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	42:28:0:25:25	SEE Marks	50
Credits	4	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course Outcomes (Course Skill Set):

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

1. Apply Fourier series techniques to represent periodic functions and perform harmonic analysis relevant to engineering applications.
2. Utilize Fourier Transforms and Z-Transforms to analyze engineering systems and solve difference equations arising in mechanical and allied engineering problems.
3. Formulate and solve partial differential equations and apply numerical methods for the solution of heat, wave, and Laplace equations encountered in engineering practice.
4. Employ Laplace Transform techniques to solve ordinary differential equations and engineering problems involving dynamic systems.
5. 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 Videos	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).

Materials Science & Metallurgy			
Course Code	**1BME302**	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	42:0:28:25:25	SEE Marks	50
Credits	**4**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	3

Course Outcomes (Course Skill Set):
At the end of the course, the student will be able to:

1. Summarize the atomic arrangements in the crystal structures with computation of crystal parameters, packing factor and theoretical density.
2. Apply the mechanics of diffusion to enhance the desirable properties on the metal surfaces.
3. Examine the significance of various mechanical properties and testing of metals.
4. Assess the amounts of phases, constituents in the alloys and kinetics of phase transformations.
5. Describe the application of composites, ceramics and polymers.

Module-1

Introduction, Crystalline Solids, Defects in Crystals:
Classification of Materials: Metals, composites, ceramics, polymers. Advanced materials: Semiconductors, biomaterials, smart materials, nanomaterials, modern material's needs.
Structure of Crystalline Solids: Fundamental concepts, arrangement of atoms and packing density in unit cells-BCC, FCC, HCP, density computations, numerical problems.
Determination of crystal structures through X-ray diffraction techniques (principles only).
Defects in Crystals: Classification of crystal imperfections, point defects, line defects, volume defects.

Number of Hours: 9

Module-2

Microscopic examination: Basic concepts in microscopy, microscopic techniques - Optical microscopy, Scanning electron microscopy, Transmission electron microscopy.

Diffusion:
Introduction, diffusion mechanisms, Fick's laws for steady state and non-steady state diffusion. Factors affecting diffusion. Numerical problems on determining the depth of diffusion, time of diffusion and diffusion cycles. Diffusion in semiconducting materials.

Number of Hours: 8

Module-3

Mechanical Properties of Metals:
Stress, strain, Concepts of loading: tensile, compressive, shear and torsion.
Elastic deformation: Stress-strain behaviour, elastic properties of materials, numerical problems.
Plastic deformation: tensile properties, tensile strength, ductility, Resilience, Toughness, numerical problems.
True stress and true strain. Hardness, Hardness tests. Dislocations and strengthening mechanisms.
Fatigue properties and tests. factors affecting the fatigue behaviour.
Creep properties and tests, factors affecting the creep behaviour.

Number of Hours: 8

Module-4

Phase Diagrams and Phase Transformations:
Concept of solid solution formations and fundamentals of phase diagrams, unary and binary phase systems, rules governing formation of iso-morphous phase systems, Construction, development of microstructures and interpretation of Cu-Ni and Pb-Sn phase systems, discussion on mechanical properties.
Iron-Iron carbide phase diagram: Phase reactions in $Fe\text{-}Fe_3C$ system, Development of microstructures, interpretation and numerical problems in $Fe\text{-}Fe_3C$ system. Properties and Designations for steels and cast irons.
Basic concepts of phase transformations, homogeneous nucleation, derivation of critical radius and change in free energy. Iso-thermal transformation diagram and Continuous cooling transformation diagrams: Construction, interpretation, microstructures formed, properties of Iron-carbon alloys.

Number of Hours: 9

Module-5

Composites, Ceramics and Polymers:
Composites: Classification, particle reinforced composites, fibre reinforced composites, structural composites. Expressions for elastic modulus of composites with axial and transverse loading.
Ceramics: Basics, types and applications of glasses, clay products, refractories, abrasives, cements.
Polymers: Factors influencing melting and glass transition temperatures, plastics, elastomers, Fibers.

Number of Hours: 8

PRACTICAL COMPONENTS OF IPCC

LIST OF EXPERIMENTS

1. Specimen preparation for macro and micro structural examinations and study the macrostructure and microstructure of a sample metal/alloy.
2. Study the heat treatment processes (Hardening and tempering) of steel/Aluminium specimens.
3. To determine the impact strength of a given specimen using Izod and Charpy Testing machine.
4. To study the creep behaviour of a given Cast Iron or Aluminium specimen.
5. To study the fatigue behaviour of EN8 bars.
6. To identify and examine the defects in welded Mild Steel components.
7. To determine the tensile strength, modulus of elasticity, yield stress, % of elongation and % of reduction in area of Cast Iron, Mild Steel/Brass/Aluminium and to observe the necking.
8. To determine the shear strength of a given specimen.
9. To determine the compression strength of a given specimen.
10. To conduct a wear test on Mild steel/ Cast Iron/Aluminium/Copper to find the volumetric wear rate and coefficient of friction.
11. Study the chemical corrosion and its protection. (Demonstration)
12. Computer Aided Selection of Materials: Application of GRANTA Edupack for material selection: Case studies based on material properties. (Demonstration)

Suggested Learning Resources:

Textbooks:

1. William D Callister, "Materials Science & Engineering - An Introduction", 2nd Ed., John Wiley & Sons Inc, 2010.
2. William F Smith, "Principles of Materials Science and Engineering", 7th Ed., McGraw Hill Publishing Co.1996
3. V Raghavan, "Materials Science & Engineering", 6th Ed., Prentice Hall of India, 2002.

Reference Books / Manuals:

1. Donald R Askeland, Pradeep P Fulay and Wendelin J Wright, "The Science and Engineering of Materials", 6th Ed., Cengage Learning, 2010.
2. Michael F Ashby and David R H Jones, "Engineering Materials 2 - An Introduction to Microstructures, Processing and Design", 3rd Ed., Butterworth-Heinemann.
3. Sidney Avner, "Introduction to Physical Metallurgy", 2nd Ed., McGraw Hill Education, 2017.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112106293
2. https://nptel.ac.in/courses/113102080
3. https://nptel.ac.in/courses/112102319

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.	05 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.	05 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	05 marks
	Subtotal	**10**
	Total	**25**

Rubrics for Practical CIE – Continuous Assessment:

Performance Indicator	Superior	Good	Fair	Needs Improvement	Unacceptable
Ability in Conducting Experiments (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. Results are accurate and submitted on time. **(17 – 20 Marks)**	Record book is complete with good presentation; minor omissions or formatting errors; calculations and results are mostly accurate; submitted on time. **(13 – 16 Marks)**	Record book contains all essential sections but lacks detail in presentation, analysis, or interpretation; few calculation or recording errors. **(9 - 12 Marks)**	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)**

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 mechanical properties of various components used in engineering applications through literature survey.	13
2.	For a given engineering application, justify selection of a suitable material which enhances the various mechanical properties.	12
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	MOOCs/NPTEL Videos	13
2.	Video Lectures	12

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 Outcomes (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

Introduction and Review of fundamental concepts: Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Thermodynamic system, open system and closed system, isolated system, Thermodynamic boundary and Thermodynamic universe, Thermodynamic properties; definition and units, intensive, extensive properties, specific properties, pressure, specific volume, Thermodynamic state, point, path and process, quasi-static process, cyclic and non-cyclic processes;

Thermodynamic equilibrium; Zeroth law of thermodynamics, Temperature; concepts, scales, international fixed points and measurement of temperature. Constant volume gas thermometer, constant pressure gas thermometer, mercury in glass thermometer, thermocouples, electrical resistance thermometer. Numericals.

Number of Hours: 9

Module-2

Work and Heat: Mechanics, definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention. Numericals.

First Law of Thermodynamics: Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, modes of energy, Numericals.

Extension of the First law to control volume; steady flow energy equation (SFEE), Numericals.

Number of Hours: 9

Module-3

Second Law of Thermodynamics: Limitations of first law of thermodynamics, Thermal reservoir, heat engine and heat pump: Schematic representation, efficiency and COP. Reversed heat engine. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Carnot cycle, Carnot principles. Numericals

Entropy- definition, Clausius inequality, entropy as a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, entropy as a coordinate. Numericals.

Number of Hours: 8

Module-4

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

Gas Turbines: Open cycle gas turbine, Methods for improvement of thermal efficiency of open cycle gas turbine plant-Intercooling, Reheating, Regeneration, Closed cycle gas turbine (Brayton cycle), Sterling cycle. Numericals.

Number of Hours: 8

Module-5

Refrigeration Cycles: Refrigeration, units of refrigeration, COP, reversed Carnot cycle, Bell- colleman refrigeration (air refrigeration), Vapour compression refrigeration system; description, analysis, refrigerating effect. Refrigerants and their desirable properties, alternate Refrigerants. Vapour absorption refrigeration system, Numericals.

Psychrometric and Air-conditioning Systems: Psychrometric properties of Air, specific humidity, relative humidity, degree of saturation, dry bulb temperature, wet bulb temperature, dew point temperature, Psychrometric Chart, Analyzing Air-conditioning Processes; Heating, Cooling, Dehumidification and Humidification, Evaporative Cooling. Adiabatic mixing of two moist air streams. (No Numericals based on Psychrometric Chart)

Number of Hours: 8

Suggested Learning Resources:

Textbooks:

1. R K Rajput, "A Textbook of Engineering Thermodynamics", 5th Ed., Laxmi Publications, 2016.
2. P K Nag, "Basic and Applied Thermodynamics", 2nd Ed., McGraw Hill Education, 2009.

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.
3. Dr D S Kumar, "Engineering Thermodynamics", S. K. Kataria & Sons, 2012.
4. B K Venkanna and Swati B. V, "Basic Thermodynamics", PHI, New Delhi, 2010.
5. B T Nijaguna and B S Samaga, "Thermodynamics Data Hand Book", Sudha Publications, 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	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Identification and Classification of Thermodynamic System (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 (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 (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 (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	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Identification of States and Properties **(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 **(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 **(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 **(PO2)**	Provides excellent interpretation of results and relates findings to engineering applications.	Good interpretatio n with minor gaps.	Basic interpretation of obtained results.	Poor interpretation of obtained results.	No interpretation
Technical Report Preparation **(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 Outcomes (Course Skill Set):

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

1. 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; Linear Elasticity, 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; Changes in Lengths under Nonuniform Conditions; Statically Indeterminate Structures; Thermal Effects, Misfits, and Pre-strains; Stresses on Inclined Sections; Strain Energy; Stress Concentrations. (Numericals).

Number of Hours: 8

Module-3

Torsion: Introduction; Torsional Deformations of a Circular Bar; Circular Bars of Linearly Elastic Materials; Nonuniform Torsion; Stresses and Strains in Pure Shear; Relationship Between Moduli of Elasticity E and G; Transmission of Power by Circular Shafts; Statically Indeterminate Torsional Members; Strain Energy in Torsion and Pure Shear. (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; Nonprismatic Beams; 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; Beams with Axial Loads; Stress Concentrations in Bending. (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; Triaxial Stress; Plane Strain. (Numericals).
Pressure Vessels, Beams, and Combined Loadings: Spherical Pressure Vessels; Cylindrical Pressure Vessels; Combined Loadings (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	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 Videos	10

Manufacturing Technology - I			
Course Code	**1BME305**	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 Outcomes (Course Skill Set)

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

1. Explain the fundamental principles and applications of casting, welding and metal forming processes.
2. Apply engineering principles to solve numerical problems related to casting and metal forming processes.
3. Analyse the influence of process variables on the quality of casting, welding, and metal forming products.
4. Analyse the suitability of casting, welding, and metal forming processes for engineering applications based on their advantages and limitations.

Module-1

Metal Casting: Introduction, Types of Foundries. basic steps in making sand castings.
Patterns: Patternmaking, Types of Patterns, Pattern Allowances, Functions of Patterns, Core Boxes.
Molding Process and Materials: Introduction and classification of Molding Process, Sand Casting: Green-sand Molding, Dry sand molds, Floor and Pit molding, Cement-bonded Sand Molds, Core sand or Core Molds, Shell Molding, Investment Casting. Permanent Molds: Die Casting, Centrifugal Casting.
Casting Defects: Gas Defects, Shrinkage Cavities, Molding Material Defects, Pouring Metal Defects, Metallurgical Defects.

Number of Hours: 8

Module-2

Solidification of Metals: Introduction, solidification variables; Freezing of a Pure Metal: Skin Effect; Solidification in a Mold, Nucleation and Growth, Shrinkage. Directional solidification-need and methods.
Pouring and Feeding Castings: Introduction, Pouring Ladles; Gating System: Elements of Gating System; Types of Gates: Parting Gate, Bottom Gate, Horn Gate; Design of Gating System: Fluid Flow, Factors involved in Gating Design, Pouring time, Choke Area, Sprue Design, Sprue-runner-gate Ratios. Risers: Primary Function of a Riser, Theoretical Considerations, Riser Shape, Riser size as a Function of Casting Shape, Location of Risers, Blind Risers, Internal Risers; Numerical Problems on Gates and Risers.
Melting Practices: Cupola, Electric Arc Furnace, Crucible Furnace, Induction Furnace, and Reverberatory Furnace.

