., McGraw Hill Education, 2017.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/113102080
2. https://nptel.ac.in/courses/112106293
3. https://nptel.ac.in/courses/112104122
4. https://nptel.ac.in/courses/112106139
5. https://nptel.ac.in/courses/112104250

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Simulation and Virtual Labs
- ICT-Enabled Teaching

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**

Internal Assessment Test (IA) + Continuous Comprehensive Assessments (CCA) = Continuous Internal Evaluation CIE [25+25=50 marks]

i) A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.
ii) In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.
It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Case Study on Material Failure & Selection	10
2.	Measurement System Demonstration / Mini Project	15

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Comprehensive Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Rubrics for Learning Activity 1:
Case Study on Material Failure & Selection

Performance Indicator (COs/POs)	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Understanding of Case (5 Marks) (PO 1)	Demonstrates deep understanding (5 Marks)	Good understanding (4 Marks)	Adequate understanding. (3 Marks)	Limited understanding. (2 Marks)	No clear understanding. (0-1 Mark)
Analysis & Critical Thinking (5 Marks) (PO 2)	Thorough, logical analysis with strong reasoning and innovative insights. (5)	Clear analysis with mostly logical reasoning. (4)	Basic analysis with some reasoning gaps. (3)	Weak analysis; mostly descriptive without reasoning. (2)	No clear analysis or reasoning. (0-1)
Presentation Skills & Organization (10 Marks) (PO 10)	Well-structured, clear, confident delivery; excellent visuals. (9-10)	Good structure, clear delivery; visuals mostly effective. (7-8)	Average structure; delivery clear but lacks engagement. (5-6)	Poor organization; visuals unclear. (3-4)	Unclear, disorganized presentation. (0-2)
Q&A Handling (5 Marks) (PO 10)	Confident, accurate, and concise responses.	Good responses	Adequate responses;	Weak or hesitant responses.	Unable to answer questions.

	(5)	with minor gaps. (4)	some uncertainty. (3)	(2)	(0-1)
Documentation (5 Marks) (PO 10)	Documentation is complete, accurate, well-structured, follows all formatting guidelines. (5)	Documentation is mostly complete and accurate, well-organized, follows formatting guidelines with minor deviations. (4)	Documentation covers most required elements but has some inaccuracies or omissions. (3)	Documentation is incomplete with noticeable inaccuracies. (2)	Documentation is largely missing or irrelevant, lacks structure. (0-1)

Rubrics for Learning Activity 2:
Measurement System Demonstration / Mini Project

Performance Indicator (COs/POs)	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Measurement System Design & Suitability *(10 Marks) (PO 1)*	Appropriate measurement system selected (e.g., force, pressure, torque, strain, slip gauges, transducers) exactly matching the application; strong justification with real-world/industrial relevance. (9–10)	Mostly correct system selection with good justification. (7–8)	Partially correct selection; justification incomplete or lacks clarity. (5–6)	Incorrect selection for fire type; weak reasoning. **(3–4)**	Completely inappropriate system; no justification. (0–2)
Technical Knowledge & Working Principle *(5 Marks) (PO 2)*	Clear and accurate explanation of working principle, components, transducers, and measurement process; includes advantages, limitations, and applications. (5)	Mostly accurate explanation with minor errors. (4)	Basic understanding; some important concepts missing. (3)	Several errors; weak conceptual clarity. (2)	Incorrect or very limited technical knowledge. (0–1)
Error Analysis & Measurement Characteristics *(5 Marks) (PO 2 / PO 1)*	Clearly explains measurement errors (systematic, random), static & dynamic characteristics (accuracy, precision, sensitivity, etc.) with proper application to the system. (5)	Good explanation with minor gaps. (4)	Basic understanding; limited discussion of errors/characteristics. (3)	Poor linkage between theory and system performance. (2)	No application to shipboard scenarios. **(0–1)**

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Case Study on Material Failure & Selection	12
2.	Measurement System Demonstration / Mini Project	16
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
2.	MOOCs/NPTEL Courses	20

Computer Aided Machine Drawing Lab		Scheme	**2025**
Course Code	1BMEL306	Semester	III
Teaching Hours/Week (L:T:P)	0:0:4	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0:0:56:4:0	SEE Marks	50
Credits	2	Total Marks	100
Examination type (SEE)	**Practical**	Exam Hours	2

Course Outcome (Course Skill Set)

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

1. Apply 2D sketching and parametric constraints using CAD software.
2. Develop 3D models of machine components using feature-based modeling.
3. Create assembly models with proper constraints and interference checks.
4. Generate detailed & drafted production drawings with GD&T, BOM and standards.

Module 1- Engineering Graphics Standards and CAD Sketching

- Introduction to BIS Specification for line conventions, dimension, tolerance representation, basic terminology of GD&T, feature control frame, tolerance characteristic and symbols, modifiers and surface texture symbols
- Thread Forms: Thread terminology, Thread conventions, ISO Metric (Internal & External), BSW (Internal & External), Acme and Sellers Thread. Representation of Hexagonal headed bolt and nut assembly with washer.
- Orthographic Views: Conversion of pictorial views into orthographic views of simple machine parts with and without section. (Bureau of Indian Standards conventions are to be followed for the drawings), Precedence of lines, Basics of geometric dimension. (Component drawing to be done in CAD software)
- Overview of CAD software interface, environment of 2D Sketching:
  Sketch tools: line, circle, arc, spline
  Constraints: geometric & dimensional
  Editing tools and construction geometry

Number of Hours: 14

Module 2- Parametric Part Modelling

- Introduction to parametric modeling
- Basic part modeling:
  Extrude, Revolve, Cut, Sweep
- Dimensioning standards (ISO)
- Practice Exercises:
  Simple machine components (washer, bracket, flange)
- Advanced features:
  Fillet, Chamfer, Shell, Draft
- Patterning:
  Linear, circular, mirror
- Hole features:
  Threaded holes, standard hole tables
- Rib and thin features
- Editing and modification tools
- Practice Exercises:
  Knuckle joint components, Connecting rod, Spanner, Cranking Handle, Bearing bracket (part modeling)

Number of Hours: 14

Module 3- Assembly Modelling and Engineering Documentation

- Drafting environment
- Orthographic projections & sectional views
- Dimensioning and annotations
- Geometric Dimensioning & Tolerancing (GD&T)
- Limits, fits and tolerances
- Bill of Materials (BOM)
- Title block and standards
- Exporting drawings (PDF, DWG)
- Assembly environment in CAD software
- Bottom-up and top-down assembly
- Assembly constraints: Mate, align, insert, angle
- Exploded views
- Interference detection

- Keys and Coupling: Assembly of muff coupling with taper sunk key & protected flange coupling with sunk key.
- Assembly Drawing Exercises:
  - Plummer block
  - Screw Jack
  - Machine Vice
  - Engine Piston
  - Tailstock of Lathe
  - I.C. Engine Connecting Rod

Number of Hours: 28

Suggested Learning Resources:

Textbooks:

1. N D Bhat & V M Panchal, "Machine Drawing", Charotar Publishing House, 1999.
2. K R Gopala Krishna, "Machine Drawing", Subhash Publications.
3. "A Primer on Computer Aided Machine Drawing – 2007", Published by VTU, Belagavi.

Reference books / Manuals:

1. S Trymbaka Murthy, "A Text Book of Computer Aided Machine Drawing", 2nd Ed., CBS Publishers, New Delhi, 2007.
2. N Siddeshwar, P Kannaih and V V S Sastry, Machine Drawing, Tata McGraw-Hill, 2006.
3. K L Narayana, P Kannaiah and K Venkata Reddy, "Machine Drawing", 6th Ed., New Age International, 2006.
4. Solid Edge ST/2023/2024 User Manual, Siemens Digital Industries Software (Official Documentation).
5. Solid Edge Tutorials & Training Guides, Siemens Learning Resources.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/@NxTutor
2. https://www.youtube.com/watch?v=vXpbeN6ryWM&list=PLpfdJLK2qQLbua_nqAVrg33-vclj76Vr2
3. https://www.youtube.com/watch?v=Q1T4d4TBGn0&list=PLpfdJLK2qQLbua_nqAVrg33-vclj76Vr2&index=5
4. https://www.autodesk.com/certification/learn/course/fusion360-intro-modeling-design-professional

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- ICT-Enabled Teaching
- Adopt collaborative (Group Learning) learning in the class.
- Demonstrations

Assessment Structure:

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation (CIE):

- CIE marks for the practical course is 50 Marks.
- CIE shall be evaluated for 50 marks as detailed below:
  The final CIE (50) = Class work marks (30) + Test marks (20)
- CIE component should comprise of
  - Continuous evaluation of Drawing work of students as and when the Modules are covered based on the weightage as shown in the following table.

Module	Max. Marks weightage	Evaluation Weightage in marks	
		Computer display & printout (a)	Preparatory sketching (b)
Module-1	20	10	10
Module-2	20	20	0
Module-3	60	60	0
Total	100	90	10
Consideration of Class work		Total of [(a) + (b)] = 100 Scaled down to 30 Marks	

- At least one Test covering all the modules is to be conducted for 100 marks and evaluation to be based as per SEE pattern, and the obtained marks is to be scaled down to 20 Marks.

Semester End Examination (SEE):

- SEE shall be conducted in batches similar to practical's and evaluated for maximum of 100 Marks. Obtained marks shall be accounted for SEE final marks, reducing it by 50%.
- Two full questions shall be set from Modules 1, 2 and 3. Students need to answer one full question from each module.
- Two full questions set from each Module shall cover the entire topic of the respective module.
- Question papers shall be provided by the University for each batch as per schedule.
- SEE shall be conducted by one Internal and one External Examiner.
- Evaluation shall be carried out jointly by both the examiners.
- The student may be awarded full marks, if he/she completes a solution on computer display without sketch.
- The weightage and distribution of marks for each Module is as shown in the following table:

Module	Max. Marks weightage	Evaluation Weightage in marks	
		Computer display & printout (a)	Preparatory sketching (b)
Module-1	20	20	0
Module-2	20	20	0
Module-3	60	60	0
Total	100	100	0
Consideration of SEE Marks		Total of [(a)/2] = Final SEE Marks	

Rubrics for CIE – Continuous assessment:					
Performance Indicators	**Superior**	**Good**	**Fair**	**Needs Improvement**	**Unacceptable**
Engineering Graphics Standards and CAD Sketching (PO1) (20 Marks)	Accurate application of BIS standards, GD&T, threads and orthographic views (17-20)	Good understanding with minor errors (13-16)	Basic understanding (9-12)	Limited understanding (5-8)	No understandin g (1-4)
Parametric Part Modelling (PO1, PO3, PO5) (20 Marks)	Complete parametric models with correct features (17-20)	Minor modelling errors (13-16)	Acceptable models (9-12)	Incomplete models (5-8)	Incorrect models (1-4)
Assembly Modelling and Engineering Documentatio n (PO1, PO3, PO5, PO10) (60 Marks)	Correct constraints, exploded view and interference analysis, Accurate GD&T, BOM and standards (49-60)	Minor assembly issues, Minor documentation errors (37-48)	Functional assembly with errors, Acceptable quality (25-36)	Incomplete assembly, Poor documentation (13-24)	Incorrect assembly, Unsatisfactory documentatio n (1-12)

Rubrics for SEE / CIE Test:					
Performance IndicatorS	**Superior**	**Good**	**Fair**	**Needs Improve ment**	**Unacceptabl e**
Engineering Graphics Standards and CAD Sketchin g/ Parametric Part Modelling (CO1/CO2, PO1, PO2, PO3) (20 Marks)	Fully constrained model with correct dimensions and features; no modelling errors (17-20)	Minor feature or dimensional errors (13-16)	Functional model with noticeable errors (9-12)	Incomple te model (5-8)	Incorrect or failed model generation (1-4)
Assembly Modelling and Engineering Documentation (PO1, PO3, PO5, PO10) (80 Marks)	Complete assembly with proper constraints, exploded view and interference-free operation, correct GD&T, tolerances, BOM and title block (65-80)	Minor assembly or mating errors, Minor documentatio n errors (49-64)	Functional assembly with moderate errors, document ation errors (33-48)	Partially assemble d model, Incomple te documen tation (17-32)	Assembly not completed, Drawing does not meet standards (1-16)

MATLAB for Engineering Computation			
Course Code	**1BMEL307A**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	III
Teaching Hours/Week (L :T : P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2

Course outcome (Course Skill Set)

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

1. Use MATLAB commands and built-in functions for engineering computations and matrix-based problem solving.
2. Develop MATLAB programs using scripts, functions, decision-making statements, and loops.
3. Implement numerical methods for solving engineering mathematics problems.
4. Analyze, visualize, and interpret engineering data through graphical and regression techniques.
5. Solve differential equation models representing engineering systems using MATLAB tools.
6. Apply computational techniques to mechanical engineering problems involving vibrations and heat transfer.

SET OF EXPERIMENTS

1. Introduction to MATLAB Environment and Basic Computations
This experiment familiarizes students with the MATLAB environment, including the Command Window, Workspace, Editor, and basic mathematical operations. Students are expected to create variables, perform arithmetic calculations, use built-in mathematical functions, and understand MATLAB syntax for engineering computations.

2. Matrix and Vector Operations
This experiment introduces vectors and matrices, which form the basis of many engineering analyses. Students are expected to perform matrix addition, multiplication, transpose, inverse, determinant, and eigenvalue calculations and interpret the significance of these operations in engineering applications.

3. Solution of Simultaneous Linear Equations
Students will solve systems of linear equations using matrix methods and MATLAB commands. They are expected to formulate engineering problems in matrix form, obtain numerical solutions, and verify the correctness of the results.

4. MATLAB Scripts and User-Defined Functions
This experiment focuses on developing scripts and functions for engineering calculations. Students are expected to create reusable programs, pass input arguments, generate outputs, and organize calculations efficiently using modular programming techniques.

5. Control Statements and Looping Structures
Students will use decision-making statements such as if-else and switch-case along with for and while loops. They are expected to develop programs involving repetitive calculations and conditional execution commonly encountered in engineering computations.

6. Numerical Solution of Nonlinear Equations
This experiment introduces numerical methods for solving nonlinear equations using MATLAB. Students are expected to implement methods such as Bisection and Newton-Raphson, determine roots of engineering equations, and compare the convergence characteristics of different methods.

7. Curve Fitting and Regression Analysis
Students will analyze experimental data and determine mathematical relationships using curve fitting techniques. They are expected to fit linear and polynomial models to data, evaluate fitting accuracy, and interpret the resulting equations for engineering applications.

8. Numerical Differentiation and Integration
This experiment deals with the numerical evaluation of derivatives and integrals. Students are expected to apply MATLAB tools for differentiation and integration, compare numerical and analytical results, and solve engineering problems involving rates of change and accumulated quantities.

9. Solution of Ordinary Differential Equations
Students will solve first-order and second-order ordinary differential equations using MATLAB solvers. They are expected to model simple mechanical systems, obtain numerical solutions, and visualize the response of engineering systems through plots.

10. Data Visualization and Graphical Representation

This experiment introduces 2D and 3D plotting techniques for engineering data. Students are expected to generate professional-quality graphs, label axes, add legends and titles, and effectively present engineering results using graphical tools.

11. Vibration Analysis of a Spring-Mass System

Students will model and analyze the motion of a simple spring-mass system using MATLAB. They are expected to determine displacement, velocity, and acceleration responses, plot time histories, and understand the fundamentals of mechanical vibrations.

12. Heat Transfer Analysis Using MATLAB

This experiment involves solving simple heat conduction problems using MATLAB. Students are expected to calculate temperature distributions, visualize thermal profiles, and understand the application of computational methods to basic heat transfer problems encountered in mechanical engineering.

Suggested Learning Resources:

Textbooks

1. Amos Gilat, "MATLAB: An Introduction with Applications", 6th Ed., Wiley India, 2018.
2. Steven C Chapra, "Applied Numerical Methods with MATLAB for Engineers and Scientists", 8th Ed., McGraw-Hill Education, 2018.

Reference Books / Manuals

1. Stormy Attaway, "MATLAB: A Practical Introduction to Programming and Problem Solving", 5th Ed., Butterworth-Heinemann (Elsevier), 2023.
2. Duane Hanselman and Bruce Littlefield, "Mastering MATLAB", Pearson Education.
3. MathWorks, MATLAB Documentation and User Guides
4. Rudra Pratap, "Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers", 7th Ed., Oxford University Press, 2017.
5. William J Palm III, "Introduction to MATLAB for Engineers", 4th Ed., McGraw-Hill Education, 2020.

Web Links and Video Lectures (e-Resources):

1. MATLAB Documentation Center
   https://www.mathworks.com/help/matlab/
2. MATLAB Official YouTube Channel
   https://www.youtube.com/@MATLAB
3. MIT OpenCourseWare YouTube Channel
   https://www.youtube.com/@mitocw
4. MATLAB Academy Video Courses
   https://matlabacademy.mathworks.com/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes:

- Demonstration-Based Learning
- Hands-on Laboratory Sessions
- Problem-Based Learning (PBL)
- Case Study Approach
- Interactive Learning Activities
- Project-Oriented Learning
- Visualization-Based Learning
- Peer Learning and Collaborative Programming

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final total marks for report and test shall be out of 50 marks.

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A **student** is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (9-10 Marks)	Good (7-8 Marks)	Fair (5-6 Marks)	Needs Improvement (3-4 Marks)	Unacceptable (1-2 Marks)
Programming and Problem-Solving Skills	Develops complete, error-free MATLAB programs independently and obtains accurate results.	Develops programs with minor errors and obtains mostly accurate results.	Develops basic programs with some guidance; results are partially correct.	Requires significant assistance; results contain major errors.	Unable to develop programs or obtain meaningful results.
MATLAB Implementation and Computational Skills	Demonstrates excellent command of MATLAB commands, functions, and numerical methods independently.	Uses MATLAB tools correctly with minor guidance.	Uses basic MATLAB commands with limited understanding of advanced features.	Demonstrates difficulty in using MATLAB tools effectively.	Unable to use MATLAB tools and functions appropriately.
Result Analysis and Interpretation	Accurately analyzes results, presents clear conclusions, and relates findings to engineering applications.	Interprets results correctly with minor omissions.	Provides basic interpretation but lacks detailed analysis.	Interpretation is incomplete or contains significant errors.	Unable to interpret or explain results.
Laboratory Record, Documentation and Participation	Maintains complete records, submits work on time, and actively participates in all laboratory activities.	Maintains good records with minor omissions and participates regularly.	Records are partially complete; participation is satisfactory.	Records are incomplete and participation is limited.	Fails to maintain records or participate in laboratory activities.

Rubrics for SEE / CIE Test:					
Performance Indicator (CO/PO Mapping)	**Superior**	**Good**	**Fair**	**Needs Improvement**	**Unacceptable**
Understanding of MATLAB Concepts and Numerical Methods **(10 marks)**	Demonstrates comprehensive understanding of MATLAB concepts, syntax, and numerical methods; applies them correctly without assistance. **(9-10 Marks)**	Demonstrates good understanding with minor conceptual errors. **(7-8 Marks)**	Demonstrates basic understanding but requires some guidance. **(5-6 Marks)**	Shows limited understanding and frequent conceptual errors. **(3-4 Marks)**	Unable to demonstrate understanding of fundamental concepts. **(1-2 Marks)**
Program Development and Execution **(20 Marks)**	Develops complete, efficient, and error-free programs that generate accurate results. **(17-20 Marks)**	Develops programs with minor errors and mostly accurate results. **(13-16 Marks)**	Develops basic programs with some errors; results are partially correct. **(9-12 Marks)**	Requires substantial assistance to complete programs; results contain major errors. **(5-8 Marks)**	Unable to develop or execute programs successfully. **(1-4 Marks)**
Analysis, Interpretation and Presentation of Results **(10 Marks)**	Accurately analyzes outputs, interprets results logically, and presents conclusions clearly. **(9-10 Marks)**	Interprets results correctly with minor omissions. **(7-8 Marks)**	Provides basic interpretation but lacks detailed analysis. **(5-6 Marks)**	Interpretation is incomplete or contains significant errors. **(3-4 Marks)**	Unable to analyze or explain results. **(1-2 Marks)**
Viva Voce and Problem-Solving Ability **(10 Marks)**	Responds confidently and accurately to all questions; demonstrates excellent problem-solving ability. **(9-10 Marks)**	Responds correctly to most questions with minor prompting. **(7-8 Marks)**	Answers basic questions satisfactorily. **(5-6 Marks)**	Answers only a few questions and requires significant prompting. **(3-4 Marks)**	Unable to answer questions or demonstrate problem-solving skills. **(1-2 Marks)**

Virtual Reality			
Course Code	**1BMEL307B**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	III
Teaching Hours/Week (L :T:P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2

Course outcome (Course Skill Set)

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

1. Explain the basic concepts of Virtual Reality and its relevance in Mechanical Engineering.
2. Import and visualize CAD models in VR environments.
3. Apply VR tools for product visualization, manipulation and assembly.
4. Develop simple interactive VR environments for mechanical components.
5. Evaluate VR as a tool for design communication and simulation.

SET OF EXPERIMENTS

1. Introduction to VR systems, hardware, and navigation
2. Importing CAD models (from AutoCAD / SolidWorks / Fusion 360) into VR platforms and optimizing
3. Lights, Material application and visualization
4. Scene creation and basic interaction in VR
5. Blueprint creation
6. Animation and walkthrough experience in VR
7. VR-based assembly simulation 1
8. VR-based assembly simulation 2
9. Product visualization project
10. Interactive mechanical model
11. Mini Project Part 1: Design a mechanical component/s and develop the interactive VR environment for the mechanical component
12. Mini Project Part 2: Design a mechanical component/s and develop the interactive VR environment for the mechanical component

Suggested Learning Resources:

Textbooks:

1. Steven M LaValle , "Virtual Reality", Cambridge University Press, 2023
2. William R Sherman and Alan B Craig, "Understanding Virtual Reality: Interface, Application, and Design", 2nd Ed., Morgan Kaufmann, 2018

Reference books / Manuals:

https://dev.epicgames.com/documentation/

- Unreal Engine Documentation
- Twinmotion Learning Guides

Web links and Video Lectures (e-Resources):

- Unreal Engine Learning Portal- https://dev.epicgames.com/community/unreal-engine/learning
- https://docs.unrealengine.com
- https://developer.oculus.com
- https://www.blender.org/support/tutorials/

YouTube: CAD to VR workflows

- https://youtu.be/i3xNb5R_xos
- https://youtu.be/kM27HYbpvc0
- https://youtu.be/fiQ2OgEBbkc
- https://www.udemy.com/course/unreal-engine-5-for-games-physics/

- https://www.udemy.com/course/unreal-engine-5-blueprints-game-developer-masterclass/

Software Required:

1. CAD SOFTWARE (PREREQUISITE)
    - AutoCAD/ SolidWorks / Fusion 360 / Creo
2. VR & VISUALIZATION SOFTWARE
    - Twinmotion
    - Unreal Engine
    - Unity
3. FILE PIPELINE / CONNECTORS
    - Datasmith Plugin (for CAD → Unreal workflow)
    - FBX / OBJ exporters

HARDWARE REQUIRED:

- VR Headsets (Meta Quest 2 / 3 or equivalent)
- High-performance PC (RTX GPU recommended)

1. CPU: AMD Ryzen Threadripper 3970X or Intel Core i9-13900K (at least 12 cores, 24 threads) GPU: NVIDIA GeForce RTX 4090 or AMD Radeon RX 7900 XTX (with at least 24 GB of VRAM) RAM: 64 GB of DDR5 RAM (or more) Storage: Fast NVMe SSD (at least 2 TB) Motherboard: Compatible with your CPU and has features like Wi-Fi, USB 3.2 Gen 2, and high-quality audio. Preferred Computers are **Precision 3660 Tower Workstations. Alienware Aurora R16 Gaming Desktop or higher-end PC for 3d visualizations and the latest versions of Unreal Engine.**
2.META Quest 3 VR Headset Motion Controller (White, For PC, PS4, Xbox) • 512GB of Internal Storage • Full-Color Passthrough • Elite Strap Included • 2064 x 2208 Resolution • XR2 Gen 2 Snapdragon Processor • Ring-Free Touch Plus Controllers • TruTouch Haptic Feedback • Built-In 3D Spatial Audio

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Hands-on lab-based learning
2. CAD to VR workflow demonstration
3. Project-based learning

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks.**
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Semester End Examination: Virtual Reality for Mechanical Engineers

Total Marks: 50 | **Time:** 3 Hours

PART – A: VR Fundamentals & Asset Integration (20 Marks)

*Instructions: Answer any **two** out of the following four questions. (10 Marks each)*

Asset Optimization & Import: Export a moderately complex assembly (at least 5 to 10 components) from SolidWorks/Fusion 360. Import it into a VR platform (Unity/Unreal). Demonstrate optimization by reducing the poly-count or managing the hierarchy to ensure a stable frame rate. Apply realistic metallic and matte materials to the components.

Environment & Lighting: Create a "Virtual Workshop" scene. Place a mechanical workstation in the center. Configure **Global Illumination** and at least two local light sources (Point/Spot) to highlight the mechanical features of your model. Ensure no light leakage through mesh walls.

Navigation & Basic Blueprinting: Develop a VR scene where the user can move using **Teleportation** and **Snap Turn** mechanics. Create a basic Blueprint/Script where clicking a "Start" button changes the color of a specific mechanical part to indicate it is "Active."

Animation & Walkthrough: Create a guided walkthrough experience. Program a camera path or a character movement that takes the viewer through the internal cross-section of a large mechanical system (e.g., an engine block or a turbine).

PART – B: Immersive Engineering Applications (30 Marks)

*Instructions: Perform **one** of the following Mini-Project simulations. (30 Marks)*

Interactive Assembly Simulation:
Design a simple 3-part assembly (e.g., Bolt, Washer, Nut).
In the VR environment, implement **Grab Interactors.**
The user must be able to pick up the parts and "snap" them into the correct assembly sequence.

Mechanical Model Interaction (Mini-Project):
Design a mechanical component (e.g., a Gearbox or Piston-Cylinder).
Develop a VR experience where the user can trigger an "Exploded View" animation using a trigger press.