Number of Hours: 9

Module-3

Mechanical Working of Metals: Introduction; Nature of Plastic Deformation, Hot Working and Cold Working: Principal Methods, Advantages and Disadvantages.
Rolling: Principle of Rolling, Rolling-Stand Arrangements; -High, Two-High Reversible, Three-High, Four-High and Cluster Rolling Mills. Rolling Load, Rolling Passes, Rolling Defects.
Smithing and Forging: Introduction, Forging Materials, Heating Devices, Smith Forging Operations, Forging Processes; Hand Forging, Power Forging; Power Hammers, Impression Die Forging, Drop Hammers, Press Forging.
Extrusion: Principle of Extrusion; Types of Extrusion: Direct or Forward Extrusion, Indirect or Backward Extrusion, Impact Extrusion, Extruding Tubes, and Hydrostatic Extrusion, Wire Drawing.

Number of Hours: 8

Module-4

Sheet Meal Operations: Introduction, Metals used in Sheet Metal Work. Press Tool Operations: Classification of Press Tool Operations; Shearing Action, Blanking and Piercing: Stripping Force, Punching Force and Shear Force; Numerical Problems. Trimming, Shaving, Nibbling, Notching and Lancing Operations. Drawing: Draw Die Design, Draw Radius on Die, Blank Size, Drawing Force, Ironing Force, Percentage Reduction, Drawing Speed; Numerical Problems. Bending: Bending Allowance, Bending Force; Numerical Problems. Stretch Forming, Embossing and coining operations.
Sheet Metal Design: Types of Dies; Progressive Dies, Compound Dies and Combination Dies. Die Construction; Screws and Dowels, Die Block. Punch Design: Plain Punches, Pedestal Punches and Punches Mounted in Punch Plate.

Number of Hours: 9

Module-5
Welding Process: Definition, classification, application, advantages & limitations of welding, weldability. Gas Welding: Oxy-Acetylene Welding, Air-Acetylene Welding, Oxy-Hydrogen Welding. Arc Welding: Carbon-arc, Metal arc, Metal-inert-gas (MIG), Tungsten-inert-gas (TIG), Atomic Hydrogen, Plasma-arc, Submerged-arc, Flux-cored arc, Electro-slag welding. Resistance Welding: Butt, Spot, Seam, Projection and Percussion welding; Thermit Welding; Solid State Welding Methods: Diffusion, Ultrasonic, Friction and Explosive Welding; Welding Defects. Number of Hours: 8

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. S K Hajra Choudhury, A.K. Hajra Choudhury, Nirjhar Roy, "Elements of Workshop Technology Vol 1: Manufacturing Processes", 15th Ed., Media Promoter and Publishers Pvt. Ltd., 2019

Reference books / Manuals:

1. Serope Kalpakjian and Steven R. Schmid, "Manufacturing Engineering and Technology", Pearson Education, 8th Ed, 2023.
2. Amitabha Ghosh, Asok Kumar Mallik, "Manufacturing Science", Affiliated East-West Press Private Limited, New Delhi; Second Edition, 2022
3. Richard W. Heine, Carl R. Loper Jr., Philip C. Rosenthal, "Principles of metal casting", 3rd Ed., McGraw Hill Education (India).

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112107219
2. https://nptel.ac.in/courses/112104301

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.	Determination of Compression, Shear and Tensile properties using Universal Sand Testing Machine for a given sand and preparation of green sand moulds by using pattern and core.	10
2.	Determination of Permeability of green sand and core sand OR Determination of AFS fineness number and distribution coefficient of given sand sample.	10

3.	Explore casting simulation, welding simulation, or forming simulation software and prepare a technical report.	5

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:
Determination of Compression, Shear and Tensile properties using Universal Sand Testing Machine for a given sand and preparation of green sand moulds by using pattern and core.

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Determination of Compression, Shear and Tensile Properties of Sand (PO1, PO2, PO4)	Accurately performs compression, shear and tensile tests using the Universal Sand Testing Machine; obtains reliable readings and demonstrates complete understanding of the test procedures and parameters.	Performs all three tests correctly with minor procedural or measurement errors.	Performs the tests with some assistance and obtains reasonably acceptable readings with limited understanding of the procedure.	Performs the tests with significant procedural or measurement errors and requires considerable assistance.	Unable to perform the tests or obtain meaningful readings even with assistance.
Preparation of Green Sand Mould using Pattern and Core (PO1, PO2, PO5)	Independently prepares a sound green sand mould using the given pattern and core with proper ramming, venting, parting, gating and core placement, demonstrating excellent practical skill.	Successfully prepares the mould with minor deficiencies in one or more moulding operations.	Prepares the mould with acceptable quality but requires some guidance and shows limited control over moulding operations.	Mould preparation is incomplete or contains significant defects due to improper moulding practices.	Unable to prepare a functional green sand mould using the pattern and core.
Analysis and Interpretation of Test Results (PO2, PO3, PO4)	Accurately calculates and interprets the compression, shear and tensile properties; critically relates the results to sand characteristics and moulding requirements with sound technical justification.	Correctly calculates and interprets most results with good technical reasoning and minor gaps.	Performs basic calculations and provides a limited interpretation of the results.	Shows significant errors in calculations or provides superficial interpretation of the results.	Unable to calculate or interpret the test results meaningfully.

Technical Knowledge, Safety and Experimental Practice **(PO1, PO5)**	Demonstrates excellent knowledge of foundry sand properties, green sand moulding, pattern and core functions, and follows experimental procedures and safety practices consistently.	Demonstrates good technical knowledge and follows experimental and safety practices with minor lapses.	Demonstrates satisfactory knowledge and generally follows the required procedures and safety practices.	Demonstrates limited knowledge and requires frequent guidance to follow procedures or safety practices.	Demonstrates little or no understanding of the experiment and does not follow the required procedures or safety practices.
Observation, Documentation and Technical Communication **(PO9)**	Systematically records observations, presents results clearly with appropriate units and format, and explains the experimental procedure and findings confidently and accurately.	Records and presents the results clearly with minor omissions or communication deficiencies.	Maintains basic observations and communicates the results adequately.	Observations are incomplete or poorly organized, with limited clarity in communication.	Fails to maintain meaningful observations or communicate the experimental results effectively.

Rubrics for Learning Activity 2:
Determination of Permeability of green sand and core sand OR Determination of AFS fineness number and distribution coefficient of given sand sample.

Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Experimental Procedure and Operation of Equipment (PO1, PO5)	Accurately explains and independently performs the complete procedure for determining permeability or AFS fineness number and distribution coefficient using the appropriate equipment, following all required steps correctly.	Performs the experiment correctly with minor procedural errors and demonstrates good understanding of equipment operation.	Performs the experiment with some assistance and demonstrates basic understanding of the procedure.	Requires considerable assistance and makes significant procedural errors.	Unable to perform the experiment or operate the equipment appropriately.
Measurement, Observation and Data Recording (PO1, PO2)	Takes accurate measurements, systematically records all observations with appropriate units, and ensures reliable and consistent experimental data.	Records most observations accurately with minor errors or omissions.	Records basic observations with some errors but obtains usable data.	Observations are incomplete or contain significant measurement/recording errors.	Fails to obtain or record meaningful experimental observations.
Calculation and Determination of Properties (PO2, PO4)	Accurately determines permeability or AFS fineness number and distribution coefficient using appropriate equations, calculations and data interpretation, with technically correct results.	Performs calculations correctly with minor errors and obtains largely appropriate results.	Performs basic calculations with some errors but demonstrates an understanding of the required method.	Shows significant errors in calculations or application of the required method.	Unable to perform the required calculations or determine the properties.

Analysis and Interpretation of Results (PO2, PO3, PO4)	Critically interprets the results and clearly relates permeability, fineness number and/or distribution coefficient to sand characteristics and their significance in mould/core performance, with strong technical justification.	Provides good interpretation of the results and relates them to sand characteristics with minor gaps in justification.	Provides basic interpretation with limited technical reasoning.	Provides superficial interpretation with weak or incorrect justification.	Provides no meaningful interpretation of the experimental results.
Technical Knowledge and Experimental Practice (PO1, PO5)	Demonstrates excellent understanding of green sand, core sand, permeability, AFS fineness, grain-size distribution and their relevance to foundry practice; follows experimental and safety practices consistently.	Demonstrates good technical knowledge with minor conceptual errors and follows the required practices.	Demonstrates satisfactory understanding with occasional errors and generally follows the required practices.	Demonstrates limited understanding and requires frequent guidance during the experiment.	Demonstrates little or no understanding of the relevant concepts or experimental practice.

Rubrics for Learning Activity 3: Explore casting simulation, welding simulation, or forming simulation software and prepare a technical report.					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Understanding of Software Features and Applications (PO1)	Demonstrates comprehensive understanding of the software, its features, workflow, and manufacturing applications.	Demonstrates good understanding with minor gaps.	Demonstrates basic understanding of the software and its applications.	Demonstrates limited understanding of the software.	Unable to explain the software or its applications.
Understanding of Manufacturing Applications (PO2)	Clearly explains how the software supports casting, welding, or metal forming analysis with appropriate examples.	Explains the applications with minor omissions.	Provides a basic explanation of the applications.	Provides limited or inaccurate explanation.	Unable to explain the manufacturing applications.
Use of Technical Resources (PO12)	Effectively utilizes user manuals, vendor documentation, tutorials, research articles, and online educational resources with proper citations.	Uses appropriate technical resources with minor deficiencies.	Uses limited authentic resources.	Uses very few or inappropriate resources.	No evidence of use of technical resources.
Technical Report and Documentation (PO9)	Report is well-organized, technically accurate, and includes software overview, features, workflow, applications, advantages, limitations, and references.	Report is complete with minor omissions or formatting issues.	Report contains essential information but lacks detail or clarity.	Report is incomplete or poorly organized.	Report is inadequate or not submitted.

Presentation of Findings (PO9)	Presents the study clearly with effective technical communication and responds confidently to questions.	Presents the findings clearly with minor communicat ion gaps.	Adequately presents the study with basic technical explanation.	Presentation lacks clarity and technical content.	Unable to communicate the findings 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.	Foundry Activity	28
2.	Technical Report	10
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
2.	MOOCs/NPTEL Videos	10

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	3

Course Outcomes (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, Overview of industrial drawings. (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 Bhatt and V M Panchal, "Machine Drawing", 51st Ed., Charotar Publishing House, 2022.
2. K R Gopala Krishna, "Machine Drawing", 20th Ed., Subhas Publications, 2007.
3. VTU Editorial Committee, "A Primer on Computer Aided Machine Drawing", 1st Ed., Visvesvaraya Technological University (VTU) Belagavi, 2007.

Reference books / Manuals:

1. S Trymbaka Murthy, "A Text Book of Computer Aided Machine Drawing", 2nd Ed., CBS Publishers, New Delhi, 2008.
2. K L Narayana, P Kannaiah, and K Venkata Reddy, Machine "Drawing", 6th Ed., New Age International, 2019.
3. Solid Edge ST/2023/2024 User Manual, Siemens Digital Industries Software (Official Documentation).
4. 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.youtube.com/watch?v=YTg-2Fdghr8&list=PLzS3ms4mHQp5RQC28QgXFch4_-80dSP_9
5. https://www.youtube.com/watch?v=I4OPnuryLSc&list=PLHkqQrzjeuK4utYccN1WsjNNXMsE-Fk9
6. https://www.youtube.com/watch?v=bAKP76FKA3o
7. https://www.youtube.com/watch?v=vA0qoO2hemw
8. https://www.youtube.com/watch?v=iXxeJOs70xc&list=PLr1_GACt9RnUFhCzQ_kyYDt37DVbwJaHV
9. 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 Improvement**	**Unacceptable**
Engineering Graphics Standards and CAD Sketching (PO1) (20 Marks)	Accurately applies BIS standards, GD&T, thread representation and orthographic projection principles; creates fully constrained and dimensionally accurate CAD sketches. **(17–20)**	Applies standards and CAD sketching principles correctly with minor errors in dimensions, constraints or representatio n. **(13–16)**	Demonstrates basic understandin g and produces reasonably correct sketches with some errors. **(9–12)**	Demonstrates limited understanding; sketches contain significant errors in standards, dimensions or constraints. **(5–8)**	Fails to apply engineering graphics standards or produce a meaningful CAD sketch. **(1–4)**
Parametric Part Modelling (PO1, PO3, PO5) (20 Marks)	Independently creates a complete, accurate and fully parametric model using appropriate features, dimensions, constraints and modelling strategy. **(17–20)**	Creates a substantially correct parametric model with minor errors in features, dimensions or constraints. **(13–16)**	Creates an acceptable model using basic parametric features, with some modelling errors or inconsistenci es. **(9–12)**	Produces an incomplete model with significant errors in feature selection, dimensions or parametric relationships. **(5–8)**	Unable to create the required parametric model or produces an incorrect/non-functional model. **(1–4)**

Assembly Modelling and Engineering Documentation **(PO1, PO3, PO5, PO10)** **(60 Marks)**	Creates a complete and functional assembly with correct constraints, exploded view and interference analysis; prepares accurate GD&T, BOM and engineering documentation in accordance with standards. **(49–60)**	Creates a substantially correct assembly with minor constraint or documentation errors; BOM, exploded view and engineering documentation are largely accurate. **(37–48)**	Produces a functional assembly with some errors; documentation, BOM or exploded view is adequate but requires improvement. **(25–36)**	Assembly is incomplete or has significant constraint/functional issues; documentation is inadequate or contains major errors. **(13–24)**	Fails to create a functional assembly and provides incomplete or incorrect engineering documentation. **(1–12)**

Engineering Computation Laboratory			
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 Outcomes (Course Skill Set)

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

1. Use computational software commands and built-in functions for engineering computations and matrix-based problem solving.
2. Develop 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.
6. Apply computational techniques to mechanical engineering problems involving vibrations and heat transfer.

SET OF EXPERIMENTS

1. Introduction to Computational Software Environment and Basic Computations
This experiment familiarizes students with the software 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 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. They are expected to formulate engineering problems in matrix form, obtain numerical solutions, and verify the correctness of the results.

4. 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. 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 computational software 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 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. They are expected to determine displacement, velocity, and acceleration responses, plot time histories, and understand the fundamentals of mechanical vibrations.
12. Heat Transfer Analysis
This experiment involves solving simple heat conduction problems. 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.

Note: MATLAB/SCILAB/any other relevant computational software may be used.

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.
6. https://www.scilab.org/tutorials
7. https://scilab.in/spoken-tutorial

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	**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 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.
Implementation and Computational Skills	Demonstrates excellent command of software commands, functions, and numerical methods independently.	Uses software tools correctly with minor guidance.	Uses basic software commands with limited understanding of advanced features.	Demonstrates difficulty in using software tools effectively.	Unable to use software 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	**Superior**	**Good**	**Fair**	**Needs Improvement**	**Unacceptable**
Understanding of the software Concepts and Numerical Methods **(10 marks)**	Demonstrates comprehensive understanding of the software concepts, syntax, and numerical methods; applies them correctly without assistance. **(9-10 Marks)**	Demonstrates good understandin g with minor conceptual errors. **(7-8 Marks)**	Demonstrates basic understandin g 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 Outcomes (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.

LIST 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. Basic VR-based assembly simulation
8. Advanced VR-based assembly simulation
9. Product visualization project
10. Interactive mechanical model
11. Mini Project (Basic): Design a mechanical component/s and develop the interactive VR environment for the mechanical component
12. Mini Project (Advanced): 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, 1st Ed., Cambridge University Press, 2023.
2. William R. Sherman and Alan B. Craig, Understanding Virtual Reality: Interface, Application, and Design, 3rd Ed., Morgan Kaufmann, 2018.

Reference books / Manuals:

1. https://dev.epicgames.com/documentation/
2. Unreal Engine Documentation
3. 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://learn.unrealengine.com
- https://developer.oculus.com
- https://www.blender.org/support/tutorials/

YouTube: CAD to VR workflows

- Export CAD to Unreal Engine- https://www.youtube.com/watch?v=n72hza1LIqg
- Unreal Engine Fundamentals- https://www.youtube.com/watch?v=XRmn-EYt8wI&list=PLncmXJdh4q88DFCEVuGpOY3AGQwBvoQnh
- Materials, Lighting and Visualization- https://www.youtube.com/watch?v=vC1W76FpIA8&list=PLULbDkdbO4tpyexu2DwNnTwwfgjknfY5X
- Blueprint Basics- https://www.youtube.com/watch?v=opyV7rhKSFc
- VR Setup- https://www.youtube.com/watch?v=yTZyAPGuf6U

- VR Object Interaction (Grab-Release-Picl & Place)-
  https://www.youtube.com/watch?v=0f8DkKfl_9Y
- Exploded View, Animation & Walkthrough- https://www.youtube.com/watch?v=9getRmp3GGk
- https://www.youtube.com/watch?v=i3xNb5R_xos
- https://www.youtube.com/watch?v=kM27HYbpvc0
- https://www.youtube.com/watch?v=fiQ2OgEBbkc
- https://www.youtube.com/watch?v=YBQ_ps6e71k
- https://www.youtube.com/watch?v=QxoB20j0cEE
- https://www.youtube.com/watch?v=wqjJU4V6bGM
- https://www.youtube.com/watch?v=DcRCJ4cO1Do
- 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**.

Rubrics for CIE – Continuous assessment:

Performance Indicator	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	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 Outcomes (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.

LIST OF EXPERIMENTS

1.	Charting: Create an XY scatter graph, XY chart with two Y-Axes, to add error bars to the 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.
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

Note: Any relevant software may be used.

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 (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 (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) (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 (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 (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 (PO1)	Clearly understands problem independently	Minor clarifications needed	Partial understandi ng	Misinterprets problem	No understanding
Solution Approach (PO2)	Optimal method selected correctly	Good method with minor inefficiencies	Basic method	Incorrect approach	No approach
Execution (Excel/VBA) (PO3,5)	Accurate implementation (Excel/VBA/ tools)	Minor execution errors	Partial execution	Major errors	Student has not understood the concepts clearly
Output & Accuracy (PO4)	Correct results with validation	Minor deviations	Partially correct	Incorrect results	No output
Viva-Voce (PO9)	Answers confidently with deep knowledge	Good understandin g	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.

LIST OF EXPERIMENTS

1. Introduction to AI Tools (ChatGPT, Gemini, etc.,)
2. Zero-Shot Prompting: Writing prompts for Thermodynamics problems
3. One-Shot Prompting: Solving of Strength of Materials problems
4. Few-Shot Prompting: Heat transfer concepts
5. Role-Based Prompting: Using AI for CAD design idea generation (AutoCAD/SolidWorks/etc., 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:

Textbooks:

1. Russell, S. & Norvig, P., “Artificial Intelligence: A Modern Approach”, 4th 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.

Reference books / Manuals:

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 of AI Outputs (PO4)	Critically analyses AI-generated responses, identifies limitations, validates results, and provides sound engineering interpretation.	Correctly interprets AI outputs with minor omissions.	Provides basic interpretation with limited validation.	Interpretation is weak or partially incorrect.	Unable to analyse or 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 appropriate conclusions.	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.
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 satisfactorily.

Community Project (Project Based Learning)/ Societal Project [Common to all disciplines of Engineering]			
Course Code	**1BCP308**	Scheme	**2025**
Type of Course	**SDC**	Semester	III
Teaching Hours/Week (L:T:P)	30 (0:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L:T:P:SL/TW	30 (0:0:0:30)	SEE Marks	50
Credits	**1**	Total Marks	100
Type of Examination	Practical	Exam Hours	3

Course objective:
Rapid urbanisation, population growth, environmental concerns, energy demand, water scarcity, waste management, transportation issues and rural development challenges have created practical problems affecting communities and public welfare. This course aims to integrate technical knowledge, field exposure and societal engagement so that students identify real community issues, frame problem statements and attempt appropriate, feasible and sustainable engineering responses within the scope of a one-semester project.

Course outcome (Course Skill Set):
At the end of the course, the student will be able to:

1. Identify and analyse societal problems through field interaction and technical assessment.
2. Develop skills in project planning, field survey, data collection, implementation, documentation and reporting.
3. Formulate feasible engineering problem statements and solutions considering practical constraints and sustainability aspects.
4. Apply principles of environmental responsibility, ethics and societal welfare in engineering practice through community-oriented interventions.
5. Exhibit multidisciplinary learning and problem-solving ability based on collected data, user feedback and baseline conditions.
6. Demonstrate teamwork and communication skills while interacting with technical and non-technical stakeholders and reflect on project impact on society.

Restrictions and professional conduct:
Community / Societal Projects shall remain **academic, socially responsible, technically focused, and politically neutral**. Students and faculty shall maintain professionalism, ethical conduct, public respect and institutional integrity while interacting with communities, public groups, organisations and stakeholders.

Students and faculty **shall avoid** the following during project execution:

- Association with political party activities, campaigns or propaganda.
- Participation in activities that may disturb communal harmony, public order or institutional reputation.
- Use of the project platform for personal, political, ideological or commercial promotion.
- Disrespectful, discriminatory or unethical interaction with community members or stakeholders.

Projects must also recognise constraints related to **cost, resources, environment and safety, and stakeholder behaviour/cooperation/acceptance** when planning and implementing activities.

Sustainable Development Goals
The faculty shall encourage students to undertake community projects that align with and contribute towards satisfying the National Board of Accreditation (NBA) Criterion 3.6, namely, Evidence of Addressing Sustainable Development Goals (SDGs), which is a major emphasis of the United Nations (UN). The Sustainable Development Goals (SDGs) are illustrated in the figure shown below:

SET OF PROJECT ACTIVITIES (TW/SL = 30 HOURS)
Methods for project identification: Students may identify the project topic using one or more of the following methods: • Interaction with local rural or urban stakeholders such as local leaders, corporation/ municipality personnel, NGOs, panchayat representatives, etc. • Review of issues highlighted in print and electronic media, and social networks (WhatsApp, Facebook, X, Instagram, etc.). • After selecting a broad topic, students shall collect data, conduct a feasibility survey, estimate timelines and resources, approximate expenditure, and then define the problem statement and objectives clearly.

List of Project Topics and Engineering Outcomes

The following structured sequence of activities is to be carried out during the semester:

Sl. No.	Project Title	Measurable Engineering Outcome	Mapped POs	SDGs
1.	Rural and urban water conservation and management systems	Prepare a site-specific water-saving plan, estimate water demand–supply gap, and propose a feasible conservation intervention with quantified savings.	PO1, PO2, PO3, PO4, PO10, PO11	SDG 6 SDG 11 SDG 12
2.	Waste management and recycling	Conduct waste audit, classify waste streams, and design a segregation/recycling workflow with measurable reduction in mixed waste.	PO2, PO3, PO4, PO6, PO8, PO10	SDG 11 SDG 12 SDG 13
3.	Afforestation	Identify a degraded area, prepare plantation layout, and demonstrate survival-rate tracking and maintenance schedule for saplings.	PO2, PO3, PO4, PO6, PO7, PO11	SDG 11 SDG 13 SDG 15
4.	Biogas generation and power generation	Estimate organic waste availability, size a small biogas system, and document expected gas output or energy yield.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 7 SDG 11 SDG 12

5.	DPR for solar power rural plant	Prepare a DPR with load assessment, panel sizing, cost estimate, and projected energy generation and payback.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 7 SDG 9 SDG 11
6.	DPR for electrification of village/tribal community	Map unserved/underserved households, propose electrification layout, and estimate coverage, losses, and implementation cost.	PO1, PO2, PO3, PO4, PO10, PO11	SDG 7 SDG 9 SDG 10
7.	DPR for rural drainage system	Survey drainage bottlenecks, develop a drainage layout, and estimate runoff handling capacity and flood-risk reduction.	PO1, PO2, PO3, PO4, PO6, PO10	SDG 6 SDG 9 SDG 11
8.	Sustainability and environmental health projects	Assess local environmental health issues and propose interventions with measurable improvement in hygiene, safety, or resource use.	PO2, PO3, PO4, PO6, PO7, PO8	SDG 3 SDG 6 SDG 11 SDG 12
9.	Plastic free campaigns	Measure plastic usage before and after awareness intervention and report percentage reduction or behavioural change.	PO2, PO3, PO6, PO7, PO8, PO10	SDG 11 SDG 12 SDG 13
10.	Health and nutrition awareness	Conduct baseline and post-program awareness survey and document improvement in awareness score or adoption of healthier practices.	PO2, PO6, PO7, PO8, PO9, PO10	SDG 2 SDG 3 SDG 11
11.	Societal projects involving health wellness	Identify a community health need and develop an awareness/service module with measurable participation and feedback outcomes.	PO2, PO3, PO6, PO8, PO9, PO10	SDG 3 SDG 11 SDG 17
12.	Air quality monitoring system	Collect air-quality data, compare with reference limits, and present trends along with possible mitigation suggestions.	PO2, PO3, PO4, PO5, PO6, PO10	SDG 3 SDG 11 SDG 13
13.	Plastic waste reduction campaign	Track collection, segregation, and replacement actions, and quantify reduction in plastic waste generation or littering.	PO2, PO3, PO6, PO7, PO8, PO10	SDG 11 SDG 12 SDG 13
14.	Urban greening projects	Prepare greening plan, identify planting locations, and assess environmental benefits such as shade, aesthetics, or heat mitigation.	PO2, PO3, PO4, PO6, PO7, PO11	SDG 11 SDG 13 SDG 15
15.	Smart agriculture solution	Design a low-cost monitoring or irrigation support solution and estimate improvement in water use efficiency or crop support.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2 SDG 6 SDG 9
16.	Smart irrigation system	Estimate crop water requirement, propose control logic, and quantify water savings compared with conventional irrigation.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2 SDG 6 SDG 12
17.	Youth mentoring programmes	Deliver a structured mentoring activity and measure participation, engagement, and skill/awareness improvement.	PO6, PO8, PO9, PO10, PO11	SDG 4 SDG 10 SDG 17
18.	Adult education	Conduct learner-needs assessment, prepare instructional content, and measure improvement in basic literacy or numeracy indicators.	PO6, PO8, PO9, PO10, PO11	SDG 4 SDG 10 SDG 17
19.	Food security initiatives / cold storage system	Estimate storage need, design a simple cold-chain concept, and document reduction in spoilage or wastage.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2 SDG 9 SDG 12
20.	Human rights awareness with legal systems	Prepare and deliver an awareness module and assess increase in legal awareness and access-to-rights understanding.	PO6, PO7, PO8, PO9, PO10	SDG 5 SDG 10 SDG 16

21.	House tax collection through digital media	Develop a simple digital workflow or awareness support and measure improvement in compliance, convenience, or response time.	PO2, PO3, PO4, PO5, PO10, PO11	SDG 9 SDG 11 SDG 16
22.	Use of application / application program	Build or demonstrate a useful community app and measure usability, adoption, or efficiency improvement.	PO1, PO3, PO4, PO5, PO9, PO10	SDG 9 SDG 11 SDG 17
23.	Creation of Panchayat library	Plan the library model, catalogue resources, and measure usage, accessibility, or participation outcomes.	PO6, PO8, PO9, PO10, PO11	SDG 4 SDG 10 SDG 11 SDG 17

Suggested Learning Resources:

Textbooks:

1. Phadke, N. D. Community Engagement and Social Innovation. 1st ed., Oxford University Press, New Delhi.
2. Garg, N. R. Project-Based Learning in Engineering Education. 1st ed., Pearson India Education Services, Noida.
3. Gupta, A. and P. Singh. Service Learning and Community Projects. 1st ed., McGraw-Hill Education (India), New Delhi.
4. Wilson, G. Practical Guide to Community Development Projects. 2nd ed., Routledge, London.