Rubrics for CIE – Continuous assessment:					
Performance Indicator (COs/POs)	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Understanding of VR Concepts and Workflow (PO1)	Clearly explains the concepts, workflow, and applications of VR tools and CAD integration with appropriate technical terminology.	Demonstrates good understanding with minor conceptual gaps.	Demonstrates basic understanding of the concepts and workflow.	Demonstrates limited understanding with several inaccuracies.	Unable to explain the concepts or workflow.
Observation and Interpretation (PO2)	Accurately records observations, explains outcomes, and relates them to the objectives of the experiment.	Records observations correctly with minor omissions in interpretation.	Records basic observations with limited explanation.	Observations are incomplete or inaccurate with poor interpretation.	Fails to record meaningful observations or interpretations.
Documentation (PO9)	Record is complete, well-organized, and includes objectives, procedure, screenshots, observations, and conclusions for all experiments.	Record is complete with minor omissions or formatting issues.	Record contains most essential sections with acceptable organization.	Record is incomplete or poorly organized with several missing sections.	Record is inadequate or not submitted.
Use of Figures, Screenshots and Technical Presentation (CO3/PO9)	Includes clear screenshots, annotated figures, and well-formatted content that effectively supports the report.	Includes appropriate figures and screenshots with minor presentation issues.	Includes basic figures/screenshots with acceptable presentation.	Limited or poorly presented figures/screenshots.	No relevant figures or screenshots included.

Rubrics for SEE / CIE Test:

Performance Indicator (COs/POs)	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
CAD Model Integration and VR Environment Development (PO1, PO2)	CAD models are accurately imported, optimized, and integrated into a well-structured VR environment with appropriate scene organization.	CAD models are correctly integrated with minor issues in optimization or scene organization.	CAD models are integrated with basic functionality and acceptable organization.	CAD integration is incomplete or contains significant errors.	Unable to import or integrate CAD models into the VR environment.
Application of VR Features and Interactivity (PO2, PO3)	Effectively implements lighting, materials, animations, Blueprints, navigation, and interactive features to create an immersive VR experience.	Implements most VR features correctly with minor functional issues.	Implements basic VR features with limited interactivity.	Implements few VR features with frequent errors.	Fails to implement essential VR features or interactivity.
Assembly Simulation / Product Visualization (PO3, PO4)	Successfully develops an accurate assembly simulation or product visualization demonstrating correct sequence, functionality, and engineering relevance.	Develops a functional assembly simulation/product visualization with minor deficiencies.	Develops a basic assembly simulation/product visualization with limited functionality.	Develops an incomplete or partially functional simulation.	Unable to demonstrate assembly simulation or product visualization.
Technical Quality and Engineering Application (PO2, PO4)	Demonstrates excellent engineering understanding, realistic visualization, and effective application of VR to solve engineering problems.	Demonstrates good engineering application with minor limitations.	Demonstrates satisfactory engineering application with basic understanding.	Demonstrates limited engineering understanding and application.	Demonstrates poor understanding of engineering application.
Demonstration, Viva Voce and Technical Communication (PO9)	Demonstrates the project confidently, explains workflow and design decisions clearly, and answers viva questions accurately.	Demonstrates the project well with minor communication gaps.	Demonstrates the project with acceptable explanation and responses.	Demonstration lacks clarity and responses are partially correct.	Unable to explain the project or respond to viva questions satisfactorily.

Spreadsheet for Engineers			
Course Code	**1BMEL307C**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	III
Teaching Hours/Week (L :T : P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2

Course outcome (Course Skill Set)

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

1. Create various plots and charts, and compute mathematical functions for data interpretation.
2. Apply iterative techniques to solve roots, perform optimization, and carry out non-linear regression analysis.
3. Perform matrix operations and apply numerical methods such as integration and solving differential equations using computational tools.
4. Develop and implement VBA programs including User Defined Functions (UDFs), subroutines, and macros to automate engineering computations.

SET OF EXPERIMENTS

Sl. No.	Experiments
1.	Charting: Create an XY scatter graph, XY chart with two Y-Axes, add error bars to your plot, create a combination chart
2.	Functions: Computing Sum, Average, Count, Max and Min, Computing Weighted Average, Trigonometric Functions, Exponential Functions, Using The CONVERT Function to Convert Units
3.	Conditional Functions: Logical Expressions, Boolean Functions, IF Function, Creating a Quadratic Equation Solver, Table VLOOKUP Function, AND, OR and XOR functions.
4.	Regression Analysis: Trendline, Slope and Intercept, Interpolation and Forecast, The LINEST Function, Multilinear Regression, Polynomial Fit Functions, Residuals Plot, Slope and Tangent, Analysis ToolPack.
5.	Iterative Solutions Using Excel: Using Goal Seek in Excel, Using The Solver To Find Roots, Finding Multiple Roots, Optimization Using The Solver, Minimization Analysis, NonLinear Regression Analysis.
6.	Matrix Operations Using Excel: Adding Two Matrices, Multiplying a Matrix by a Scalar, Multiplying Two Matrices, Transposing a Matrix, Inverting a Matrix and Solving System of Linear Equations.
7.	VBA User-Defined Functions (UDF): The Visual Basic Editor (VBE), The IF Structure, The Select Case Structure, The For Next Structure, The Do Loop Structure, Declaring Variables and Data Types, An Array Function The Excel Object Model, For Each Next Structure.
8.	VBA Subroutines or Macros: Recording a Macro, Coding a Macro Finding Roots by Bisection, Using Arrays, Adding a Control and Creating User Forms.
Demonstration Experiments (For CIE)	
9.	Numerical Integration Using Excel: The Rectangle Rule, The Trapezoid Rule, The Simpson's Rule, Creating a User-Defined Function Using the Simpson's Rule.
10.	Differential Equations: Euler's Method, Modified Euler's Method, The Runge Kutta Method, Solving a Second Order Differential Equation

Suggested Learning Resources: (Textbook/ Reference Book/ Manuals):

1. McFedries Paul, “Microsoft Excel 2019 Formulas and Functions” Microsoft Press, U.S, 2019.
2. Joan Lambert and Curtis D Frye, “Microsoft Excel Step by Step”, Pearson Education, 2022.

Web links and Video Lectures (e-Resources):

https://www.youtube.com/watch?v=q02ROKSTGBY

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Flipped Classroom with pre-lab video resources
2. Demonstration-based and hands-on learning
3. Problem-based and case-based learning approaches
4. Mini projects and open-ended experiments

5. ICT-Enabled Teaching
6. Peer learning and collaborative activities
7. Exposure to industry tools like Excel Solver and VBA

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for CIE – Continuous assessment:

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Concept Understanding & Application (CO1/PO1)	Complete understanding of concepts	Good understanding with minor conceptual errors	Basic understanding but limited application	Partial understanding with incorrect application	No clear understanding
Problem Solving & Numerical Methods (CO2/PO2,3)	Accurately applies iterative, optimization, and regression technique	Minor mistakes in approach or calculation	Uses correct method but incomplete execution	Incorrect method selection or major errors	Unable to solve problems
Computational Implementation (Excel/VBA) (CO3,4/PO3,5)	Efficient implementation of Excel tools, matrix,VBA	Correct implementation with minor issues	Basic implementation with limited efficiency	Errors in coding or formula usage	Unable to implement
Data Analysis & Interpretation (CO1,2/PO4)	Insightful analysis of graphs, regression, and results	Good interpretation with minor gaps	Basic analysis without depth	Incorrect or weak interpretation	No analysis
Lab Record, Presentation & Documentation (CO4/PO9, 10)	Complete with explanation of results	Organized with minor missing details	Acceptable but lacks clarity	Poor organization	Incomplete / missing

Rubrics for SEE / CIE Test:					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Problem Understanding (CO1/PO1)	Clearly understands problem independently	Minor clarifications needed	Partial understanding	Misinterprets problem	No understanding
Solution Approach (CO2/PO2)	Optimal method selected correctly	Good method with minor inefficiencies	Basic method	Incorrect approach	No approach
Execution (Excel/VBA) (CO3,4/PO3,5)	Accurate implementation (Excel/VBA/ tools)	Minor execution errors	Partial execution	Major errors	Student has not understood the concepts clearly
Output & Accuracy (CO2/PO4)	Correct results with validation	Minor deviations	Partially correct	Incorrect results	No output
Viva-Voce (CO1-4/PO9)	Answers confidently with deep knowledge	Good understanding	Basic answers	Limited responses	Unable to answer

Prompt Engineering			
Course Code	**1BMEL307D**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	III
Teaching Hours/Week (L :T : P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2

Course outcomes (Course Skill Set)

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

- Explain the fundamentals of Artificial Intelligence.
- Design effective prompts for engineering problem-solving.
- Apply AI tools for CAD, simulation, thermodynamics and manufacturing tasks.
- Analyze mechanical systems using AI-assisted reasoning.
- Develop domain-specific prompts for design optimization and analysis.
- Demonstrate problem-solving using prompt engineering in real-world ME scenarios.

SET OF EXPERIMENTS

1. Introduction to AI Tools (ChatGPT, Gemini)
2. Zero-Shot Prompting: Writing prompts for Thermodynamics problems
3. One-Shot Prompting: Solving of Strength of Materials numerical problems
4. Few-Shot Prompting: Heat transfer concepts
5. Role-Based Prompting: Using AI for CAD design idea generation (AutoCAD/SolidWorks concepts)
6. Instruction-Based Prompting: Prompt engineering for Manufacturing Processes (casting, welding, machining)
7. Iterative Prompting: Error analysis and refinement of engineering solutions
8. Develop AI prompt for the datasets given.
9. Design a prompt to optimize a heat exchanger system
10. Develop AI prompts for failure analysis of mechanical components
11. Develop AI prompts for inspection of cad model and final machined part using image files.
12. Create prompts for predictive maintenance using sensor data
13. Generate AI-based design concepts for sustainable mechanical systems

Suggested Learning Resources:

<u>Textbooks:</u>

1. Russell S & Norvig P, “Artificial Intelligence: A Modern Approach”, 3rd Ed., Pearson, 2020.
2. Phoenix J & Taylor M, “Prompt Engineering for Generative AI”, O’Reilly, 2024.
3. Tabatabaian M, “Prompt Engineering Using ChatGPT”, Mercury Learning, 2024.
4. Hibbeler R C, “Engineering Mechanics: Statistics & Dynamics,” 15th Ed., Pearson, Latest Edition.

<u>Reference books / Manuals:</u>

1. Ian Khan, “The Quick Guide to Prompt Engineering”, Wiley, 2024.
2. Sharma R C & Bozkurt A, “Transforming Education with Generative AI”, IGI Global, 2024.
3. Chip Huyen, “AI Engineering”, O’Reilly, 2024.

Web links and Video Lectures (e-Resources):

- https://www.promptingguide.ai
- https://openai.com
- https://towardsdatascience.com

YouTube Links:

- https://www.youtube.com/watch?v=YhRfgYH_AoU
- https://www.youtube.com/watch?v=n0VpK1RfYGA
- https://www.youtube.com/watch?v=AgGu96_rnXo&list=PLYio3GBcDKsPP2_zuxEp8eCulgFjI5a3g
- https://www.youtube.com/watch?v=BzIF4hrEgyk

Teaching-Learning Process (Innovative Delivery Methods):
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.
1. **Hands-on Learning using AI Tools:**
2. **Problem-Based Learning (PBL) using Mechanical Case Studies**

Assessment Structure:
The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final total marks for report and test shall be out of 50 marks.

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for CIE – Continuous assessment:

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Concept Understanding & AI Tool Application (PO1)	Demonstrates comprehensive understanding of AI tools, prompting techniques, and their engineering applications.	Demonstrates good understanding with minor conceptual gaps.	Demonstrates basic understanding with limited application.	Demonstrates partial understanding with incorrect application.	Demonstrates little or no understanding of AI concepts.
Prompt Design and Engineering (PO2, PO3)	Develops clear, well-structured, and context-specific prompts that consistently generate relevant engineering solutions.	Develops effective prompts with minor improvements needed.	Develops basic prompts that produce partially relevant outputs.	Develops incomplete or ambiguous prompts with limited effectiveness.	Unable to formulate meaningful prompts.
AI-Based Problem Solving and Refinement (PO3, PO4)	Effectively applies iterative prompting to solve engineering problems, refine AI outputs, and justify improvements.	Solves engineering problems using AI with minor refinements required.	Solves basic problems with limited refinement of AI responses.	Requires significant guidance to obtain acceptable AI outputs.	Unable to use AI effectively for engineering problem solving.
Analysis and Interpretation	Critically analyses AI-	Correctly interprets AI	Provides basic	Interpretation is weak or	Unable to analyse or

of AI Outputs (PO4)	generated responses, identifies limitations, validates results, and provides sound engineering interpretation.	outputs with minor omissions.	interpretation with limited validation.	partially incorrect.	interpret AI-generated results.
Laboratory Record, Prompt Documentation & Presentation (PO9, PO10)	Laboratory record is complete, well-organized, and includes prompts, AI outputs, observations, refinements, conclusions, and proper documentation.	Record is complete with minor omissions or presentation issues.	Record contains essential information but lacks clarity or detail.	Record is incomplete, poorly organized, or lacks proper documentation.	Record is inadequate or not submitted.

Rubrics for SEE / CIE Test:

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Problem Understanding (PO1)	Clearly understands the engineering problem and independently identifies the appropriate AI prompting strategy.	Understands the problem with minor clarifications.	Demonstrates basic understanding but requires guidance.	Partially understands or misinterprets the problem.	Unable to understand the problem.
Prompt Design and Solution Strategy (PO2, PO3)	Develops well-structured, context-specific prompts and selects the most appropriate prompting technique to obtain accurate engineering solutions.	Develops appropriate prompts with minor deficiencies in structure or strategy.	Develops basic prompts that produce partially relevant responses.	Develops incomplete or ineffective prompts requiring significant guidance.	Unable to formulate meaningful prompts or solution strategy.
Prompt Refinement and AI Tool Utilization (PO3, PO5)	Effectively uses AI tools and iterative prompting to refine responses, improve solution quality, and accomplish the assigned engineering task.	Uses AI tools correctly with minor refinements needed.	Uses AI tools with basic prompting and limited refinement.	Uses AI tools with frequent errors or ineffective prompting.	Unable to use AI tools effectively for the assigned task.
Output Analysis and Engineering Interpretation (PO4)	Critically analyses AI-generated outputs, validates engineering relevance, identifies limitations, and provides	Correctly interprets outputs with minor omissions or inaccuracies.	Provides basic interpretation with limited engineering validation.	Interpretation is incomplete or technically weak.	Unable to analyse or interpret AI-generated outputs.

	appropriate conclusions.				
Viva-Voce **(PO9)**	Answers confidently with comprehensive understanding of AI tools, prompting techniques, engineering applications, and limitations.	Demonstrates good understanding with minor conceptual gaps.	Provides basic answers with acceptable understanding.	Responds with limited understanding and requires prompting.	Unable to answer questions satisfactoril y.

Complex Analysis and Probability Distributions

Course Code	**1BMATM401**	Scheme	**2025**
Type of Course	**ASC**	Semester	IV
Teaching Hours/Week (L: T: P)	2:2:0	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42:0:0:24:24	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

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

CO1: Apply concepts of complex analysis, Cauchy-Riemann equations, Milne-Thomson method, and harmonic functions to construct and analyze analytic functions in engineering applications.

CO2: Apply Laplace Transform to solve ODE' S and PDE'S of Engineering Problems.

CO3: Apply probability distributions and joint probability concepts to model and analyze uncertainties encountered in mechanical engineering systems.

CO4: Utilize sampling theory, hypothesis testing, and Markov chain models for statistical inference and stochastic system analysis.

CO5: Analyze engineering reliability and queueing problems using statistical measures, queueing models, and reliability indices for performance evaluation and decision-making.

Module-1: Complex Analysis

Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms. Construction of analytic functions: Milne-Thomson Method-Problems, Harmonic Functions-Problems.

Number of Hours: **9**

Module-2: Laplace Transforms

Laplace Transform: Definition and Laplace transform of elementary functions (statements only) Problems on Properties: $L[f(at)] = \left(\frac{1}{a}\right)\bar{f}\left(\frac{s}{a}\right)$, $L[e^{at}f(t)] = \bar{f}(s-a)$, $L[t^n f(t)] = (-1)^n \frac{d^n}{ds^n}[\bar{f}(s)$, $L = \left[\frac{f(t)}{t}\right] = \int_s^\infty \bar{f}(s)ds$. Laplace transforms of unit-step function – problems.

Inverse Laplace Transform: Definition and problems on inverse Laplace transforms (without Proof). Solution of linear ordinary differential equations using Laplace transforms.

Number of Hours: **9**

Module-3: Probability Distributions

Review of basic probability theory. Random variables (discrete and continuous), probability mass and density functions. Binomial, Poisson and normal distributions- problems.

Joint Probability Distribution: Joint Probability distribution for two discrete random variables, expectation, covariance and correlation.

Number of Hours: **8**

Module-4: Sampling theory

Sampling theory: Sampling, Sampling distributions, standard error, Type I and Type II errors, Level of significance, confidence limits for means, one tailed and two tailed tests, test of hypothesis (Single mean, Single proportion, difference of means and difference of proportions), student's t-distribution, Chi-square distribution (goodness of fit of poison),

Number of Hours: **8**

Module-5: Markov Chain, Queueing Theory and Reliability Engineering

Stochastic Process: Stochastic processes, probability vector, stochastic matrices, fixed points, regular stochastic matrices, Markov chains, higher transition probability-problems.

Queueing Theory: Problems on Queueing model with M/M/1 (No derivation)

Reliability Engineering: Reliability of systems, Problems on MTTF, MTBF. (No derivations).

Number of Hours: **8**

Suggested Learning Resources: (Textbook/ Reference Book/ Manuals):

Textbooks:

1. S C Gupta and V K Kapoor, "Fundamentals of Mathematical Statistics", 12th Ed., S. Chand Publishing.
2. R K Jain and S R K Iyengar, "Advanced Engineering Mathematics", 5th Ed., Narosa Publishing House.
3. B S Grewal, "Higher Engineering Mathematics", 45th Ed., Khanna Publishers.

Reference books / Manuals:

1. B V Ramana, "Higher Engineering Mathematics", Mc Graw-Hill Education, 2017
2. M R Spiegel, J Schiller, and R A Srinivasan, "Schaum's Outline of Probability and Statistics", McGraw Hill.
3. S P Gupta," Statistical Methods", 46th Ed., Sultan Chand & Sons, 2023.
4. V K Rohatgi and A K Md. Ehsanes Saleh, "An Introduction to Probability and Statistics", 2nd Ed., Wiley

Web links and e-Resources:

- https://nptel.ac.in/courses/111105160
- https://nptel.ac.in/courses/127106019
- https://ocw.mit.edu/courses/18-335j-introduction-to-numerical-methods-spring-2019/
- https://ocw.mit.edu/courses/18-330-introduction-to-numerical-analysis-spring-2012/pages/syllabus/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop students' theoretical and applied mathematical skills.
2. State the need for Mathematics with Engineering Studies and Provide real-life examples.
3. Support and guide the students for self–study.
4. You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress.
5. Encourage the students to learn groups to improve their creative and analytical skills.
6. Show short-related video lectures in the following ways:
   - As an introduction to new topics (pre-lecture activity).
   - As a revision of topics (post-lecture activity).
   - As additional examples (post-lecture activity).
   - As an additional material of challenging topics (pre-and post-lecture activity).
   - As a model solution of some exercises (post-lecture activity).

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.
The CIE Theory component consists of average of TWO IA tests for 25 marks and Continuous Comprehensive Assessments (CCA) for 25 marks.

To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE is at least 40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]
A minimum of **two Internal Assessment Tests (IA)**shall be conducted, carrying a total of **25 marks.**
In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**
It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Assignment (at RBL3 or RBL4 levels) for Teamwork	10
2.	GATE-based Aptitude Test	15

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1.	Seminar on Complex Analysis	5
2.	MATLAB/Python Simulation of Laplace-Transform problems	5
3.	Mini Project on statistical Models in Engineering Applications	9
4.	Case Study on Signal Processing using Transform Techniques	5
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	MOOCs/NPTEL Courses	24

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):
1. Sample Rubrics - Mini-Project

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Problem definition & data	Clear, relevant engineering questions; data source and limitations documented.	Mostly clear; minor gaps in context or data description.	Vague questions or poorly documented data.	10%
Data processing & descriptive statistics	Correct cleaning, visualization, and computation of key measures; patterns clearly highlighted.	Mostly correct; minor computational errors.	Significant errors, missing key measures or plots.	25%
Probabilistic modelling (distributions, inference)	Appropriate distributions and tests used; assumptions stated; results interpreted in context.	Reasonable choice of models; some assumptions implicit; interpretation mostly sound.	Inappropriate or poorly justified models; limited interpretation.	30%
Engineering insight / risk framing	Clear link to design/assessment decisions, safety and uncertainty; limitations discussed.	Some discussion of implications; limited treatment of limitations.	Minimal engineering interpretation on beyond numbers.	20%
Report & communication	Well-structured report, clear figures/tables, reproducible calculations; effective brief presentation.	Acceptable structure; some clarity issues; presentation adequate.	Disorganized or incomplete report; weak presentation.	15%

Students' activities for TW/SL under NCrF: Samples only
As per National credit formwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/ Self learning (TW/Sl-50 hours). Hence, students must complete minimum of two activities as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.

2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

Automotive Engines			
Course Code	**1BAU402**	Scheme	**2025**
Type of course	**IPCC**	Semester	IV
Teaching Hours/Week (L:T:P)	3:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42:0:28:20:30	SEE Marks	50
Credits	**4**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	3

Course Outcome (Course Skill Set):

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

1. Differentiate between the constructions details of spark ignition and compression ignition engines and to classify engines.
2. Explain the construction and working principle of fuel systems
3. Explain combustion process in SI and CI engines and identify the abnormal combustion
4. Explain supercharging and turbo charging and apply the same to IC engines
5. Choose cooling and lubrication systems for automotive engines

Module-1

Construction and Operation: Engine classification, Constructional details of spark ignition (SI) and compression ignition (CI) engines. Working principles. Two stroke SI and CI engines – construction and working. Comparison of SI and CI engines and four stroke and two stroke engines, theoretical and actual valve timing diagrams for engines.

Modern engine layouts: In-line, V-engine, Boxer, opposed cylinder engines, radial engines

Number of Hours: 9

Module-2

Fuel Systems: Air fuel ratio requirements of SI engines, Working of a simple fixed venturi carburetor and limitations, gasoline injection system, types, Diesel fuel injection systems-inline pumps, distributor pumps, Types of Nozzles, Unit injector and common rail injection systems, Need and types of governor for diesel engines and their comparison.

Number of Hours: 8

Module-3

Combustion in S. I. and C. I. Engines: Introduction to combustion in SI and CI engines and stages of combustion. Factors effecting ignition lag and flame propagation in S.I. Engines, factors effecting delay period and uncontrolled combustion in C.I. Engines. Importance of Swirl, squish and turbulence in C.I. Engines.

Number of Hours: 8

Module-4

Supercharging, Turbocharging: Introduction to supercharging and Turbocharging, Different methods of turbocharging, Intercooling, Turbocharger controls including, waster gate, variable geometry Cooling systems: Need for cooling, types of cooling systems- air and liquid cooling systems. Thermo-syphon and forced circulation and pressurized cooling systems. Properties of coolants.

Number of Hours: 9

Module-5

Fuels for S. I. and C. I Engines Fuels for S.I and C. I engines and their requirements, Fuel ratings necessity of lubrication systems. Types-mist, pressure feed, dry and wet sump systems.

Properties of lubricants, SAE viscosity grading of lubricants, Oil additives and their functions. Selection criteria of engine lubricants, Bharath Stage (BS) norms.

Number of Hours: 8

PRACTICAL COMPONENTS OF IPCC

PART – A: FIXED SET OF EXPERIMENTS

1. Dismantling, Study and Assembling of Single cylinder / Multi Cylinder SI Engine.
2. Dismantling, Study and Assembling of Single cylinder and Multi Cylinder C I Engine.
3. Study of Oil filter, Fuel filter, Fuel injection system and Carburettor.
4. Study of MPFI and CRDI Systems.
5. Study of Ignition Systems – Battery coil, Magneto and Electronic.
6. Performance test on Single Cylinder and multi cylinder SI / CI engines
7. Study on SI and CI engines performance by changing parameters like valve timing, ignition timing, compression ratio, etc
8. Morse test on multi cylinder engine for finding FP, IP, Indicated thermal efficiency and Mechanical efficiency.
9. Study of engine performance using alternate fuels like alcohol blends/ bio diesel / LPG.
10. Study and testing on MPFI Engine and Variable compression ratio Engine.
11. Exhaust Emission test of S. I. and C I Automotive engine.

Suggested Learning Resources:

Textbooks:

1. V. Ganesan, "Internal Combustion Engines", Tata McGraw Hill, 2007.
2. Ramalingam K K, "Internal Combustion Engines", Sci-Tech Publications, 2005.

<u>Reference Books / Manuals:</u>

1. Heinz Heisler, "Advanced Engine Technology", Butterworth-Heinemann, 1995.
2. H N Gupta, "Fundamentals of Internal Combustion Engines", 2nd Ed., PHI, 2013.
3. M L Mathur and R P Sharma, "Internal Combustion Engines", Dhanpat Rai Publications, 2018.
4. John B. Heywood, "Internal Combustion Engines – Fundamentals", 2nd Ed., McGraw-Hill, 2018.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/107106088
2. https://www.youtube.com/watch?v=Y32gDgLq6hE
3. https://www.youtube.com/watch?v=mmmcj53TNic
4. https://www.youtube.com/watch?v=fw8Jfoif1BM

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Simulation and Virtual Labs
- ICT-Enabled Teaching

Assessment Structure:
The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks**.