Reference books/ Web links/Video Lectures (e-Resources):

1. NPTEL courses on Project-Based Learning and Social Innovation.
2. SWAYAM courses on community engagement and sustainability.
3. UN Sustainable Development Goals portal: https://sdgs.un.org
4. MyGov India and local civic body portals for community initiatives.
5. YouTube resources on design thinking, social innovation, and community service learning.
6. NGO and government field-action case studies related to sanitation, water, health, education, and environment.

Teaching Learning Process

The suggested TLP for Community / Societal Project is as follows;

Week / Phase	Teaching–Learning Activity	Faculty Role	Student Activity	Output / Evidence
1.	Course introduction, objectives, ethics, conduct, and assessment briefing	Explain course scope, rules, rubrics, and expected deliverables	Understand course requirements and form teams	Team list, course plan
2.	Community problem identification and topic selection	Guide topic framing and feasibility	Identify local issues through discussion and observation	Shortlisted project topic
3.	Stakeholder interaction and preliminary survey	Demonstrate survey methods and stakeholder engagement	Collect initial data from community/users	Survey notes, interview record
4.	Problem statement and objective formulation	Review and refine problem statement	Prepare problem statement, scope, and objectives	Approved problem statement
5.	Literature/case study review and baseline analysis	Suggest relevant references and examples	Study existing solutions and compare approaches	Baseline analysis summary
6.	Project planning and role assignment	Help teams organize tasks, timeline, and responsibilities	Plan activities, divide roles, and prepare schedule	Work plan / Gantt chart

7.	Feasibility analysis and solution brainstorming	Check technical feasibility and practicality	Generate possible engineering solutions	Solution alternatives sheet
8.	Selection of final solution and design approach	Review final concept and design logic	Finalize concept, methods, and expected outcome	Concept note / design outline
9.	Data processing / calculations / sizing / mapping	Support computations and technical review	Analyze data, perform calculations, prepare maps/charts	Technical analysis sheet
10.	Prototype / model / audit / DPR / app development	Monitor progress and correct technical issues	Develop the selected output	Working model / draft DPR / map / app
11.	Testing, refinement, and implementation planning	Evaluate technical correctness and improvements	Test prototype or validate proposal with users	Test results / revised output
12.	Field implementation / demonstration / awareness activity	Facilitate community interaction and documentation	Conduct implementation or demonstration	Photos, attendance, implementation record
13.	Documentation of outcomes, feedback, and impact	Review report structure and completeness	Compile findings, stakeholder feedback, and observations	Draft report
14.	Presentation preparation and viva practice	Conduct mock presentation and feedback	Prepare slides/poster and rehearse	Presentation deck
15.	Final presentation, submission, and reflection	Evaluate performance using rubrics	Present project, submit report, reflect on learning	Final report, presentation, viva

Assessment structure:

A. Continuous Internal Evaluation (CIE) – 50 marks

- Students, in batches of 3–4, shall undertake at least one project (or a combination of two related activities) aiming, as far as possible, at a logical implemented or implementable outcome.
- CIE will be conducted by a departmental committee (HoD/nominee, guide and one senior faculty) using the following rubrics totalling 50 marks:

CIE pass requirement:

- A student shall secure a minimum of 20 marks out of 50 in CIE to become eligible to appear for SEE.
- Students who fail to earn the required CIE marks may be given additional opportunities before closure of the semester; no re-doing of CIE is permitted after the end of the semester.

B. Semester End Examination (SEE) – 100 marks (scaled to 50)

- Examination duration: 2 hours.
- Maximum examination marks: 100 (entered as 100 in the VTU portal; the ITI-SMU module automatically scales 100 → 50 for result processing).
- The SEE shall be conducted batch-wise by a committee of three faculty: project guide, one faculty from the same department and one from a different department.

SEE pass requirement and overall passing rule:

- For a pass in SEE, a student shall secure minimum 35 marks out of 100.
- For declaration of a pass grade, the sum of CIE marks (out of 50) and scaled SEE marks (out of 50) shall be ≥ 40; otherwise, the student is awarded grade F (Fail).

CIE Rubric — Continuous Internal Evaluation (Total 50 marks):					
Criterion	**Weight (marks)**	**Excellent**	**Good**	**Fair**	**Needs Improvement**
Problem identification & Relevance to society/industry /community	8	Problem is clearly identified with strong evidence of societal relevance and well-defined scope.	Problem is relevant and scope is clear with adequate supporting evidence.	Problem defined but justification or evidence is weak.	Problem unclear or not relevant; little/no supporting evidence.
Formation of problem statement; Engineering approach, innovation & feasibility	10	Problem statement is precise; approach is sound, innovative and clearly feasible.	Problem statement adequate; approach feasible with minor gaps.	Problem statement partial; approach feasibility is marginal.	Problem statement missing or approach not feasible.
Interaction with stakeholders; Data collection, analysis & interpretation	8	Thorough stakeholder engagement; data collection is comprehensive; analysis is well interpreted.	Good engagement; data and analysis adequate with minor gaps.	Limited engagement; data incomplete and analysis superficial.	Little/no stakeholder contact; insufficient or no data/ analysis.
Project documentation; Clarity, organization & problem-solving demonstrated	10	Documentation is complete, well-organized, analytical, and shows strong problem-solving.	Documentation complete and clear with some analytical content.	Documentation basic with omissions; problem-solving limited.	Documentation missing/poorly organized; no clear problem-solving
Communication & Presentation skills	6	Presentation is confident, structured, and answers queries fully; visuals effective.	Presentation clear and satisfactory; responds to most queries.	Presentation acceptable but lacks clarity or confidence; weak responses.	Presentation poor or absent; unable to respond.
Contribution & Benefit to society (impact, sustainability)	8	Clear, demonstrable societal benefit and sustainability; realistic path to implementation.	Benefit plausible; sustainability considered with minor gaps.	Limited or unclear societal benefit; sustainability not well addressed.	No evident benefit or sustainability; project not community-oriented.

Notes for CIE rubric:

- Minimum CIE pass requirement: 20/50 to be eligible for SEE. [Use departmental committee (HoD/guide + senior faculty) to apply the rubric and record marks.]

SEE Rubric — Semester End Examination (Enter marks out of 100; scaled to 50 later):					
Criterion	**Weight (marks)**	**Excellent (Full marks)**	**Good**	**Fair**	**Needs Improvement**
Problem identification & Relevance to society/industry/ community	16	Problem and relevance are articulated clearly with strong evidence and context.	Problem relevance clear with reasonable evidence.	Problem stated but evidence/ context weak.	Problem poorly defined or irrelevant.
Formation of problem statement; Engineering approach, innovation & feasibility	20	Problem statement is precise; approach demonstrates engineering depth, novelty and feasibility.	Approach is technically sound and feasible with minor limitations.	Approach basic; limited technical depth or feasibility concerns.	No viable engineering approach or infeasible plan.
Interaction with stakeholders; Data collection, analysis & interpretation	16	Excellent stakeholder engagement; rigorous data collection and insightful analysis.	Good engagement and acceptable analysis.	Superficial data collection and limited analysis.	Inadequate or no data; poor analysis.
Project documentation; Clarity, technical rigor & problem-solving demonstrated	20	Report is comprehensive, technically rigorous, and demonstrates systematic problem-solving.	Report is complete and technically correct with minor gaps.	Report lacks technical depth or has notable omissions.	Report missing key elements or technically incorrect.
Communication, Presentation & Viva-voce responses	12	Candidate presents expertly, defends work persuasively and answers all queries correctly.	Good presentation and satisfactory answers to most queries.	Presentation adequate but fails to answer some technical questions.	Poor presentation and unable to defend work.
Contribution & Benefit to society; Impact assessment & sustainability	16	Clear, evidence-based assessment of social impact and Sustainability with scaling recommendations.	Reasonable impact discussion and sustainability considerations.	Limited evaluation of impactor sustainability.	No coherent assessment of impact or sustainability.

SEE pass rule:

- Student must secure at least 35/100 in SEE itself to be eligible for pass consideration.
- Final passing is based on CIE (out of 50) + SEE (scaled to 50) >= 40. Otherwise, grade F (Fail) is awarded.

Suggested implementation notes (for BoS / exam committees):

- Use numerical scores from the rubric and keep brief evaluator comments for each criterion.
- For team projects: record individual contribution within the documentation and adjust individual marks using a peer-evaluation sheet or guide’s assessment.
- Maintain evidence (field notes, photos, questionnaires, DPRs, reports) as annexures for SEE moderation.
- Use standardized score sheet (spreadsheet) mapping rubric items to columns for easy aggregation and archival.

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

Course Outcomes (Course Skill Set):
At the end of the course, the student will be able to:

1. Apply concepts of complex analysis, Cauchy-Riemann equations, Milne-Thomson method, and harmonic functions to construct and analyze analytic functions in engineering applications.
2. Apply Laplace Transform to solve ODE' S and PDE'S of Engineering Problems.
3. Apply probability distributions and joint probability concepts to model and analyze uncertainties encountered in mechanical engineering systems.
4. Utilize sampling theory, hypothesis testing, and Markov chain models for statistical inference and stochastic system analysis.
5. 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 Videos	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).

Manufacturing Technology – II			
Course Code	**1BME402**	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	42:0:28:25:25	SEE Marks	50
Credits	4	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	3

Course Outcomes (Course Skill Set):
At the end of the course, the student will be able to:

1. Apply the mechanics of metal cutting to determine various forces in orthogonal cutting.
2. Analyze tool wear mechanisms and equations to enhance tool life and minimize machining cost.
3. Explain the constructional features of Lathe and Milling machines & the operations that can be performed by the machine tools
4. Understand the working principle of reciprocating machine tools and the importance of grinding machines in industries
5. Appreciate the use of NC & CNC Technology in the Manufacturing Industries

Module-1

Theory of Metal Cutting: Introduction; Chip formation- Continuous chips, Continuous chips with built-up edge, and Discontinuous chips; Orthogonal and Oblique cutting- Thin zone models in Orthogonal cutting, Determination of Shear plane angle, Cutting forces in orthogonal cutting, Merchant's Model for Orthogonal cutting, Lee and Shaffer's solution, Ploughing Force, Chip velocity; Numericals.

Classification of cutting tools: single, and multipoint; tool signature for single point cutting tool; Mechanics of Turning process, Power and Forces in Turning, Specific Cutting Resistance in Turning; Mechanics of Milling Processes-Up-Milling and Down Milling, Chip Thickness in Milling; Mechanics of Drilling Process; Numericals.

Benefits of using Cutting Fluids, Types and selection of cutting fluids.

Number of Hours: 10

Module-2

Tool Life, Tool Wear and Machinability: Introduction; Tool Wear Mechanisms- Diffusion wear, Adhesive wear, Abrasive wear, Fatigue wear; Types of Tool Damage During Cutting- Flank wear, Crater wear, Chipping; Wear and chipping characteristics of different tool materials; Tool Failure Criteria- Direct criteria, Indirect criteria; Tool Life Equations- Taylor's Tool Life Equation, Colding's Equation, Effect of process parameters on Tool Life; Machinability- Machinability criteria; Numericals.

Economics of Machining Processes: Introduction; Costs for single pass turning operations, Optimum cutting speed for minimum costs in turning, Optimum cutting speed for maximum rate of production in turning, Optimum cutting speed for maximum profit rate in turning; Numericals.

Number of Hours: 8

Module-3

Machine tools: Lathe- Introduction, Classification; Center Lathe, Capstan and turret lathes (schematic diagram), - Constructional Features, specification; Machining Time and Power Estimation; Numericals.