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

CIE Practical component:
The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.
The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

Continuous Internal Evaluation (CIE)
(i) Theory component
The CIE marks of 25 shall be earmarked for two tests.
The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.
Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component
Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.
The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.
(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

Passing requirement in SEE
For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

Table – ICs/IPCCs 1 Distribution of marks		
Component	**Description**	**Marks**
Allotment of marks for regular class work		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Rubrics for Practical CIE – Continuous Assessment:

Performance Indicator (COs/POs)	Superior	Good	Fair	Needs Improvement	Unacceptable
Ability in Conducting Experiments (CO3/PO2, PO3, PO4, PO8) **(10 Marks)**	Demonstrates excellent understanding of the experiment, independently prepares specimens, safely operates equipment, follows procedures accurately, records observations systematically, actively participates in the experiment and analyse the results effectively **(9 – 10 Marks)**	Performs the experiment correctly with minimal guidance, follows safety practices, and records observations with only minor errors. **(7 - 8 Marks)**	Performs the experiment satisfactorily with occasional guidance, follows procedures adequately, and records acceptable observations **(5 - 6 Marks)**	Requires frequent assistance in conducting the experiment, shows limited understanding of equipment/procedure, and records incomplete or inaccurate observations. **(3 – 4 Marks)**	Unable to perform the experiment independently, does not follow procedures or safety practices, and fails to obtain or record meaningful observations. **(1 - 2 Marks)**
Laboratory Record / Journal (PO9) **(20 Marks)**	Record book is complete, neat, and well-organized with objectives, theory, procedure, observations, calculations, graphs/microstructures, results, discussion, and precautions.	Record book is complete with good presentation; minor omissions or formatting errors; calculations and results are mostly accurate;	Record book contains all essential sections but lacks detail in presentation, analysis, or interpretation; few calculation or recording errors.	Record book is incomplete, poorly organized, contains several errors or missing sections, and/or delayed submission. **(5 - 8 Marks)**	Record book is largely incomplete, inaccurate, poorly maintained, or not submitted. **(2 - 4 Marks)**

	Results are accurate and submitted on time. **(17 – 20 Marks)**	submitted on time. **(13 – 16 Marks)**	**(9 - 12 Marks)**		

Term Work (TW) and Self Learning (SL) components in Number of hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Study of recent developments in internal combustion engines, alternative fuels, turbocharging, and Bharat Stage (BS) emission norms through literature survey.	10
2.	Industrial/ workshop visits	10
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	MOOCs/NPTEL Courses/Video Lectures	30

Theory of Machines			
Course Code	**1BAU403**	Scheme	**2025**
Type of Course	**PCC**	Semester	IV
Teaching Hours/Week (L:T:P)	3:2:0	CIE Marks	50
Total Hours of Pedagogy per semester L:T:P:SL:TW	42:28:0:35:15	SEE Marks	50
Credits	04	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. identify and enumerate different link-based mechanisms with basic understanding of motion, types of vibration, SHM and methods of finding natural frequencies of simple mechanical systems.
2. Explain the causes and effects of vibration in mechanical systems.
3. Develop schematic models for physical systems and formulate governing equations of motion and vibrations.
4. To analyse the mathematical models and to determine its response of real-life engineering systems.

Module-1

Introduction: Mechanisms and machines, Kinematic pairs-types, degree of freedom, Kinematic chains and their classification, Kinematic inversions, Velocity and Acceleration analysis of planar mechanisms.

Graphical method: Velocity and Acceleration Analysis of Mechanisms Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Corioli's component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing.

Number of Hours: 9

Module-2

Static force analysis: Static equilibrium, analysis of four bar mechanism, slider crank mechanism, shaper mechanism.

Dynamic force analysis: D'Alembert's principle, analysis of four bar and slider crank mechanism, shaper mechanism. Flywheel: Introduction to Flywheel and calculation of its size for simple machines like punching machine.

Number of Hours: 8

Module-3

Spur Gears: Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference, condition and expressions for minimum number of teeth to avoid interference.

Gear Trains: Simple gear trains, compound gear trains. Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains.

Number of Hours: 8

Module-4

Balancing of Rotating Masses: Static and Dynamic Balancing, Balancing of single rotating mass by balancing

masses in the same plane and in different planes. Balancing of several rotating masses by balancing masses in the same plane and in different planes.

Governors: Types of Governors; Force Analysis of Porter and Hartnell Governors. Controlling Force, Stability, Sensitiveness, Isochronism, Effort and Power.

Number of Hours: 9

Module-5

Free vibrations: Basic elements of vibrating system, Types of free vibrations, Longitudinal vibrations-Equilibrium method, D'Alembert's principle, Determination of natural frequency of single degree freedom Systems.

Damped free vibrations: Under damped, over damped and critically damped systems. Logarithmic decrement.

Forced vibrations: Undamped forced vibration of spring mass system, Damped forced vibrations, Rotating unbalance, Reciprocating unbalance, Vibration isolation, Critical speed.

Number of Hours: 9

Suggested Learning Resources:

Textbooks:

1. Rattan S S, "Theory of Machines", 3rd Ed., Tata McGraw-Hill Publishing Company Ltd., 2009.
2. Sadhu Singh, "Theory of Machines", 2nd Ed., Pearson Education Inc., 2006.
3. V P Singh, "Mechanical Vibrations", 3rd Ed., Dhanpat Rai & Company, 2006.

Reference books / Manuals:

1. S S Rao, "Mechanical Vibrations", 4th Ed., Pearson Education Inc., 2003.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112105268
2. https://nptel.ac.in/courses/112106270
3. https://nptel.ac.in/courses/112101096
4. https://nptel.ac.in/courses/112103111
5. https://nptel.ac.in/courses/112107212
6. https://nptel.ac.in/courses/112107087

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Video demonstrations
- Simulations.
- Flipped Classroom
- Problem-Based Learning (PBL)
- Group Learning

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Internal Assessment Test (IA) + Continuous Comprehensive Assessments (CCA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**. It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Case Study Presentation on Applications of Mechanisms, Gear Trains, Governors, and Flywheels in Mechanical Systems.	10
2.	Kinematic and Dynamic Analysis of Mechanical Systems – Technical Report	15

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Comprehensive Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Rubrics for Learning Activity 1
Case Study Presentation on Applications of Mechanisms, Gear Trains, Governors, and Flywheels in Mechanical Systems.

Performance Indicator (COs/POs)	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Understanding of Mechanical Systems (PO1)	Demonstrates comprehensive understanding of the selected mechanical system and its components	Good understanding with minor gaps	Basic understanding	Limited understanding	Unable to explain the system
Application of Kinematic and Dynamic Principles (PO2)	Correctly explains the application of kinematic and dynamic principles to the selected system	Mostly correct explanation	Partial application	Minimal application	No application of concepts
Case Study Analysis and Interpretation (PO2, PO4)	Presents comprehensive analysis with appropriate interpretation and engineering justification	Good analysis with minor omissions	Adequate analysis	Limited analysis	No meaningful analysis
Presentation and Technical Communication (PO10)	Well-organized, technically sound, and confidently presented	Good presentation with minor errors	Average presentation	Poor organization and communication	Unable to present effectively
Team Participation and Collaboration (PO9, PO10)	Highly active and collaborative throughout the activity	Good participation	Moderate participation	Limited participation	No participation

Rubrics for Learning Activity 2 Kinematic and Dynamic Analysis of Mechanical Systems – Technical Report					
Performance Indicator (COs/POs)	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Selection and Understanding of Mechanical System (PO1)	Appropriately selects the mechanical system and demonstrates comprehensive understanding of its working principles	Appropriate selection with good understandi ng	Basic understanding of the selected system	Limited understanding	Unable to explain the selected system
Kinematic and Dynamic Analysis (PO2)	Performs accurate and comprehensive kinematic and dynamic analysis with proper engineering justification	Mostly accurate analysis with minor errors	Partial analysis	Limited analysis	Unable to perform the analysis
Interpretation of Results (PO2, PO4)	Correctly interprets results and provides meaningful engineering conclusions	Good interpretatio n with minor omissions	Adequate interpretation	Limited interpretation	No meaningful interpretation
Technical Report Quality (PO10)	Well-structured, technically sound, and professionally presented	Good structure with minor errors	Average quality	Poor organization	Incomplete report
Presentation of Findings (PO10)	Presents findings clearly with confidence and effectively responds to queries	Good presentation with minor deficiencies	Average presentation	Poor presentation	Unable to present findings

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Case Study	15
2.	Technical Report	20
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Video Lectures	15

Fluid Mechanics			
Course Code	**1BME404**	Scheme	**2025**
Type of Course	**PCC**	Semester	IV
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42:0:0:38:10	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Identify and calculate the key fluid properties used in the analysis of fluid behavior.

CO2: Understand and apply the principles of pressure, buoyancy and floatation

CO3: Apply the knowledge of fluid dynamics while addressing problems of mechanical and chemical engineering.

CO4: Understand the concept of boundary layer in fluid flow and apply dimensional analysis to form dimensionless numbers in terms of input output variables

CO5: Understand the basic concept of compressible flow and

Module-1

Basics: Introduction, Properties of fluids-mass density, weight density, specific volume, specific gravity, viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus. Concept of continuum, types of fluids etc, pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, Absolute, gauge, atmospheric and vacuum pressures pressure measurement by simple, differential manometers and mechanical gauges. **Fluid Statics:** Total pressure and center of pressure for horizontal plane, vertical plane surface and inclined plane surface submerged in static fluid.

Number of Hours: 10

Module-2

Fluid Kinematics: Types of Flow-steady, unsteady, uniform, non-uniform, laminar, turbulent, one, two and three dimensional, compressible, incompressible, rotational, irrotational, streamlines, path lines, streak lines, velocity components, convective and local acceleration, velocity potential, stream function, continuity equation in Cartesian co-ordinates. Rotation, vorticity and circulation, Laplace equation in velocity potential and Poisson equation in stream function, flow net, Problems.

Laminar and Turbulent flow: Flow through circular pipe, between parallel plates, Power absorbed in viscous flow in bearings, Poiseuille equation.

Number of Hours: 8

Module-3

Fluid Dynamics: Momentum equation, Impacts of jets- force on fixed and moving vanes, flat and curved. Numericals. Euler's equation, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem, Application of Bernoulli's theorem such as venture meter, orifice meter, rectangular and triangular notch, pitot tube, orifices etc., related numericals.

Loss of head due to friction in pipes, Major and minor losses, pipes in series and parallel.

Number of Hours: 8

Module-4

Flow over bodies: Development of boundary layer, Lift and Drag, Flow around circular cylinders, spheres, aerofoils and flat plates, Streamlined and bluff bodies, boundary layer separation and its control.

Dimensional Analysis: Derived quantities, dimensions of physical quantities, dimensional homogeneity, Rayleigh method, Buckingham Pi-theorem, dimensionless numbers, similitude, types of similitude.

Number of Hours: 8

Module-5

Compressible flows: Speed of sound, adiabatic and isentropic steady flow, Isentropic flow with area change stagnation and sonic properties, normal and oblique shocks, flow through nozzles. **Introduction to CFD:** Necessity, limitations, philosophy behind CFD, applications.

Number of Hours: 8

Suggested Learning Resources:

Textbooks:

1. Fox R W, Pitchard P J and McDonald A T, "Introduction to Fluid Mechanics", 8th Ed., John Wiley & Sons Inc., 2010.
2. Cimbal J M, Cengel Y A, "Fluid Mechanics: Fundamentals and Applications", 5th Ed., McGraw-Hill, 2010.
3. Frank M White., "Fluid Mechanics", 9th Ed., McGraw-Hill, 2016.

Reference books / Manuals:

1. Dr. R K Bansal , "A textbook of Fluid Mechanics and Hydraulic Machines", 11th Ed., Laxmi Publications (P) Ltd., 2010.
2. Bruce R Munson, Theodore H. Okiishi, Wade W. Huebsch and Alric P. Rothmayer, "Fundamentals of Fluid Mechanics", 7th Ed., John Wiley & Sons Inc., 2012.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/112105171
- https://nptel.ac.in/courses/112105183

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Problem-Based Learning (PBL)
- Simulation and Virtual Labs
- ICT-Enabled Teaching

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Internal Assessment Test (IA) + Continuous Comprehensive Assessments (CCA) = Continuous Internal Evaluation CIE [25+25=50 marks]

i) A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.
ii) In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Case Study Presentation on Fluid Mechanics Applications (Venturimeter, Pitot Tube, Pipe Flow Systems, Aerofoil Applications)	15
2.	Application of Buckingham π-Theorem and Dimensional Analysis in Fluid Mechanics – Technical Report	10

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Comprehensive Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Rubrics for Learning Activity 1
Case Study Presentation on Fluid Mechanics Applications (Venturimeter, Pitot Tube, Pipe Flow Systems, Aerofoil Applications)

Performance Indicator (COs/POs)	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Understanding (CO2,3,4,5 / PO1)	Demonstrates comprehensive understanding of all components and their functions	Good understandi ng with minor gaps	Basic understanding	Limited understanding	Unable to explain components
Application of Concepts (CO2,3,4,5, PO2)	Correctly relates plant operation to cycle and efficiency concepts	Mostly correct analysis	Partial analysis	Minimal application	No application
Technical Report Quality (CO2,3,4,5, PO10)	Well-structured, detailed and professional	Good structure with minor errors	Average quality	Poor organization	Incomplete report
Observation and Data Interpretation (CO2,3,4,5, PO4)	Excellent observations with meaningful conclusions	Good observations	Adequate observation	Limited observation	No observation
Team Participation and Presentation (PO9, PO10)	Highly active and collaborative	Good participation	Moderate participation	Limited participation	No participation

Rubrics for Learning Activity 2
Application of Buckingham π-Theorem and Dimensional Analysis in Fluid Mechanics – Technical Report

Performance Indicator (COs/POs)	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Understanding (PO1)	Demonstrates comprehensive understanding of all components and their functions	Good understandi ng with minor gaps	Basic understanding	Limited understanding	Unable to explain components
Application of concepts (PO2)	Correctly identifies all major	Identifies Most components	Identifies some components	Few components	Unable to identify
Analysis (PO2)	Accurate analysis	Mostly correct analysis	Partial analysis	Minimal analysis	No analysis
Technical Report Preparation (PO10)	Comprehensive and professional report	Good report	Average report	Poor report	No report
Team Participation and	Highly active and collaborative	Good participation	Moderate participation	Limited participation	No participation

Presentation (PO9, PO10)					

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Case Study	23
2.	Technical Report	15
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	MOOCs/NPTEL Courses	10

Mechanical Measurements and Metrology Lab

Course Code	**1BMEL405**	Scheme	2025
Type of Course	PCCL	Semester	IV
Teaching Hours/Week (L:T:P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Examination type (SEE)	**Practical**	Exam Hours	2

Course outcome (Course Skill Set)

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

1. Explain the principles of measurement and metrology and recognize the importance of precision, accuracy, calibration, and standards in engineering applications.
2. Use conventional measuring instruments effectively, such as vernier calipers, micrometers, slip gauges, bevel protractors, comparators, and gauges for dimensional inspection.
3. Perform linear, angular, and comparative measurements of engineering components and interpret the results with reference to tolerances, limits, and fits.
4. Analyse measurement errors and assess instrument performance by identifying sources of uncertainty, repeatability, and calibration deviations in practical measurements.
5. Apply metrology concepts to open-ended engineering problems, including inspection planning, calibration studies, reverse engineering, and quality evaluation of manufactured parts.

PART – A
FIXED SET OF EXPERIMENTS

1. Introduction to Metrology and Basic Linear Measurements
   - Measurement using Vernier Caliper, Micrometer, Vernier Height Gauge, and Vernier Depth Gauge.
2. Measurement of Angles
   - Taper angle measurement using Sine Bar/Sine Centre and Slip Gauges.
3. Angular Measurement using Universal Bevel Protractor
4. Calibration of Outside Micrometer using Slip Gauges as Standard
5. Calibration of LVDT for Linear Displacement Measurement
6. Calibration of Load Cell for Force Measurement
7. Calibration of Thermocouple for Temperature Measurement
8. Inspection of Circular Run-out using Dial Indicator
9. Measurement of Surface Roughness using Surface Roughness Tester
10. Determination of the Effective Diameter of a Metric Thread using the Three-Wire Method

PART – B
OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Selection of suitable measuring instruments for dimensional and geometrical inspection of a given engineering component.
2. Calibration and performance assessment of a measuring instrument or sensor.
3. Evaluation of Surface Roughness of Engineering Components Manufactured by Different Machining Processes.

Suggested Learning Resources:

Textbooks:

1. Beckwith Marangoni and Lienhard, “Mechanical Measurements” 6th Ed., Pearson Education, 2007.
2. R K Jain, “Engineering Metrology”, 22nd Ed., Khanna Publishers, 2011.

<u>Reference books / Manuals:</u>

1. I C Gupta, “Engineering Metrology”, 7th Ed., Dhanpat Rai Publications, Delhi, 2012.
2. Graham T Smith, “Industrial Metrology”, 3rd Ed., Springer Publications, USA.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/112104250
- https://nptel.ac.in/courses/112106179

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- ICT-Enabled Teaching
- Adopt collaborative (Group Learning) learning in the class.
- Demonstrations

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for **30 marks.** Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to **20 marks.** Final average marks for report and test shall be out of 50 marks.

For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for CIE – Continuous assessment:					
Performance Indicator (COs/POs)	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Understanding of Metrology Concepts and Measurement Techniques (PO1)	Clearly explains the principles, operating procedures, and applications of measuring instruments and calibration techniques using appropriate technical terminology.	Demonstrates good understanding with minor conceptual gaps.	Demonstrates basic understanding of measurement concepts and instrument operation.	Demonstrates limited understanding with several inaccuracies.	Unable to explain the concepts or operation of measuring instruments.
Observation and Interpretation (PO2)	Accurately records measurements and observations, analyses the results, estimates measurement errors (where applicable), and relates the findings to the objectives of the experiment.	Records observations correctly with minor omissions in analysis or interpretation.	Records basic observations with limited analysis or interpretation.	Observations are incomplete or inaccurate with poor interpretation.	Fails to record meaningful observations or interpret the results.
Documentation (PO9)	Laboratory record is complete, well-organized, and includes objectives, instrument details, procedure, observations, calculations, graphs/tables (where applicable), results, and conclusions for all experiments.	Laboratory record is complete with minor omissions or formatting issues.	Laboratory record contains most essential sections with acceptable organization.	Laboratory record is incomplete or poorly organized with several missing sections.	Laboratory record is inadequate or not submitted.
Use of Figures, Sketches and Technical Presentation (PO9)	Includes clear sketches, instrument layouts, calibration curves / graphs, tables, and neat technical presentation that effectively supports the report.	Includes appropriate sketches, figures, or tables with minor presentation issues.	Includes basic sketches/tables with acceptable presentation.	Limited or poorly presented sketches, figures, or tables.	No relevant sketches, figures, graphs, or tables included.

Rubrics for SEE / CIE Test:					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Problem Understanding (PO1)	Clearly understands the measurement/inspection or calibration problem independently and identifies the appropriate measuring instrument and procedure.	Understands the problem with minor clarifications.	Demonstrates partial understanding and requires guidance.	Misinterprets the problem or selects an inappropriate measurement method.	Unable to understand the problem or identify the required measuring instrument.
Measurement / Inspection Approach (PO2)	Selects the appropriate measuring instrument, follows the correct measurement/calibration procedure, and applies the method systematically.	Selects the correct method with minor procedural errors.	Uses the basic measurement method with occasional guidance.	Incorrect selection of instrument or procedure; requires frequent assistance.	Unable to select or apply an appropriate measurement/calibration method.
Execution of Measurement / Calibration (PO3, PO5)	Performs measurement/calibration accurately, handles instruments properly, follows standard procedures and safety practices, and records observations systematically.	Performs the experiment correctly with minor execution or observation errors.	Performs the experiment satisfactorily with acceptable measurements and observations.	Frequent errors in instrument handling, measurement technique, or recording of observations.	Unable to perform the experiment or demonstrates inadequate understanding of the measuring instrument.
Results, Accuracy and Interpretation (PO4)	Obtains accurate results, validates measurements through appropriate calculations/comparisons, estimates errors (where applicable), and draws correct conclusions.	Results are generally accurate with minor deviations and acceptable interpretation.	Results are partially correct with limited analysis or interpretation.	Results are inaccurate with weak or incorrect interpretation.	Unable to obtain meaningful results or interpret the observations.
Viva-Voce (PO9)	Answers confidently with thorough understanding of metrology principles, measuring instruments, calibration methods, and applications.	Demonstrates good understanding with minor conceptual gaps.	Provides basic answers with acceptable understanding.	Gives limited responses and requires prompting.	Unable to answer questions satisfactorily.

Machine Learning using Python

Course Code	**1BMEL406A**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	IV
Teaching Hours/Week (L :T : P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2

Course outcome (Course Skill Set)

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

1. Explain the basic concepts of Machine Learning.
2. Use Python for simple data analysis tasks.
3. Perform data preprocessing using Python libraries.
4. Visualize data using basic plotting tools.
5. Develop simple machine learning models and evaluate their performance.

SET OF EXPERIMENTS

1. Introduction to Python programming – variables, operators, input/output, and basic functions.
2. Working with NumPy arrays and basic mathematical operations.
3. Introduction to Pandas – creating and manipulating data frames.
4. Reading and analyzing datasets using Pandas.
5. Handling missing values and basic data preprocessing.
6. Data visualization using Matplotlib (bar chart, line chart, pie chart, and histogram).
7. Introduction to Machine Learning and Scikit-Learn library.
8. Dataset splitting into training and testing sets.
9. Simple Linear Regression for prediction.
10. Classification using K-Nearest Neighbors (KNN).
11. Evaluating model performance using accuracy score and confusion matrix.
12. Mini-project: Build a simple prediction model using a small real-world dataset.

Suggested Learning Resources:

Textbooks:

1. Jake VanderPlas, “Python Data Science Handbook”, 2nd Ed., O'Reilly, 2016.
2. Andreas C Müller and Sarah Guido, “Introduction to Machine Learning with Python”, O'Reilly, 2016
3. Wes McKinney, “Python for Data Analysis”, 3rd Ed., O'Reilly, 2022.

<u>Reference books / Manuals:</u>

1. Ethem Alpaydin, “Introduction to Machine Learning”, 4th Ed., MIT Press, 2014.
2. Reema Thareja, Python Programming using Problem Solving Approach, Oxford University Press, 2017.
3. Scikit-Learn User Documentation.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/106106182
- https://nptel.ac.in/courses/106106212

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Demonstration-based laboratory sessions.
2. Hands-on coding exercises using Jupyter Notebook or Google Colab.
3. Learning through real-life datasets.
4. Peer discussions and collaborative problem-solving.
5. Mini-project-based learning.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final total marks for report and test shall be out of 50 marks.

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for CIE – Continuous assessment:

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Concept Understanding & Python Programming (PO1)	Demonstrates comprehensive understanding of Python programming concepts, data structures, libraries, and their applications in data analysis and machine learning.	Demonstrates good understanding with minor conceptual gaps.	Demonstrates basic understanding with limited application.	Demonstrates partial understanding with incorrect application.	Demonstrates little or no understandin g of Python programming concepts.
Program Development and Implementation (PO2, PO3)	Develops well-structured, efficient, and error-free Python programs using appropriate libraries to solve the assigned problem.	Develops correct programs with minor logical or syntax errors.	Develops basic programs with limited functionality or efficiency.	Develops incomplete programs requiring significant corrections.	Unable to develop a functional program.
Data Analysis and Machine Learning Implementation (PO3, PO4)	Effectively applies data preprocessing, visualization, and machine learning techniques to analyse datasets and obtain meaningful results.	Correctly applies the required techniques with minor refinements needed.	Performs basic data analysis or machine learning with limited interpretation.	Requires significant guidance to complete data analysis or model development.	Unable to perform data analysis or implement machine learning techniques.
Analysis and Interpretation of Results (PO4)	Critically analyses program outputs, validates results using appropriate evaluation metrics, and provides meaningful interpretation and conclusions.	Correctly interprets results with minor omissions.	Provides basic interpretation with limited validation.	Interpretation is weak or partially incorrect.	Unable to analyse or interpret the program results.
Laboratory Record, Program Documentation & Presentation (PO9, PO10)	Laboratory record is complete, well-organized, and includes objectives, algorithms, source code, outputs, observations, analysis, conclusions, and proper documentation.	Record is complete with minor omissions or presentation issues.	Record contains essential information but lacks clarity or detail.	Record is incomplete, poorly organized, or lacks proper documentation.	Record is inadequate or not submitted.

Rubrics for SEE / CIE Test:					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Problem Understanding (PO1)	Clearly understands the programming or machine learning problem and independently identifies the appropriate Python libraries, algorithms, and solution approach.	Understands the problem with minor clarifications.	Demonstrates basic understanding but requires guidance.	Partially understands or misinterprets the problem.	Unable to understand the problem.
Program Design and Solution Strategy (PO2, PO3)	Develops a well-structured program and selects the most appropriate Python constructs, libraries, and machine learning techniques to solve the assigned problem efficiently.	Develops an appropriate program with minor deficiencies in logic or implementation.	Develops a basic program that partially solves the problem.	Develops an incomplete or inefficient program requiring significant guidance.	Unable to develop a meaningful program or solution strategy.
Program Implementation and Tool Utilization (PO3, PO5)	Correctly implements the program using Python and relevant libraries (NumPy, Pandas, Matplotlib, Scikit-Learn), executes it successfully, and effectively utilizes the required tools.	Implements the program correctly with minor coding or execution errors.	Implements a basic program with limited functionality or minor execution issues.	Implements the program with frequent coding or execution errors.	Unable to implement or execute the program successfully.
Output Analysis and Interpretation (PO4)	Critically analyses the program output, validates results using appropriate evaluation methods or performance metrics, and provides meaningful conclusions.	Correctly interprets the output with minor omissions or inaccuracies.	Provides basic interpretation with limited validation of results.	Interpretation is incomplete or technically weak.	Unable to analyse or interpret the program output.
Viva-Voce (PO9)	Answers confidently with comprehensive understanding of Python programming, data analysis, machine learning concepts, algorithms, libraries, and applications.	Demonstrates good understanding with minor conceptual gaps.	Provides basic answers with acceptable understanding.	Responds with limited understanding and requires prompting.	Unable to answer questions satisfactorily.

PLC and Automation			
Course Code	**1BMEL406B**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	IV
Teaching Hours/Week (L :T : P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2

Course outcome (Course Skill Set)

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

1. Explain the fundamentals of Programmable Logic Controllers (PLCs) and industrial automation.
2. Identify basic PLC hardware components and their functions.
3. Develop simple ladder logic programs for industrial control applications.
4. Interface input and output devices with PLCs.
5. Design and implement basic automation systems using PLC programming.

SET OF EXPERIMENTS

1. Familiarization with PLC hardware, software, and programming environment.
2. Study of PLC architecture, input/output modules, and wiring concepts.
3. Development of basic ladder logic programs using logic gates (AND, OR, NOT).
4. Implementation of start-stop control of a motor using PLC.
5. Design of timer-based control circuits using ON-delay and OFF-delay timers.
6. Development of counter-based applications using PLC counters.
7. Control of traffic light sequencing using ladder logic.
8. Automatic water tank level monitoring and pump control using PLC.
9. Sequential control of industrial processes using PLC.
10. Interfacing sensors and actuators with PLC systems.
11. Introduction to Human Machine Interface (HMI) and monitoring of PLC operations.
12. Mini-project: Design and implementation of a simple industrial automation application using PLC.