Milling Machines: up milling & down milling, classification of milling machines, constructional features - Column and Knee, vertical milling machine, milling cutter nomenclature, various milling operations, calculation of machining time. Indexing: Need of indexing Simple, compound and differential indexing calculations. Numericals.

Number of Hours: 8

Module-4

Reciprocating Machine Tools: Introduction; Constructional features of Shaper, Planer and Slotter; Driving mechanisms of Shaper, Slotter and Planer. Operations on Shaper, Planer & Slotter. Difference between shaping and planing operations.

Drilling Machines: Constructional features of Bench & Radial drilling Machines, types of drill & drill bit nomenclature. Calculation of machining time.

Grinding: Introduction, working principle, classification of grinding processes: cylindrical, surface & centreless grinding. Grinding wheel types, Grinding Wheel Designation and Selection.

Number of Hours: 8

Module-5
Computer Control of Manufacturing Systems: Basic Concepts in Manufacturing Systems, Fundamentals of Numerical Control, Advantages of NC System, Classification of NC Systems- Point to Point and Contouring, NC and CNC, Incremental and Absolute Systems, Open Loop and Closed Loop Systems. Features of NC Machine Tools: Fundamentals of Machining, Design Consideration of NC Machine Tools, Methods of Improving Machine Accuracy- Tool Deflection and Chatter, Lead screws, Thermal Deformations; Increasing productivity with NC Machines, Machining Centers- Horizontal Machining Center, Vertical Machining Center; MCU functions, Readout Displays, CNC controller. Number of Hours: 8

PRACTICAL COMPONENTS OF IPCC

LIST OF EXPERIMENTS

1. Preparation of a model on lathe involving - Plain turning, Facing, Knurling, Drilling, Internal Thread cuts and Eccentric turning.
2. Preparation of a model on lathe involving - Plain turning, Facing, Taper turning, Step turning, and Thread cutting.
3. Producing flat surfaces and Cutting of V Groove/ dovetail / Rectangular groove using a shaper.
4. Cutting of Gear Teeth using Milling Machine.
5. Simple operations and a Job on the drilling and grinding machine.
6. Cutting force measurement with dynamometers for turning, drilling, grinding operations.
7. Demonstration/Experimentation of simple programming of CNC machine operations.

Suggested Learning Resources:

Textbooks:

1. B L Juneja, G S Sekhon, Nitin Seth, “Fundamentals of Metal Cutting and Machine Tools”, New Age International Publishers; Revised 2nd Ed., 2003, Reprint 2018
2. Yoram Koren, “Computer Control of Manufacturing Systems”, McGraw Hill Education (India), 2005
3. P N Rao, “Manufacturing Technology”, Vol. 2 - Metal Cutting and Machine Tools, 4th Ed. McGraw Hill Education (India) Pvt. Limited, 2018.

Reference books / Manuals:

1. S K Hajra Choudhury, A K Hajra Choudhury and Nirjhar Roy, ”Elements of Workshop Technology, Vol 2: Manufacturing Processes”, Media Promoter and Publishers Pvt. Ltd.
2. Amitabha Ghosh and Asok Kumar Mallik, “Manufacturing Science”, 3rd Ed., Affiliated East-West Press Private Limited, New Delhi; Second Edition, 2022.
3. Serope Kalpakjian and Steven R. Schmid, “Manufacturing Engineering and Technology”, Pearson Education, 8th Ed, 2023.
4. A B Chattopadhyay, “Machining and Machine Tools”, 2nd Ed., Wiley, 2017.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112105126
2. https://nptel.ac.in/courses/112107219

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
2. Simulation and Virtual Labs
3. 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, machining skill, adherence to safety practices, proper selection and handling of cutting tools, measuring instruments, and machine tools while performing lathe, shaper, milling, drilling, grinding, cutting force measurement, and CNC programming exercises during regular laboratory sessions.	5 marks
Laboratory Record / Journal	Regular and systematic maintenance of the laboratory record including objectives, machine setup, cutting parameters, procedures, observations, sketches of jobs, calculations (where applicable), results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up the machine, select appropriate cutting tools and machining parameters, perform the assigned machining operation following standard procedures, take accurate measurements/observations, and produce the required job or obtain correct experimental results.	5 marks
Viva-Voce	Understanding of machining principles, machine tool operations, cutting tools, machining parameters, measurement techniques, CNC programming fundamentals, cutting force measurement, safety precautions, and the ability to explain the procedure, observations, and results.	5 marks
	Subtotal	**10**
	Total	**25**

Rubrics for Practical CIE – Continuous Assessment:

Performance Indicator	Superior	Good	Fair	Needs Improvement	Unacceptable
Ability in Conducting Experiments (PO2, PO3, PO4, PO8) **(10 Marks)**	Demonstrates excellent understanding of the machining operation, independently sets up the machine, selects appropriate cutting tools and machining parameters, follows safety practices, performs the operation accurately, obtains the required job/experimental results, and records observations systematically. **(9–10 Marks)**	Performs the machining operation correctly with minimal guidance, follows safety practices, selects appropriate tools and parameters, and records observations with only minor errors. **(7–8 Marks)**	Performs the machining operation satisfactorily with occasional guidance, follows standard procedures, and produces acceptable work with reasonable observations. **(5–6 Marks)**	Requires frequent assistance in machine setup, tool selection, or operation; demonstrates limited understanding of machining procedures; produces incomplete work or inaccurate observations. **(3–4 Marks)**	Unable to perform the machining operation independently, does not follow standard procedures or safety practices, and fails to produce the required job or obtain meaningful observations/results. **(1–2 Marks)**
Laboratory Record / Journal (PO9) **(20 Marks)**	Laboratory record is complete, neat, and well-organized, including objectives, machine specifications, cutting parameters, procedure, sketches of jobs, observations, calculations (where applicable), results, precautions, and conclusions. Submitted on time. **(17–20 Marks)**	Laboratory record is complete with good presentation; minor omissions or formatting errors; observations and results are mostly accurate; submitted on time. **(13–16 Marks)**	Laboratory record contains all essential sections but lacks detail in presentation, sketches, observations, or interpretation; contains a few recording errors. **(9–12 Marks)**	Laboratory record is incomplete, poorly organized, contains several errors or missing sections, and/or is submitted late. **(5–8 Marks)**	Laboratory record is largely incomplete, inaccurate, poorly maintained, or not submitted. **(2–4 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 Cutting Tool Materials and Machining Parameters for Engineering Applications through Literature Survey.	13
2.	Selection and justification of an appropriate machining process and machine tool for manufacturing a given engineering component.	12
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	MOOCs/NPTEL Videos	13
2.	Video Lectures	12

Data Structures and Algorithms			
Course Code	**1BMM403**	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	4	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes (Course Skill Set)

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

1. Explain the fundamentals of data structures and algorithm analysis techniques.
2. Apply linear and non-linear data structures using an appropriate programming language.
3. Analyze the efficiency of algorithms using complexity measures.
4. Apply suitable data structures and algorithms to solve engineering problems.

Module-1

Introduction to Data Structures and Algorithm Analysis: Introduction to Data Structures; Classification of Data Structures; Abstract Data Types; Characteristics of Algorithms; Algorithm Design and Development; Performance Analysis of Algorithms; Time and Space Complexity; Best, Worst and Average Case Analysis; Asymptotic Notations – Big O, Omega and Theta; Introduction to Recursive Algorithms and Applications of Recursion.

Number of Hours: 8

Module-2

Arrays, Strings and Linked Lists: Array Representation and Operations; Traversal, Insertion, Deletion and Searching; Multidimensional Arrays; Sparse Matrices and their Representation; String Representation and Operations; Dynamic Memory Allocation; Singly Linked Lists; Circular Linked Lists; Doubly Linked Lists; Operations and Applications of Linked Lists.

Number of Hours: 8

Module-3

Stacks and Queues: Stack ADT; Array and Linked List Implementation of Stacks; Applications of Stacks; Recursion and Stack Processing; Infix, Prefix and Postfix Expressions; Expression Conversion and Evaluation; Queue ADT; Circular Queues; Linked Queues; Double Ended Queues; Priority Queues; Applications of Queues

Number of Hours: 8

Module-4

Trees and Heaps

Tree Terminology and Representation; Binary Trees; Binary Tree Traversals; Threaded Binary Trees; Binary Search Trees; Operations on Binary Search Trees; AVL Trees; Quadtree, Octree; Heap Data Structures; Heap Operations; Priority Queues using Heaps; Applications of Trees and Heaps.

Number of Hours: 9

Module-5

Graphs, Hashing, Searching and Sorting

Graph Terminology and Representation; Adjacency Matrix and Adjacency List Representations; Breadth First Search (BFS); Depth First Search (DFS); Minimum Spanning Trees; Shortest Path Concepts; Hashing; Hash Functions; Collision Resolution Techniques; Linear Search; Binary Search; Introduction to Internal Sorting Techniques, Bubble Sort, Selection Sort, Insertion Sort, Quick Sort.

Number of Hours: 9

Suggested Learning Resources:

Textbooks:

1. Reema Thareja, "Data Structures Using C", Oxford University Press, 2014.
2. Ellis Horowitz, Sartaj Sahni, and Susan Anderson-Freed, "Fundamentals of Data Structures in C", Universities Press, 2014.
3. Seymour Lipschutz, "Data Structures Schaum's Outlines", Revised 1st Ed., McGraw Hill, 2014.

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

1. S K Srivastava and Deepali Srivastava, "Data Structures Through C in Depth", BPB Publications, 2004.
2. Narasimha Karumanchi, "Data Structures and Algorithms Made Easy", CareerMonk Publications, 2011.
3. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Benjamin/Cummings Publishing Company, 1994.
4. Anany Levitin, "Introduction to the Design and Analysis of Algorithms", 2nd Ed., Pearson, 2009.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/106102064
2. https://www.geeksforgeeks.org/data-structures/
3. https://www.programiz.com/dsa
4. https://www.tutorialspoint.com/data_structures_algorithms

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.	Develop the programs and find the time complexity for the sorting techniques such as Bubble Sort, Selection Sort, Insertion Sort, and Quick Sort.	10
2.	Mini Project – Develop a small application that integrates at least three data structures, justify their selection and analyse the efficiency of the implemented solution.	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 Develop the programs and find the time complexity for the sorting techniques such as Bubble Sort, Selection Sort, Insertion Sort, and Quick Sort.					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Conceptual Understanding	Demonstrates complete understanding of the concept and selects the appropriate data structure/algorithm	Minor conceptual errors	Basic understanding with few errors	Limited understanding	No understanding of the concept
Solution Accuracy	Solution is complete and correct	Minor errors with correct approach	Partially correct solution	Major errors in solution	Incorrect or no solution
Application of Data Structures/Algorithms	Correctly applies suitable data structure/algorithm to solve the problem	Appropriate application with minor mistakes	Basic application with limited effectiveness	Inappropriate application	Unable to apply appropriate data structure/algorithm
Analysis and Interpretation	Correctly analyzes the solution (e.g., complexity, traversal, or operations) and interprets results	Minor errors in analysis	Basic analysis	Limited analysis	No analysis provided
Presentation and Organization	Neat, well-organized, and logically presented with proper steps	Mostly organized with minor omissions	Adequately organized	Poor organization	Disorganized or incomplete

Rubrics for Learning Activity 2 Mini Project – Develop a small application that integrates at least three data structures, justify their selection and analyse the efficiency of the implemented solution.					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Problem Analysis and Data Structure Selection	Correctly identifies the problem and selects the most appropriate data structure/algorithm with strong justification	Appropriate selection with minor gaps in justification	Reasonable selection with limited justification	Inappropriate selection with weak justification	Unable to identify or justify the data structure/algorithm
Program Design and Correctness	Complete and error-free solution producing correct results	Minor logical/coding errors	Partially correct solution	Major errors affecting functionality	Solution does not execute or is incorrect
Algorithm Efficiency	Correctly evaluates and applies an efficient solution considering time and space complexity	Minor errors in efficiency analysis	Basic understanding of efficiency	Limited consideration of efficiency	No consideration of efficiency
Testing and Result Analysis	Comprehensive testing with correct interpretation of results	Adequate testing with minor omissions	Basic testing and analysis	Limited testing	No testing or analysis
Documentation and Presentation	Well-organized report/model with clear explanation and proper documentation	Good documentation with minor omissions	Satisfactory documentation	Poorly organized documentation	Inadequate or missing documentation

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.	Assignment	10
2.	Mini Project	25
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 Outcomes (Course Skill Set)

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

1. Identify and calculate the key fluid properties used in the analysis of fluid behavior.
2. Explain the principles of pressure, buoyancy and floatation
3. Apply the knowledge of fluid dynamics while addressing problems of mechanical and chemical engineering.
4. Explain the concept of boundary layer in fluid flow and apply dimensional analysis to form dimensionless numbers in terms of input output variables
5. Explain the basic concepts of compressible flow.

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, 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's equation in stream function, flow net, Numericals.