Suggested Learning Resources:

Textbooks:

1. Frank D Petruzella, "Programmable Logic Controllers", 5th Ed., McGraw-Hill, 2023.
2. John W Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Ed., Pearson, 2002.

<u>Reference books / Manuals:</u>

1. Gary Dunning, "Introduction to Programmable Logic Controllers", 3rd Ed., Delmar Pub, 2006.
2. W Bolton, "Programmable Logic Controllers", Newnes, 6th Ed., 2015.
3. PLC Programming Manuals of Siemens.
4. PLC Programming Manuals of Allen-Bradley.
5. PLC Programming Manuals of Delta PLCs.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/108105088
- https://www.youtube.com/watch?v=jzy0so3h_kc
- https://www.youtube.com/@PLCGurusNET
- https://www.youtube.com/@realpars

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Demonstration of PLC hardware and industrial automation setups.
2. Hands-on programming using PLC simulation software.
3. Problem-based learning through industrial case studies.
4. Group activities for ladder logic development and troubleshooting.
5. Mini-project-based learning involving real-world automation applications.

Assessment Structure:
The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final total marks for report and test shall be out of 50 marks.

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for CIE – Continuous assessment:

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Concept Understanding & PLC Application (PO1)	Demonstrates comprehensive understanding of PLC architecture, programming concepts, industrial automation, and the application of PLCs in control systems.	Demonstrates good understanding with minor conceptual gaps.	Demonstrates basic understanding with limited application.	Demonstrates partial understanding with incorrect application.	Demonstrates little or no understanding of PLC concepts.
PLC Program Development and Implementation (PO2, PO3)	Develops well-structured ladder logic programs, correctly configures inputs/outputs, timers, counters, and control logic to achieve the desired automation task.	Develops effective PLC programs with minor logical or implementation errors.	Develops basic PLC programs with limited functionality.	Develops incomplete or incorrect PLC programs requiring significant guidance.	Unable to develop a functional PLC program.
Automation System Design and Troubleshooting (PO3, PO4)	Effectively designs, implements, tests, and troubleshoots PLC-based automation systems by correctly interfacing sensors, actuators, and HMI components.	Successfully implements automation tasks with minor troubleshooting or configuration issues.	Implements basic automation applications with limited troubleshooting ability.	Requires significant guidance in system implementation and troubleshooting.	Unable to implement or troubleshoot PLC-based automation tasks.
Analysis and Interpretation of PLC Operation (PO4)	Critically analyses PLC program execution, interprets input/output status, timing sequences, system response, and validates the correctness of the automation process.	Correctly interprets PLC operation with minor omissions.	Provides basic interpretation with limited validation of results.	Interpretation is weak or partially incorrect.	Unable to analyse or interpret PLC operation.

Laboratory Record, Program Documentation & Presentation **(PO9, PO10)**	Laboratory record is complete, well-organized, and includes objectives, ladder diagrams, wiring diagrams, program listings, observations, results, troubleshooting details, and conclusions with proper documentation.	Record is complete with minor omissions or presentation issues.	Record contains essential information but lacks clarity or detail.	Record is incomplete, poorly organized, or lacks proper documentation.	Record is inadequate or not submitted.

Rubrics for SEE / CIE Test:					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Problem Understanding **(PO1)**	Clearly understands the automation problem and independently identifies the appropriate PLC hardware, I/O configuration, and control strategy.	Understands the problem with minor clarifications.	Demonstrates basic understanding but requires guidance.	Partially understands or misinterprets the automation problem.	Unable to understand the problem or identify the required PLC application.
PLC Program Design and Solution Strategy **(PO2, PO3)**	Develops a well-structured ladder logic program and selects appropriate PLC instructions, timers, counters, I/O modules, and control logic to accomplish the assigned automation task.	Develops an appropriate PLC program with minor deficiencies in logic or implementation.	Develops a basic PLC program that partially satisfies the required automation task.	Develops an incomplete or ineffective PLC program requiring significant guidance.	Unable to develop a meaningful PLC program or solution strategy.
Program Execution and PLC System Implementation **(PO3, PO5)**	Correctly configures the PLC system, executes the ladder program, interfaces inputs/outputs, sensors, actuators, or HMI (where applicable), and verifies proper operation of the automation system.	Executes the PLC program correctly with minor configuration or implementation errors.	Executes a basic PLC program with limited functionality or minor operational issues.	Executes the program with frequent errors in configuration or operation.	Unable to execute the PLC program or implement the assigned automation task.
Output Analysis and Automation System Interpretation **(PO4)**	Critically analyses PLC operation, validates input/output responses, timing sequences, and	Correctly interprets PLC outputs with minor omissions or inaccuracies.	Provides basic interpretation with limited validation of system performance.	Interpretation is incomplete or technically weak.	Unable to analyse or interpret PLC operation or

	control logic, and provides appropriate engineering conclusions.				automation results.
Viva-Voce **(PO9)**	Answers confidently with comprehensive understanding of PLC architecture, ladder logic programming, industrial automation, sensors, actuators, HMI, and troubleshooting techniques.	Demonstrates good understandin g with minor conceptual gaps.	Provides basic answers with acceptable understanding.	Responds with limited understandi ng and requires prompting.	Unable to answer questions satisfactoril y.

Simulation of Kinematic Systems			
Course Code	**1BMEL406C**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	IV
Teaching Hours/Week (L :T : P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2

Course outcome (Course Skill Set)

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

1. Create and simulate kinematic models using commercial multibody dynamics software.
2. Apply kinematic constraints, joints, and motion drivers to model engineering mechanisms.
3. Analyze displacement, velocity, and acceleration characteristics of planar and spatial mechanisms.
4. Interpret simulation results and validate the kinematic behavior of mechanical systems.
5. Evaluate the performance of common engineering mechanisms such as linkages, cams, gears, and robotic systems.
6. Utilize simulation tools for the design and analysis of practical mechanical engineering systems.

SET OF EXPERIMENTS

1. Introduction to Kinematic Simulation Software and Mechanism Modelling
2. Simulation of a Four-Bar Linkage Mechanism
3. Position Analysis of a Slider-Crank Mechanism
4. Velocity Analysis of a Slider-Crank Mechanism
5. Acceleration Analysis of a Slider-Crank Mechanism
6. Simulation of Quick Return Mechanism
7. Simulation of Whitworth Quick Return Mechanism
8. Simulation of Cam and Follower Mechanism
9. Simulation of Gear Pair Mechanism
10. Simulation of Geneva Mechanism
11. Simulation of Differential Mechanism
12. Kinematic Analysis of an Industrial Robotic Manipulator

Note: Students may perform the experiments using any one of the following commercial software packages: MSC Adams /SolidWorks Motion /Autodesk Inventor Dynamic Simulation /Siemens NX Motion /CATIA Kinematics or any other equivalent free or open-source software.

Suggested Learning Resources:

Textbooks

1. Rattan S S, "Theory of Machines", 5th Ed., McGraw Hill Education, 2022.
2. Uicker J J, Pennock G R, and Shigley J E, "Theory of Machines and Mechanisms", 4th Ed., Oxford University Press, 2017.
3. Thomas Bevan, "Theory of Machines", 3rd Ed., CBS Publishers, 2019.

Reference Books / Manuals

1. Amitabha Ghosh and Ashok Kumar Mallik, "Theory of Mechanisms and Machines", 3rd Ed., East-West Press, 2019.
2. Robert L Norton, "Design of Machinery", 6th Ed., McGraw Hill Education, 2020.
3. MSC Adams User Manual.
4. SolidWorks Motion Analysis User Guide.

Web Links and Video Lectures (e-Resources)

Software Learning Resources

1. MSC Adams Documentation and Tutorials
   https://hexagon.com/products/adams
2. MSC Adams Learning Resources
   https://simcompanion.hexagon.com
3. SolidWorks Motion Analysis Tutorials
   https://help.solidworks.com
4. Autodesk Inventor Dynamic Simulation Tutorials
   https://help.autodesk.com/view/INVNTOR
5. Siemens NX Motion Simulation Resources
   https://docs.sw.siemens.com
6. CATIA Kinematics Documentation
   https://www.3ds.com/products-services/catia

Theory of Machines and Kinematics Resources

1. NPTEL – Theory of Machines
   https://nptel.ac.in/courses
2. SWAYAM Portal
   https://swayam.gov.in
3. MIT OpenCourseWare – Mechanical Engineering Courses
   https://ocw.mit.edu
4. Mechanical Engineering Video Lectures (NPTEL)
   https://www.youtube.com/@nptelhrd

Video Lecture Resources

1. SolidWorks YouTube Channel
   https://www.youtube.com/@solidworks
2. Autodesk Inventor YouTube Channel
   https://www.youtube.com/@Autodesk
3. Siemens Software YouTube Channel
   https://www.youtube.com/@SiemensSoftware
4. CATIA Official Channel
   https://www.youtube.com/@3DEXPERIENCEWorks
5. MIT OpenCourseWare YouTube Channel
   https://www.youtube.com/@mitocw

Additional Learning Resources

1. Khan Academy – Differential Equations and Mechanical Motion
   https://www.khanacademy.org/math/differential-equations
2. Engineering LibreTexts – Kinematics and Dynamics
   https://eng.libretexts.org
3. Wolfram Demonstrations Project – Mechanism Simulations
   https://demonstrations.wolfram.com

Recommended e-Resources for Course Delivery

- MSC Adams Tutorials and Documentation
- SolidWorks Motion Analysis Tutorials
- NPTEL Theory of Machines Courses
- MIT OpenCourseWare Resources
- Siemens NX Motion Tutorials
- Autodesk Inventor Dynamic Simulation Tutorials
- Official YouTube Channels of MSC Adams, SolidWorks, Autodesk, and Siemens

Teaching-Learning Process (Innovative Delivery Methods):
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes: 1. Demonstration and Guided Simulation 2. Hands-on Software-Based Learning 3. Visualization-Based Learning 4. Problem-Based Learning 5. Mini-Project and Case Study Approach
Assessment Structure: The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each). The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final total marks for report and test shall be out of 50 marks. • To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**. • To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**. • A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for CIE – Continuous assessment:

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Mechanism Modeling and Constraint Definition **(CO1, CO2)**	Accurately models mechanisms such as four-bar linkages, slider-crank, cam-follower, gears, and robotic manipulators with correct joints and constraints independently.	Models mechanisms correctly with minor errors in constraints or assembly.	Models basic mechanisms but requires guidance to define constraints correctly.	Creates incomplete models and requires significant assistance.	Unable to create a functional mechanism model.
Motion Simulation and Kinematic Analysis **(CO2, CO3)**	Successfully performs simulations and accurately obtains displacement, velocity, acceleration, trajectories, and motion characteristics.	Performs simulations correctly with minor errors in result extraction or analysis.	Performs basic simulations and obtains limited kinematic results.	Requires substantial assistance to perform simulations and interpret outputs.	Unable to perform simulations or generate meaningful results.
Analysis of Engineering Mechanisms **(CO3, CO4, CO5)**	Accurately analyzes the performance of mechanisms such as quick-return, Geneva, cam-follower, gear trains, and robotic manipulators, and clearly explains their kinematic behavior.	Demonstrates good understanding with minor interpretation errors.	Demonstrates basic understanding of mechanism operation and motion characteristics.	Shows limited understanding of mechanism behavior and simulation results.	Unable to explain mechanism operation or simulation outcomes.
Documentation, Demonstration	Maintains complete laboratory records, presents simulation	Maintains good records and	Maintains satisfactory records and	Records are incomplet	Fails to maintain records or

and Software Proficiency **(CO1, CO6)**	studies effectively, and demonstrates excellent proficiency in commercial simulation software.	demonstrates software usage with minor errors.	demonstrates basic software skills.	e and software usage requires significant guidance.	demonstrate software proficiency.

Rubrics for SEE / CIE Test:					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Mechanism Modeling and Simulation Setup **(CO1, CO2)**	Accurately creates mechanism models, applies joints, constraints, and motion drivers, and performs simulations independently without errors.	Creates and simulates mechanisms with minor errors requiring little guidance.	Creates basic mechanism models with some errors in setup or constraints.	Requires significant assistance to model and simulate mechanisms.	Unable to create a valid mechanism model or perform simulation.
Kinematic Analysis and Result Generation **(CO2, CO3)**	Accurately generates and evaluates displacement, velocity, acceleration, and trajectory results for the given mechanism.	Generates correct results with minor errors in analysis or interpretation.	Obtains basic simulation results but analysis is limited.	Generates incomplete or partially incorrect results.	Unable to generate meaningful kinematic results.
Interpretation of Mechanism Behavior **(CO3, CO4, CO5)**	Clearly explains mechanism motion, identifies key kinematic characteristics, and relates results to engineering applications.	Demonstrates good understanding with minor interpretation errors.	Demonstrates basic understanding of mechanism operation and motion characteristics.	Shows limited understanding of simulation results and mechanism behavior.	Unable to explain mechanism behavior or simulation outcomes.
Viva Voce and Software Proficiency **(CO1, CO6)**	Confidently answers questions related to mechanism modeling, simulation procedures, and result interpretation; demonstrates excellent software proficiency.	Answers most questions correctly and demonstrates good software skills.	Answers basic questions satisfactorily and demonstrates adequate software usage.	Answers few questions correctly and requires prompting to demonstrate software operations.	Unable to answer questions or demonstrate software usage.