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 venturimeter, orificemeter, rectangular and triangular notch, pitot tube, orifices, 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, Industrial flow measurements)	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	**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 understanding with minor gaps	Basic understanding	Limited understanding	Unable to explain components
Application of Concepts (PO2)	Correctly relates plant operation to cycle and efficiency concepts	Mostly correct analysis	Partial analysis	Minimal application	No application
Technical Report Quality (PO10)	Well-structured, detailed and professional	Good structure with minor errors	Average quality	Poor organization	Incomplete report
Observation and Data Interpretation (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	**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 understanding 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 Presentation (PO9, PO10)	Highly active and collaborative	Good participation	Moderate participation	Limited participation	No participation

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 Videos	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	3

Course Outcomes (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 Height Gauge, and Vernier Depth Gauge.
2. Measurement of Angles - Taper angle measurement using 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 roundness and cylindricity
10. Measurement of gear tooth thickness using gear tooth vernier caliper or gear tooth micrometer
11. Measurement of Surface Roughness using Surface Roughness Tester
12. Measurement of screw thread parameters like pitch, effective diameter, etc.,

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.

Reference books / Manuals:

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). **Continuous Internal Evaluation (CIE):** Out of 50 marks, 35marks shall be to assess the regular classwork and test of Part-A and the rest 15 marks shall be for Part-B. Out of 35 marks prescribed for Part-A, 20 marks shall be considered for the assessment of the regular classwork as per the rubrics. The rest 15 marks shall be for the test conducted by the concerned course instructor handling the laboratory classes. The allotment of marks for regular class assessment and test shall be as per the rubrics indicated in Table P1. **Semester End Examination (SEE):** The SEE marks prescribed for Part-A is 70 and 30 for Part-B. The split-up marks of 70 for SEE of Part-A are: a} Procedure/ writeup: 15 marks b) Conduction and result: 40 marks c) Viva-voce: 15 marks The allotment of marks for SEE of Part-B is as per the rubrics indicated in Table P2. • 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**.

Table P1 –Distribution of CIE marks for Part – A and Part - B		
Component	**Description**	**Marks**
Allotment of marks for regular class work of Part – A		
Attendance, punctuality, Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission, units, graphical work, etc.	10 marks
Allotment of marks for the Test under Part – A		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	10 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	05 marks
	Total	**35**
Allotment of marks for regular class work of Part – B		
Problem formulation / identification/Approach / Design & planning	Understanding the given open-ended task or defining the objective, Logical approach, innovative ideas, circuit / model design	05 marks
Implementation / experimentation / Result analysis and validation/ Report / Documentation / Presentation	Actual execution, correctness, practical skills / Interpretation, comparison with expected outcomes / Organization, clarity, creativity, technical writing.	05 marks

Allotment of marks for the Test under Part – B		
Problem understanding & planning, Implementation / design execution.	Clarity of concept, logical plan, innovative method, communication, etc.	05 marks
Viva / Justification of approach	Explanation of reasoning and methods used	
	Total	**15**

Table P2 –Distribution of SEE marks for Part - B		
Component	**Description**	**Marks**
Problem understanding & planning, Implementation / design execution.	Clarity of concept, logical plan, innovative method, communication, etc.	15 marks
Viva / Justification of approach	Explanation of reasoning and methods used	15 marks
	Total	**30**

Rubrics for CIE – Continuous assessment:

Performance Indicator	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 Outcomes (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.

LIST 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.

Reference books / Manuals:

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 Outcomes (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.

LIST 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 control logic, and provides appropriate engineering conclusions.	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 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 understanding with minor conceptual gaps.	Provides basic answers with acceptable understanding.	Responds with limited understanding and requires prompting.	Unable to answer questions satisfactorily.

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 Outcomes (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.

LIST 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	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	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	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 and Software Proficiency	Maintains complete laboratory records, presents simulation studies effectively, and demonstrates excellent proficiency in commercial simulation software.	Maintains good records and demonstrates software usage with minor errors.	Maintains satisfactory records and demonstrates basic software skills.	Records are incomplete and software usage requires significant guidance.	Fails to maintain records or 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	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	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	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	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 Outcomes (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.

LIST OF EXPERIMENTS

PART A (4 SESSIONS: 8 Hours): 30 Marks

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 components – any four

PART B (10 SESSIONS: 20 Hours): 70 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
- Engine Oil Container
- Cover of a hairdryer
- Computer mouse
- Badminton Racket
- Drone body shell

Note: Students may use any one of the following commercial software packages:
Solid Edge/ SolidWorks/ CATIA or any other equivalent Commercial or free or open-source software.

Suggested Learning Resources:

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

1. Les Piegl and Wayne Tiller, “The NURBS Book”, Springer-Verlag, 1997.
2. Sham Tickoo, “CATIA V5-6R2023 for Designers”, 21st Ed., CADCIM Technologies, 2024.
3. David F Rogers and J Alan Adams, “Mathematical Elements for Computer Graphics”, McGraw-Hill Publishing Co., 1976.
4. Ibrahim Zeid, “CAD/CAM Theory and Practice”, 2nd Ed., McGraw-Hill Education, 2009.
5. Michael E Mortenson, “Geometric Modeling”, 3rd Ed., Industrial Press, 2006.
6. “Modeling a Part Using Surfaces – Solid Edge Velocity Series”, - Siemens, 2011.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=HIg4RY4STt0
- https://www.youtube.com/watch?v=jCSoHAdEc8w
- https://www.youtube.com/watch?v=cERemsfuZ2Y
- https://www.youtube.com/watch?v=ZyH9CcqBuT8
- https://www.youtube.com/watch?v=j5VNLd8LVbM
- https://www.youtube.com/shorts/EzQq61mUmco
- 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.

Biology for Engineers			
Course Code	**1BME407**	Scheme	**2025**
Type of Course	**BSC**	Semester	IV
Teaching Hours/Week (L:T:P)	2:0:0	CIE Marks	50
Total Hours of Pedagogy per semester L:T:P:SL:TW	28:0:0:24:08	SEE Marks	50
Credits	2	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes (Course Skill Set)

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

1. Explain fundamental biological principles, biological systems relevant to engineering applications.
2. Explain bio-inspired and biomimetic principles and their applications to engineering materials, mechanisms and systems.
3. Illustrate biomimetic strategies used in mechanical and interdisciplinary engineering applications.
4. Evaluate the potential of selected bio-inspired approaches for innovative and sustainable engineering solutions.

Module-1

Introduction: Science and Engineering, Biological Engineering, Expectations for Biological Engineers. **Principles of Biology**: Form and Function, Modularity and Incremental Change, Biological Hierarchies: The Cell as the Basic Unit of Life.

Biological Engineering Solutions: Systems Approach, Relationships between Engineering and Biology, Living Things as the Solution (Bionics, or Hybrid Systems), Living Things as Models (Biomimetics), Biological Solutions to Biological Problems (Biotechnology), Living Things as Recipients (Biomedical Engineering)

Number of Hours: 6

Module-2

Molecular Machines and Biosensors: Molecular Machines and Motors, The F_0F_1-ATP Synthase Motors, The Bacterial Flagellar Motor. Cytoskeleton: Microtubules, Microfilaments, and Intermediate Filaments, Biosensors, Types of Biosensors, Glucose Biosensors, Bio-detectors: DNA Detection, Biosensor Detection of Pollutants, Biosensor in Food Industry.

Number of Hours: 6

Module-3

Human Organ Systems and Bio Designs:

Brain as a CPU System: Architecture of the Central Nervous System and Peripheral Nervous System, Electroencephalography (EEG), Robotic Arms for Prosthetics, Engineering Solutions for Parkinson's Disease.

Eye as a Camera System: Architecture of Rod and Cone Cells, Optical Corrections, Cataract, Lens Materials, Bionic Eye.

Heart as a Pump System: Architecture, Electrical Signalling and ECG Monitoring, Heart-related Issues, Pacemakers, Defibrillators.

Lungs as Purification System: Architecture, Gas Exchange Mechanisms, Spirometry, Chronic Obstructive Pulmonary Disease, Ventilator, Heart-Lung Machine.

Kidney as a Filtration System: Architecture, Mechanism of Filtration, Chronic Kidney Disease, Dialysis.

Number of Hours: 6

Module-4

Nature-Bioinspired Materials and Mechanisms:

Echolocation and its Engineering Applications - Ultrasonography and Sonar; Photosynthesis and its Engineering Applications - Photovoltaic Cells and Bionic Leaves; Bird Flight and Navigation - Aircrafts and GPS Applications; Lotus Leaf Effect - Superhydrophobic and Self-Cleaning Surfaces; Plant Burrs - Bioinspired Velcro Fasteners; Shark Skin - Bioinspired Friction-Reducing Swimsuit; Kingfisher Beak - Bioinspired Bullet Train Design.

Number of Hours: 5

Module-5

Trends in Bioengineering:

Bioprinting Techniques and Materials: Introduction to 3D printing and Bioprinting, Techniques in Bioprinting, Materials used in Bioprinting, 3D Printing of Ear, Bone and Skin, 3D Printed Foods.

Electrical Tongue and Electrical Nose in Food Science, Bioimaging and Artificial Intelligence for Disease Diagnosis, Self-healing Bio-concrete.

Number of Hours: 5

Note:
1. All modules shall be qualitative in nature. No numerical problems shall be included.
2. The contents of the modules have been selected from the following textbooks:
   - Module-1: Textbook 1 - Chapter 1, Chapter 5 & Chapter 8
   - Module-2: Textbook 2 - Chapter 4
   - Module-3: Textbook 3 - Module 3
   - Module-4: Textbook 3 - Module 4
   - Module-5: Textbook 3 - Module 5

Suggested Learning Resources:

Textbooks:
1. Arthur T Johnson, "Biology for Engineers", 2nd Ed., CRC Press, 2018.
2. Thyagarajan S, Selvamurugan N, Rajesh M P, Nazeer R A, Richard W Thilagaraj W, Barathi S, and Jaganathan M K, "Biology for Engineers", Tata McGraw-Hill, 2018.
3. Keerthi S, Diwakar S J, Paramesha M, Sharangouda J Patil, "Biology for Engineers", Narendra Publishing House, 2024.

Reference books / Manuals:
1. Marc André Meyers and Po-Yu Chen, "Biological Materials Science", Cambridge University Press, 2014.
2. Joon B Park and R S Lakes, "Biomaterials: An Introduction", 3rd Ed., Springer Publications, 2012.
3. Annamma Odaneth, "Biology for Engineers", All India Council for Technical Education, 2023.
4. Ibrahim T Ozbolat, "3D Bioprinting: Fundamentals, Principles and Applications", Academic Press, 2016.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/121106008
- https://nptel.ac.in/courses/102101058
- https://nptel.ac.in/courses/102101068

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
- ICT-Enabled Teaching
- 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.	Analyse a biological system or natural phenomenon, identify its underlying principle, establish the corresponding engineering analogy, and study its application in engineering – Technical Report	15
2.	Bio-Inspired Engineering Applications – 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:
Analyse a biological system or natural phenomenon, identify its underlying principle, establish the corresponding engineering analogy, and study its application in engineering – Technical Report

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Selection and understanding of biological system / natural phenomenon	Selects a highly relevant biological system or natural phenomenon and demonstrates a clear, accurate and comprehensive understanding of its structure and function.	Selects a relevant system or phenomenon and demonstrates good understanding of its structure and function with minor gaps.	Selects an appropriate system or phenomenon but demonstrates only a basic understanding of its structure and function.	Selection is only partly relevant and understanding of the biological system or phenomenon is limited.	Selection is inappropriate or the biological system/phenomenon is not adequately understood.
Identification and explanation of the underlying biological principle	Clearly identifies and accurately explains the underlying biological principle, mechanism or functional feature with excellent logical reasoning.	Identifies and explains the underlying principle correctly with good reasoning and minor omissions.	Identifies the underlying principle but explanation is basic or lacks sufficient clarity.	Partially identifies the principle; explanation is unclear, incomplete or contains significant gaps.	Fails to identify or incorrectly explains the underlying biological principle.
Establishment of engineering analogy / bio-inspired concept	Establishes a clear, logical and technically sound analogy between the biological principle and an engineering concept, mechanism, material or system.	Establishes a relevant engineering analogy with good technical understanding, with minor limitations.	Establishes a basic engineering analogy, but the connection between biology and engineering is not fully developed.	Engineering analogy is weak, unclear or only partially related to the biological principle.	Fails to establish a meaningful engineering analogy.

Analysis of engineering application	Provides a clear and insightful analysis of an existing or potential engineering application, explaining how the biological principle contributes to the engineering solution.	Provides a relevant engineering application and explains the connection to the biological principle adequately.	Identifies an engineering application but provides only a limited analysis of its connection with the biological principle.	Application is inadequately explained or the connection with the biological principle is weak.	No relevant engineering application is identified or analysed.
Technical report quality and presentation	Report is exceptionally well structured, technically clear and concise, with appropriate figures/illustrations, references, logical presentation and proper technical documentation.	Report is well structured and technically presented, with appropriate illustrations and references and only minor shortcomings.	Report is adequately structured and understandable but has some deficiencies in technical presentation, illustrations or referencing.	Report has weak organization, limited technical presentation and inadequate supporting illustrations/references.	Report is poorly organized, incomplete or lacks essential technical documentation and supporting evidence.

Rubrics for Learning Activity 2: Bio-Inspired Engineering Applications – Case Study Presentation					
Performance Indicator	**Superior (5 Marks)**	**Good (4 Marks)**	**Fair (3 Marks)**	**Needs Improvement (2 Marks)**	**Unacceptable (1 Mark)**
Understanding of the bio-inspired engineering application	Demonstrates excellent and comprehensive understanding of the selected bio-inspired engineering application and its underlying biological inspiration.	Demonstrates good understanding of the application and its biological inspiration with minor gaps.	Demonstrates basic understanding of the application and biological inspiration.	Demonstrates limited understanding with significant gaps or inaccuracies.	Demonstrates little or no understanding of the selected application.
Engineering interpretation and relevance	Clearly explains the relationship between the biological principle and the engineering application and establishes strong engineering relevance.	Explains the biological–engineering relationship clearly with good engineering relevance.	Explains the relationship adequately but with limited engineering interpretation.	Engineering relevance is weak or inadequately explained.	Fails to establish a meaningful connection between biology and engineering.
Case-study content and analysis	Presents relevant, accurate and well-organized case-study information with insightful analysis of the engineering application, benefits and significance.	Presents relevant and accurate information with good analysis and adequate discussion of the engineering application.	Presents relevant information but analysis is mainly descriptive and limited in depth.	Content is incomplete, insufficiently analysed or contains some inaccuracies.	Content is inadequate, largely irrelevant or substantially inaccurate.

Presentation skills and use of visual aids	Presents confidently and clearly with excellent organization, effective communication, appropriate technical terminology and highly relevant visual aids.	Presents clearly and confidently with good organization, communication and appropriate visual aids.	Presentation is understandabl e but has some issues with organization, clarity, delivery or visual aids.	Presentation lacks clarity, organization or effective use of visual aids.	Presentation is poorly organized, difficult to understand or lacks appropriate visual support.
Response to questions and overall communication	Responds accurately and confidently to questions, demonstrates strong subject understanding and communicates ideas effectively.	Responds appropriately to most questions and communicates ideas clearly.	Responds to basic questions but demonstrates limited depth of understanding.	Has difficulty responding to questions and requires considerable prompting.	Unable to respond meaningfully to questions or communicate the subject 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	14
2.	Case Study	10
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	NPTEL Videos	8

Environmental Science Project [Common to all disciplines of Engineering]			
Course Code	**1BEP408**	Scheme	**2025**
Type of Course	**SDC**	Semester	IV
Teaching Hours/Week (L:T:P)	30 (0:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L:T:P:SL/TW	30 (0:0:0:30)	SEE Marks	50
Credits	**1**	Total Marks	100
Type of Examination	Practical	Exam Hours	03

Course objective:

The Environmental Science Project is a practical, applied-learning course that builds students' environmental awareness and responsibility. It focuses on real issues such as climate change, pollution, biodiversity, resource use, soil erosion, and thermal comfort, using field surveys, case studies, data collection, audits, and analysis to develop feasible and sustainable solutions. Students may work individually or in groups of up to four, including interdisciplinary topics, and assessment is based on the prescribed rubrics.

Course outcome (Course Skill Set):

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

1. Identify and analyse environmental problems through field interaction and technical assessment.
2. Develop skills in project planning, field survey, data collection, implementation, documentation and reporting.
3. Formulate feasible engineering problem statements and solutions considering practical constraints and sustainability aspects.
4. Apply principles of environmental responsibility, ethics and societal welfare in engineering practice through community-oriented interventions.
5. Exhibit multidisciplinary learning and problem-solving ability based on collected data, user feedback and baseline conditions.
6. Demonstrate teamwork and communication skills while interacting with technical and non-technical stakeholders and reflect on project impact on society.

Restrictions and professional conduct:

Environmental Science Projects should be academic, socially responsible, technically focused, and politically neutral. Students and faculty must maintain professionalism, ethical conduct, and respect while working with communities and stakeholders, and avoid any political, ideological, commercial, or disruptive activities. Projects should also consider practical constraints such as cost, resources, safety, environmental impact, and stakeholder cooperation.

SET OF PROJECT ACTIVITIES (TW/SL = 30 HOURS)

Methods for project identification:

Students may identify the project topic using one or more of the following methods:

- Interaction with local rural or urban stakeholders such as local leaders, corporation/ municipality personnel, NGOs, panchayat representatives, etc.
- Review of issues highlighted in print and electronic media, and social networks (WhatsApp, Facebook, X, Instagram, etc.).
- After selecting a broad topic, students shall collect data, conduct a feasibility survey, estimate timelines and resources, approximate expenditure, and then define the problem statement and objectives clearly.

List of Project Topics and Engineering Outcomes

The following structured sequence of activities is to be carried out during the semester:

Sl. No.	Project Title	Measurable Engineering Outcome	Mapped POs	SDGs
1.	Rural and urban water conservation and management systems	Prepare a site-specific water-saving plan, estimate water demand–supply gap, and propose a feasible conservation intervention with quantified savings.	PO1, PO2, PO3, PO4, PO10, PO11	SDG 6 SDG 11 SDG 12
2.	Waste management and recycling	Conduct waste audit, classify waste streams, and design a segregation/recycling workflow with measurable reduction in mixed waste.	PO2, PO3, PO4, PO6, PO8, PO10	SDG 11, SDG 12 SDG 13
3.	Afforestation	Identify a degraded area, prepare plantation layout, and demonstrate survival-rate tracking and maintenance schedule for saplings.	PO2, PO3, PO4, PO6, PO7, PO11	SDG 11 SDG 13 SDG 15
4.	Biogas generation and power generation	Estimate organic waste availability, size a small biogas system, and document expected gas output or energy yield.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 7 SDG 11 SDG 12
5.	DPR for solar power rural plant	Prepare a DPR with load assessment, panel sizing, cost estimate, and projected energy generation and payback.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 7 SDG 9 SDG 11
6.	DPR for electrification of village/tribal community	Map unserved/underserved households, propose electrification layout, and estimate coverage, losses, and implementation cost.	PO1, PO2, PO3, PO4, PO10, PO11	SDG 7 SDG 9 SDG 10
7.	DPR for rural drainage system	Survey drainage bottlenecks, develop a drainage layout, and estimate runoff handling capacity and flood-risk reduction.	PO1, PO2, PO3, PO4, PO6, PO10	SDG 6 SDG 9 SDG 11
8.	Sustainability and environmental health projects	Assess local environmental health issues and propose interventions with measurable improvement in hygiene, safety, or resource use.	PO2, PO3, PO4, PO6, PO7, PO8	SDG 3 SDG 6 SDG 11 SDG 12
9.	Plastic free campaigns	Measure plastic usage before and after awareness intervention and report percentage reduction or behavioural change.	PO2, PO3, PO6, PO7, PO8, PO10	SDG 11 SDG 12 SDG 13
10.	Health and nutrition awareness	Conduct baseline and post-program awareness survey and document improvement in awareness score or adoption of healthier practices.	PO2, PO6, PO7, PO8, PO9, PO10	SDG 2 SDG 3 SDG 11
11.	Societal projects involving health wellness	Identify a community health need and develop an awareness/service module with measurable participation and feedback outcomes.	PO2, PO3, PO6, PO8, PO9, PO10	SDG 3 SDG 11 SDG 17
12.	Air quality monitoring system	Collect air-quality data, compare with reference limits, and present trends along with possible mitigation suggestions.	PO2, PO3, PO4, PO5, PO6, PO10	SDG 3 SDG 11 SDG 13
13.	Plastic waste reduction campaign	Track collection, segregation, and replacement actions, and quantify reduction in plastic waste generation or littering.	PO2, PO3, PO6, PO7, PO8, PO10	SDG 11 SDG 12 SDG 13
14.	Urban greening projects	Prepare greening plan, identify planting locations, and assess environmental benefits such as shade, aesthetics, or heat mitigation.	PO2, PO3, PO4, PO6, PO7, PO11	SDG 11 SDG 13 SDG 15

15.	Smart agriculture solution	Design a low-cost monitoring or irrigation support solution and estimate improvement in water use efficiency or crop support.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2 SDG 6 SDG 9
16.	Smart irrigation system	Estimate crop water requirement, propose control logic, and quantify water savings compared with conventional irrigation.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2 SDG 6 SDG 12
17.	Food security initiatives / cold storage system	Estimate storage need, design a simple cold-chain concept, and document reduction in spoilage or wastage.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2 SDG 9 SDG 12

Suggested Learning Resources:

Textbooks:

1. Phadke, N. D. Community Engagement and Social Innovation. 1st ed., Oxford University Press, New Delhi.
2. Garg, N. R. Project-Based Learning in Engineering Education. 1st ed., Pearson India Education Services, Noida.
3. Gupta, A. and P. Singh. Service Learning and Community Projects. 1st ed., McGraw-Hill Education (India), New Delhi.
4. Wilson, G. Practical Guide to Community Development Projects. 2nd ed., Routledge, London.

Reference books/ Web links/Video Lectures (e-Resources):

1. NPTEL courses on Project-Based Learning and Social Innovation.
2. SWAYAM courses on community engagement and sustainability.
3. UN Sustainable Development Goals portal: https://sdgs.un.org
4. MyGov India and local civic body portals for community initiatives.
5. YouTube resources on design thinking, social innovation, and community service learning.
6. NGO and government field-action case studies related to sanitation, water, health, education, and environment.

Teaching Learning Process

The suggested TLP for Community / Societal Project is as follows;

Week / Phase	Teaching–Learning Activity	Faculty Role	Student Activity	Output / Evidence
1.	Course introduction, objectives, ethics, conduct, and assessment briefing	Explain course scope, rules, rubrics, and expected deliverables	Understand course requirements and form teams	Team list, course plan
2.	Community problem identification and topic selection	Guide topic framing and feasibility	Identify local issues through discussion and observation	Shortlisted project topic
3.	Stakeholder interaction and preliminary survey	Demonstrate survey methods and stakeholder engagement	Collect initial data from community/users	Survey notes, interview record
4.	Problem statement and objective formulation	Review and refine problem statement	Prepare problem statement, scope, and objectives	Approved problem statement
5.	Literature/case study review and baseline analysis	Suggest relevant references and examples	Study existing solutions and compare approaches	Baseline analysis summary
6.	Project planning and role assignment	Help teams organize tasks, timeline, and responsibilities	Plan activities, divide roles, and prepare schedule	Work plan / Gantt chart
7.	Feasibility analysis and solution brainstorming	Check technical feasibility and practicality	Generate possible engineering solutions	Solution alternatives sheet

8.	Selection of final solution and design approach	Review final concept and design logic	Finalize concept, methods, and expected outcome	Concept note / design outline
9.	Data processing / calculations / sizing / mapping	Support computations and technical review	Analyze data, perform calculations, prepare maps/charts	Technical analysis sheet
10.	Prototype / model / audit / DPR / app development	Monitor progress and correct technical issues	Develop the selected output	Working model / draft DPR / map / app
11.	Testing, refinement, and implementation planning	Evaluate technical correctness and improvements	Test prototype or validate proposal with users	Test results / revised output
12.	Field implementation / demonstration / awareness activity	Facilitate community interaction and documentation	Conduct implementation or demonstration	Photos, attendance, implementation record
13.	Documentation of outcomes, feedback, and impact	Review report structure and completeness	Compile findings, stakeholder feedback, and observations	Draft report
14.	Presentation preparation and viva practice	Conduct mock presentation and feedback	Prepare slides/poster and rehearse	Presentation deck
15.	Final presentation, submission, and reflection	Evaluate performance using rubrics	Present project, submit report, reflect on learning	Final report, presentation, viva

Assessment structure:

A. Continuous Internal Evaluation (CIE) – 50 marks

- Students, in batches of 3–4, shall undertake at least one project (or a combination of two related activities) aiming, as far as possible, at a logical implemented or implementable outcome.
- CIE will be conducted by a departmental committee (HoD/nominee, guide and one senior faculty) using the following rubrics totalling 50 marks:

CIE pass requirement:

- A student shall secure a minimum of 20 marks out of 50 in CIE to become eligible to appear for SEE.
- Students who fail to earn the required CIE marks may be given additional opportunities before closure of the semester; no re-doing of CIE is permitted after the end of the semester.

B. Semester End Examination (SEE) – 100 marks (scaled to 50)

- Examination duration: 2 hours.
- Maximum examination marks: 100 (entered as 100 in the VTU portal; the ITI-SMU module automatically scales 100 → 50 for result processing).
- The SEE shall be conducted batch-wise by a committee of three faculty: project guide, one faculty from the same department and one from a different department.

SEE pass requirement and overall passing rule:

- For a pass in SEE, a student shall secure minimum 35 marks out of 100.
- For declaration of a pass grade, the sum of CIE marks (out of 50) and scaled SEE marks (out of 50) shall be ≥ 40; otherwise, the student is awarded grade F (Fail).