Surface Modelling

Course Code	**1BMEL406D**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	IV
Teaching Hours/Week (L :T : P)	0:0:2	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	0:0:28:2:0	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2

Course outcome (Course Skill Set)

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

1. Explain the concepts of geometric representation and surface modelling.
2. Create basic and advanced surface features using CAD software.
3. Apply surface modelling techniques for product development and styling.

SET OF EXPERIMENTS

PART A (3 SESSIONS: 6 Hours): 40 Marks

Module 1: Introduction to Surface Modelling

- Geometric modelling: Wireframe, Surface, and Solid modelling
- Applications of surface modelling in engineering
- Parametric and non-parametric modelling
- Overview of CAD software for surface modelling
- Generation of various types of curves
- Surface generation techniques by using Extrude, Revolve, Sweep, Loft, Boundary surfaces etc – Surface modeling of simple 4 components.

PART B (10 SESSIONS: 20 Hours): 60 Marks

Advanced Surface Modelling techniques using Trimming and extending surfaces, Surface blending and filleting, Surface offsetting and thickening and such of those commands / techniques used to "Develop aesthetic and functional surfaces".

Create a Surface modelling of the following components:

- Liquid container to carry a specific volume of Shampoo/Cooking oil.
- Cover of a hair-dryer for the given dimensions.
- Computer mouse for the given dimensions.
- Car bumper
- Motorcycle fuel tank
- Drone body shell
- Surface Modelling for Automotive/Aeronautical applications

Suggested Learning Resources:

Textbooks:

1. Michael E. Mortenson, "Geometric Modeling", 3rd Ed., Industrial Press, 2006.
2. Ibrahim Zeid, "CAD/CAM Theory and Practice", 2nd Ed., McGraw-Hill Education, 2009.

<u>Reference books / Manuals:</u>

1. Les Piegl and Wayne Tiller, "The NURBS Book", Springer-Verlag, 1997.
2. Gerald Farin, "Curves and Surfaces for Computer-Aided Geometric Design: A Practical Guide", Academic Press, 2002.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/112102102
- https://www.youtube.com/watch?v=4G2E_DqQteM

Teaching-Learning Process (Innovative Delivery Methods):
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Flipped classrooms
2. Reverse Engineering activities
3. Industry Case-Based Learning
4. Mini design challenges

Assessment Structure:
The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks of all the reports shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final total marks for report and test shall be out of 50 marks.

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for CIE – Continuous assessment:

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Concept Understanding of Surface Modelling (PO1)	Demonstrates comprehensive understanding of wireframe, surface, and solid modelling, surface generation techniques, and their engineering applications.	Demonstrates good understanding with minor conceptual gaps.	Demonstrates basic understanding with limited application of concepts.	Demonstrates partial understanding with incorrect application of surface modelling concepts.	Demonstrates little or no understanding of surface modelling concepts.
CAD Modelling Skills and Command Application (PO2, PO3)	Effectively applies CAD tools and commands such as Extrude, Revolve, Sweep, Loft, Boundary, Trim, Extend, Blend, Fillet, Offset, and Thicken to develop accurate and high-quality surface models.	Applies most CAD commands correctly with minor errors or refinements required.	Applies basic CAD commands with partially correct models requiring improvements.	Uses CAD commands with significant errors and requires continuous guidance.	Unable to apply appropriate CAD commands to create surface models.
Surface Design, Accuracy and Engineering Application (PO3, PO4)	Develops aesthetically pleasing and functionally accurate surface models that satisfy design intent, dimensions, continuity, and engineering requirements.	Develops accurate models with minor dimensional or surface quality deviations.	Develops acceptable models with noticeable inaccuracies in geometry or continuity.	Models are incomplete or exhibit major dimensional and geometric errors.	Unable to develop functional surface models meeting design requirements.

Laboratory Record, Model Documentation & Presentation **(PO9, PO10)**	Laboratory record is complete, well-organized, and includes modelling procedure, command sequence, screenshots, observations, dimensions, design rationale, conclusions, and proper documentation.	Record is complete with minor omissions or presentation issues.	Record contains essential informatio n but lacks clarity, screenshot s, or sufficient detail.	Record is incomplete, poorly organized, or lacks proper documentation.	Record is inadequate or not submitted.

Rubrics for SEE / CIE Test:

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Problem Understanding **(PO1)**	Clearly understands the design problem, interprets the given dimensions/specifications accurately, and identifies the appropriate surface modelling approach independently.	Understands the design problem with minor clarifications required.	Demonstrates basic understanding but requires guidance to interpret specifications.	Partially understands or misinterprets the design requirements.	Unable to understand the modelling problem or design requirements.
Surface Modelling Strategy and CAD Command Application **(PO2, PO3)**	Selects and effectively applies appropriate surface modelling techniques and CAD commands (Extrude, Revolve, Sweep, Loft, Boundary, Trim, Extend, Blend, Fillet, Offset, Thicken, etc.) to develop accurate and aesthetically pleasing models.	Applies appropriate modelling techniques with minor errors or refinements required.	Uses basic modelling commands to develop partially correct surface models.	Uses modelling commands with significant errors and requires continuous guidance.	Unable to select or apply appropriate CAD commands for surface modelling.
Surface Model Development and Engineering Application **(PO3, PO5)**	Develops complete, dimensionally accurate, functional, and aesthetically optimized surface models that satisfy engineering requirements and design intent.	Develops accurate surface models with minor dimensional or geometric deviations.	Develops acceptable models with limited accuracy or surface continuity.	Produces incomplete models with major geometric or dimensional errors.	Unable to develop a functional surface model meeting the specified requirements.
Model Evaluation and Engineering Interpretation **(PO4)**	Critically evaluates surface quality, continuity, manufacturability, and functionality; identifies modelling limitations and proposes appropriate improvements with sound engineering justification.	Correctly evaluates the model with minor omissions or inaccuracies.	Provides basic evaluation with limited validation of model quality.	Evaluation is incomplete or technically weak and requires guidance.	Unable to analyse or evaluate the developed surface model.
Viva-Voce **(PO9)**	Answers confidently with comprehensive understanding of surface modelling concepts, CAD commands, modelling strategies, engineering applications, and design considerations.	Demonstrates good understanding with minor conceptual gaps.	Provides basic answers with acceptable understanding of modelling concepts and commands.	Responds with limited understanding and requires frequent prompting.	Unable to answer questions satisfactorily.

Automotive Transmission			
Course Code	**1BAU409**	Scheme	**2025**
Type of Course	**PCC**	Semester	IV
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy per semester L:T:P:SL:TW	42:0:0:33:15	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course outcome (Course Skill Set)

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

1. Explain the constructional, design and working principles of different types of ICE transmission systems
2. Determine the various parameters of vehicle transmission systems, optimal gear ratios and compare the construction and operation of manual gearboxes and mechanical friction clutches.
3. Analyse the performance characteristics and operating principles of fluid couplings, one-way clutches, and epicyclic transmission system.
4. Analyse the design parameters, necessity, advantages, constructional and principle of operation of different types of automatic transmissions and hydraulic control.
5. Apply the concept of transmission systems to design new systems for ICE and EVs.

Module-1

Power Required for Propulsion:
The need for transmission, Various resistances to Motion of the automobile, Traction, Tractive effort, Performance curves, acceleration gradeability, drawbar pull, Numerical.
Transmission in ICE vehicles: Necessity of gear box, Calculation of gear ratios for vehicles, Performance characteristics in different gears, Desirable speed ratios of gear boxes, Constructional details of - Sliding-mesh gear box, Constant-mesh gear box, Synchromesh gear box, auxiliary transmissions, numerical.

Number of Hours: 8

Module-2

Clutch: Necessity of clutch in an automobile, Requirements of a clutch, Clutch materials, Clutch lining, different types of clutches, friction clutches-Single plate clutch, multi plate clutch, cone clutch, centrifugal clutch, electromagnetic clutch, hydraulic clutches, Vacuum operated clutch, Clutch adjustment, Clutch troubles and their causes, Numerical.
Fluid Coupling &One-way clutches:
Constructional details of various types, percentage slip, one-way clutches (Over running clutch) like sprag clutch, ball and roller oneway clutches, necessity and field of application, working fluid requirements, fluid requirements, fluid requirements and fluid coupling characteristics.

Number of Hours: 10

Module-3

Epicyclic Transmission:
Principle of operation, types of planetary transmission, Wilson planetary transmission, Ford-T model gear box, Pre selective mechanism, Vacuum control, pneumatic control, hydraulic control in the planetary gear system, Over drives, Numerical.

Number of Hours: 8

Module-4

Hydrostatic Drives:
Principles of hydrostatic drives, different systems of hydrostatic drives, constant displacement pump and constant displacement motor, variable displacement pump and variable displacement motor, applications, plunger type pump and plunger type motor, advantages and limitations, typical hydrostatic drives, hydrostatic shunt drives.
Automatic Transmission: Principle, general description and working of representative types like Borge - warner, 4-speed and 6-speed automatic transmission longitudinally mounted four speed automatic transmission, hydramatic transmission, the fundamentals of a hydraulic control system, basic four speed hydraulic control system.

Number of Hours: 9

Module-5

Electric Vehicle Drivetrain

EV Transmission Configurations, Transmission Components, Gears, Automobile Differential, Clutch, Brakes, Ideal Gearbox, Steady State Model, Gear Ratio (GR), Torque-Speed Characteristics, EV Motor Sizing, Initial Acceleration, Rated Vehicle Velocity, Maximum Velocity, Maximum Grade ability.

Control of the Electric Drive

Introduction to Control- Feedback Controller, Design Approach, Modelling the Electromechanical System, Mechanical System, The PM DC Machine, The DC-DC Power Converter, The PI Controller, Acceleration of Battery Electric Vehicle (BEV) using PM DC Machine, Acceleration of BEV using WF DC Machine.

Number of Hours: 9

Suggested Learning Resources:

Textbooks:

1. Heinz Heisler, “Advanced Vehicle Technology”, 2nd Ed., Butterworth-Heinemann, 2002.
2. N K Giri, “Automobile Mechanics”, Khanna Publications, 12th Reprint, 2025.

Reference books / Manuals:

1. Kenneth Newton, W Steeds and T K Garrett, “The Motor Vehicle”, 13th Ed., Butterworth-Heinemann, 2001.
2. John G Hayes and G Abas Goodarzi, “Electric Powertrain-Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles”, John Wiley & Sons Inc., 2018.
3. Kirpal Singh, “Automobile Engineering”, Standard Publishers and Distributors Pvt. Ltd., 2011.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/107106088
- https://www.youtube.com/watch?v=WfiTscWVfWI
- https://www.youtube.com/watch?v=HfN5dEeUyuE
- https://www.artofmanliness.com/skills/manly-know-how/how-automatic-transmission-works/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Interactive Chalk-and-Talk
- Software-Aided Mechanism Simulation:
- Project-Based Fabrication Tasks:
- Case-Studies

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Internal Assessment Test (IA) + Continuous Comprehensive Assessments (CCA) = Continuous Internal Evaluation CIE [25+25=50 marks]

i) A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks.**
ii) In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Case Study Presentation on Conventional and Electric Vehicle Transmission Technologies.	10
2.	Development of a Working Model of Automotive Transmission Systems – Mini Project	15

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Comprehensive Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Rubrics for Learning Activity 1:
Case Study Presentation on Conventional and Electric Vehicle Transmission Technologies.

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Understanding of Vehicle Transmission Technologies (PO1)	Demonstrates comprehensive understanding of conventional and electric vehicle transmission technologies and their components	Good understanding with minor gaps	Basic understanding	Limited understanding	Unable to explain the transmission technologies
Application of Transmission System Concepts (PO2)	Correctly explains the working principles, functions, and applications of the selected transmission system	Mostly correct explanation	Partial application	Minimal application	No application of concepts
Case Study Analysis and Interpretation (PO2, PO4)	Presents comprehensive analysis with appropriate interpretation and engineering justification	Good analysis with minor omissions	Adequate analysis	Limited analysis	No meaningful analysis
Presentation and Technical Communication (PO10)	Well-organized, technically sound, and confidently presented	Good presentation with minor errors	Average presentation	Poor organization and communication	Unable to present effectively
Team Participation	Highly active and	Good participation	Moderate participation	Limited participation	No participation

and Collaboration (PO9, PO10)	collaborative throughout the activity				

Rubrics for Learning Activity 2: Development of a Working Model of Automotive Transmission Systems – Mini Project					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Design and Development of the Working Model (PO3)	Develops a functional and innovative working model that meets all design requirements	Develops a functional model with minor deficiencies	Develops a basic working model	Model has limited functionality	Model is incomplete or non-functional
Application of Transmission System Concepts (PO2)	Correctly applies transmission system principles in the design and operation of the model	Mostly correct application with minor errors	Partial application	Minimal application	No application of concepts
Performance Evaluation and Problem Solving (PO2, PO4)	Effectively evaluates model performance and provides appropriate engineering justification for design decisions	Good evaluation with minor omissions	Adequate evaluation	Limited evaluation	No meaningful evaluation
Project Report and Technical Documentation (PO10)	Well-structured, detailed, and professionally documented	Good documentation with minor errors	Average quality documentation	Poorly organized documentation	Incomplete documentation
Team Participation and Project Demonstration (PO9, PO10)	Highly active and collaborative; demonstrates the working model confidently and effectively	Good participation and demonstration	Moderate participation	Limited participation	No participation or demonstration

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Case Study	13
2.	Mini Project	20
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	MOOCs/NPTEL Courses	15