CIE Rubric — Continuous Internal Evaluation (Total 50 marks):					
Criterion	**Weight (marks)**	**Excellent**	**Good**	**Fair**	**Needs Improvement**
Problem identification & relevance to society/environment	8	Problem clearly identified with strong evidence of relevance and well-defined scope.	Relevant problem with clear scope and adequate evidence.	Problem defined but justification is weak.	Problem unclear or not relevant.
Formation of problem statement; engineering approach, innovation & feasibility	10	Precise statement; sound, innovative, feasible approach.	Adequate statement; feasible with minor gaps.	Partial statement; marginal feasibility.	Missing or infeasible.
Interaction with stakeholders; data collection, analysis & interpretation	8	Thorough engagement; comprehensive data and well interpreted analysis.	Good engagement; adequate data and analysis.	Limited engagement; incomplete data and superficial analysis.	Little or no stakeholder contact; no data/analysis.
Project documentation; clarity, organization & problem-solving demonstrated	10	Complete, well-organized, analytical, and strong problem-solving.	Complete and clear with some analytical content.	Basic with omissions; problem-solving limited.	Missing/poorly organized; no clear problem-solving.
Communication & presentation skills	6	Confident, structured, and answers queries fully; visuals effective.	Clear and satisfactory; responds to most queries.	Acceptable but lacks clarity or confidence; weak responses.	Poor or absent; unable to respond.
Contribution & benefit to society (impact, sustainability)	8	Clear, demonstrable societal benefit and realistic sustainability path.	Benefit plausible; sustainability considered with minor gaps.	Limited or unclear benefit; sustainability weak.	No evident benefit or sustainability.

Notes for CIE rubric:

- Minimum CIE pass requirement: 20/50 to be eligible for SEE. [Use departmental committee (HoD/guide + senior faculty) to apply the rubric and record marks.]

SEE Rubric — Semester End Examination (Enter marks out of 100; scaled to 50 later):					
Criterion	**Weight (marks)**	**Excellent (Full marks)**	**Good**	**Fair**	**Needs Improvement**
Problem identification & relevance to society/environment	16	Clearly articulated with strong evidence and context.	Clear with reasonable evidence.	Problem stated but evidence/ context weak.	Poorly defined or irrelevant.
Formation of problem statement; engineering approach, innovation & feasibility	20	Precise; demonstrates engineering depth, novelty and feasibility.	Technically sound and feasible with minor limitations.	Basic; limited technical depth or feasibility concerns.	No viable engineering approach or infeasible plan.
Interaction with stakeholders; data collection, analysis & interpretation	16	Excellent engagement; rigorous data collection and insightful analysis.	Good engagement and acceptable analysis.	Superficial data collection and limited analysis.	Inadequate or no data; poor analysis.
Project documentation; clarity, technical rigor & problem solving demonstrated	20	Comprehensive, technically rigorous, and systematic.	Complete and technically correct with minor gaps.	Lacks technical depth or has notable omissions.	Missing key elements or technically incorrect.
Communication, presentation & viva-voce responses	12	Presents expertly, defends work persuasively and answers all queries correctly.	Good presentation and satisfactory answers to most queries.	Adequate but fails to answer some technical questions.	Poor presentation and unable to defend work.
Contribution & benefit to society; impact assessment & sustainability	16	Clear, evidence-based impact assessment with scaling recommendations.	Reasonable impact discussion and sustainability considerations.	Limited evaluation of impact or sustainability.	No coherent assessment of impact or sustainability.

SEE pass rule:

- Student must secure at least 35/100 in SEE itself to be eligible for pass consideration.
- Final passing is based on CIE (out of 50) + SEE (scaled to 50) >= 40. Otherwise, grade F (Fail) is awarded.

Suggested implementation notes (for BoS / exam committees):

- Use numerical scores from the rubric and keep brief evaluator comments for each criterion.
- For team projects: record individual contribution within the documentation and adjust individual marks using a peer-evaluation sheet or guide's assessment.
- Maintain evidence (field notes, photos, questionnaires, DPRs, reports) as annexures for SEE moderation.
- Use standardized score sheet (spreadsheet) mapping rubric items to columns for easy aggregation and archival.

Artificial Intelligence and Machine Learning			
Course Code	**1BMM409**	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	42:0:0:35:13	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes (Course Skill Set)

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

1. Explain the fundamental concepts and terminology of Artificial Intelligence and Machine Learning relevant to Mechanical Engineering.
2. Explain the machine-learning workflow, engineering datasets, data preparation and model evaluation.
3. Apply supervised and unsupervised learning techniques for prediction, classification and analysis of engineering data.
4. Apply Machine Learning and Deep Learning techniques to mechanical systems, manufacturing, predictive maintenance, computer vision, and engineering design applications
5. Apply Generative AI, Transformers, Deep Reinforcement Learning and responsible use of AI in engineering applications.

Module-1

INTRODUCTION TO MACHINE LEARNING AND ENGINEERING DATA

Machine Learning Landscape: What is Machine Learning? Why use Machine Learning? Examples of Machine Learning applications. Types of Machine Learning systems: supervised learning, unsupervised learning and reinforcement learning. Batch and online learning. Instance-based and model-based learning.

The Machine Learning Project: Looking at the big picture. Framing the problem. Getting the data. Exploring and visualizing the data. Discovering and visualizing the data. Creating a test set. Preparing the data. Selecting and training a model. Fine-tuning the model. Evaluating the system. Launching and monitoring the system.

Engineering Data for Machine Learning: Engineering datasets, experimental data, sensor data, manufacturing data, physical-system data, features and targets, training and testing data, data-driven engineering problems.

Engineering Applications: Machine-condition monitoring, tool-wear prediction, surface-roughness prediction, temperature prediction, energy-consumption prediction and manufacturing-process analysis.

Number of Hours: 10

Module-2

DATA PREPARATION, REGRESSION AND CLASSIFICATION

Data Exploration and Preparation: Explore and visualize data. Data preprocessing. Handling missing data. Handling text and categorical attributes. Feature scaling and transformation. Transformation pipelines. Training and test sets.

Regression: Linear Regression. Multiple Linear Regression. Polynomial Regression. Nonlinear Regression. Performance measures for regression. Underfitting and overfitting.

Classification: Binary classification. Multiclass classification. Multilabel classification. Multioutput classification. Classification using nearest neighbours and other standard learning approaches.

Classification Performance Measures: Confusion matrix. Accuracy. Precision. Recall. F1 score. ROC curve and related performance measures.

Engineering Applications: Surface-roughness prediction, tool-wear prediction, temperature prediction, energy-consumption prediction and component-quality classification.

Number of Hours: 8

Module-3

MACHINE LEARNING ALGORITHMS

Support Vector Machines: Linear SVM classification. Nonlinear SVM classification. SVM regression. Decision boundaries. Kernel methods.

Decision Trees: Training and visualizing a decision tree. Making predictions. Estimating class probabilities. CART training algorithm. Computational complexity. Gini impurity. Entropy. Regularization. Regression using decision trees.

Ensemble Learning and Random Forests: Voting classifiers. Bagging and pasting. Random forests. Extra-trees. Feature importance. Boosting. AdaBoost. Gradient Boosting. Stacking.

Dimensionality Reduction: The curse of dimensionality. Main approaches to dimensionality reduction. Projection. Principal Component Analysis. Preserving variance. Principal components. Randomized PCA. **Engineering Applications:** Fault classification, machine-condition classification, manufacturing-quality classification and dimensionality reduction of sensor data. Number of Hours: 8
Module-4
UNSUPERVISED LEARNING AND DEEP LEARNING **Clustering:** Introduction to clustering. K-Means. Limits of K-Means. DBSCAN. Gaussian Mixtures. Anomaly detection. Selecting the number of clusters. **From Biological Neurons to Artificial Neural Networks:** Biological neurons. Perceptron. Multilayer Perceptron. Backpropagation. Regression MLPs. Classification MLPs. Training neural networks. **Training Deep Neural Networks:** Vanishing gradients. Exploding gradients. Batch normalization. Regularization. Dropout. Learning-rate scheduling. Optimizers. **Deep Computer Vision:** Convolutional layers. Filters. Feature maps. Pooling layers. CNN architectures. LeNet. AlexNet. VGG. ResNet. Transfer learning. Object detection. YOLO. Semantic segmentation. **Engineering Applications:** Automated visual inspection, surface-defect detection, machine-fault classification, manufacturing-quality inspection and image-based engineering diagnosis. Number of Hours: 8
Module-5
GENERATIVE AI, TRANSFORMERS AND ENGINEERING APPLICATIONS **Generative Learning:** Autoencoders. Generative models. Generative Adversarial Networks. Latent generative models. Diffusion models. **Transformers:** Introduction to Transformers. Attention mechanism. Transformer architecture. Applications of Transformers. **Deep Reinforcement Learning:** Introduction to Reinforcement Learning. Deep Reinforcement Learning. Engineering applications. **Engineering-Specific Machine Learning:** Active Learning. Semi-supervised Learning. Data-driven engineering models. Machine-learning model selection for engineering problems. Uncertainty in engineering decision-making. **Generative AI for Engineering:** Generative AI for engineering design. Generative design. Engineering information retrieval. Technical-document analysis. AI-assisted engineering workflows. AI-assisted engineering documentation. **Responsible AI:** Data quality. Bias. Explainability. Reliability. Hallucination. Human-in-the-loop systems. Safety-critical AI. Intellectual property. Ethical use of AI. Number of Hours: 8
Suggested Learning Resources: **Textbooks:** 1. Mark Fuge, “Machine Learning for Mechanical Engineering,” Department of Mechanical Engineering, University of Maryland, 2025. 2. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems”, 3rd Ed., O'Reilly Media, 2022. **Reference books / Manuals:** 1. Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, 4th Ed., Pearson, 2009. 2. T. M. Mitchell, “Machine Learning”, McGraw Hill, 2017. 3. Ian Goodfellow, Yoshua Bengio and Aaron Courville, “Deep Learning”, MIT Press, 2016. 4. Christopher M. Bishop and Hugh Bishop, “Deep Learning: Foundations and Concepts”, Springer, 2023. 5. Kevin P. Murphy, “Probabilistic Machine Learning: An Introduction”, MIT Press, 2022. 6. François Chollet, “Deep Learning with Python”, Manning Publications, 2017. 7. S. Shalev-Shwartz and S. Ben-David, “Understanding Machine Learning: From Theory to Algorithms”, Cambridge University Press, 2014.
Web links and Video Lectures (e-Resources): 1. Fuge, M. (2025). *Machine Learning for Mechanical Engineering*. University of Maryland. https://ideal.umd.edu/ML4ME_Textbook/ 2. https://www.youtube.com/watch?v=fPLxFXiS9fU 3. https://www.youtube.com/watch?v=2fq9wYslV0A 4. https://www.nptel.ac.in/courses/106106139 5. https://www.nptel.ac.in/courses/108103192 6. https://www.nptel.ac.in/courses/106108841

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.	Assignment / Tutorial Sheets (CO-based Numericals)	10
2.	Mini Project / Model / Case Study/ Computer Model Development	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
Mini Project / Model / Case Study/ Computer Model Development

Performance Indicator	Superior (5 Marks)	Good (4 Marks)	Fair (3 Marks)	Needs Improvement (2 Marks)	Unacceptable (1 Mark)
Problem Identification & Formulation	Clearly identifies a relevant engineering problem, defines objectives and scope precisely, and formulates appropriate inputs, outputs and performance criteria.	Identifies a relevant problem and defines objectives, inputs and outputs appropriately with minor gaps.	Problem and objectives are identified but formulation is partially complete or lacks clarity.	Problem is vaguely defined and important objectives or parameters are missing.	Problem is inappropriate, unclear or not adequately formulated.

Data / Methodology & Model Development	Effectively prepares relevant data/information, selects an appropriate methodology, and develops a technically sound model/solution with clear justification.	Performs data preparation and selects and develops an appropriate methodology/model with minor gaps.	Performs basic data preparation and develops a generally suitable model/solution with limited justification.	Data preparation or methodology /model development has significant deficiencies.	Unable to prepare the required data or develop an appropriate methodolog y/model.
Analysis, Validation & Engineering Application	Systematically evaluates and validates the solution, interprets results accurately, establishes engineering significance, and provides well-justified conclusions or improvements.	Evaluates and validates the solution appropriately and establishes a good engineering connection.	Performs basic evaluation and demonstrates a reasonable engineering connection, but analysis is limited.	Evaluation, interpretatio n or engineering application is incomplete or weak.	Unable to evaluate results or demonstrate meaningful engineering application.
Computational / Software Implementation	Effectively uses appropriate programming, software, simulation or modelling tools to develop an accurate, well-structured and reproducible solution.	Uses appropriate tools effectively with minor errors or limitations.	Uses the required tools at a basic level but implementation has some errors or lacks clarity.	Implementat ion is incomplete or requires substantial assistance.	Unable to effectively implement the required solution.
Teamwork & Technical Communication	Demonstrates effective teamwork, planning and individual responsibility; communicates the methodology, results and conclusions clearly and confidently and responds accurately to questions.	Participates actively, completes assigned responsibilities and communicates the work clearly with minor gaps.	Participates adequately and presents the work understandably but with limited organization or depth.	Contribution or communicati on is limited and requires considerable guidance.	Fails to contribute meaningfully or communicat e the technical work.

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.	Assignment / Tutorial Sheets (CO-based Numericals)	15
2.	Mini Project / Model / Case Study/ Computer Model Development	20
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	MOOCs/NPTEL Videos	13