BE Aerospace Engineering
Third Semester Syllabus Academic Year 2026-2027

Transforms and Statistics

Course Code	1BMAT301	Scheme	2025
Type of Course	Applied Science Course (ASC)	Semester	III
Teaching Hours/Week (L: T: P)	70 (3 : 2 : 0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T):LI(P):SL&TW:	120 (42 : 28 : 0 : 50)	SEE Marks	50
Credits	4	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Apply Fourier series techniques to represent periodic functions and perform harmonic analysis relevant to engineering applications.
CO2: Utilize Fourier Transforms and Z-Transforms to analyze engineering systems and solve difference equations arising in mechanical and allied engineering problems.
CO3: Formulate and solve partial differential equations and apply numerical methods for the solution of heat, wave, and Laplace equations encountered in engineering practice.
CO4: Employ Laplace Transform techniques to solve ordinary differential equations and engineering problems involving dynamic systems.
CO5: Analyze and interpret engineering data using statistical tools, measures of central tendency, dispersion, and data visualization techniques for informed decision-making.

Module-1: Fourier Series

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

(RBT Levels: LI, L2 and L3) Number of Hours:**08**

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.

(RBT Levels: LI, L2 and L3) Number of Hours:**09**

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.

(RBT Levels: LI, L2 and L3) Number of Hours:**09**

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.

(RBT Levels: LI, L2 and L3) Number of Hours: **08**

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.

(RBT Levels: LI, L2 and L3) Number of Hours:**08**

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

Textbooks:

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

Reference books / Manuals:

1. B.V. Ramana, Higher Engineering Mathematics, Mc Graw-Hill Education,11th Ed., 2017
2. M.R.Spiegel, J. Schiller, and R.A. Srinivasan, Schaum's Outline of Probability and Statistics, McGraw Hill.
3. S. C. Gupta, Statistical Methods, S. Chand Publishing.
4. V. K. Rohatgi and A. K. Md. Ehsanes Saleh , An Introduction to Probability and Statistics, Wiley.

Web links and e-Resources:

- http://academicearth.org/
- VTUe-ShikshanaProgram
- VTUEDUSATProgram
- 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 Team Work	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	5
4.	Case Study on Signal Processing using Transform Techniques	5

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 civil-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%
Civil engineering insight / risk framing	Clear link to design/assessment decisions, safety and uncertainty; limitations	Some discussion of implications; limited treatment of limitations.	Minimal civil engineering interpretation on beyond numbers.	20%

	discussed.			
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 following sample activities are listed below. 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).

Aerospace Materials

Course Code	1BAS302 / 1BAE302	Scheme	2026
Type of course	Integrated Professional Core Course (IPCC)	Semester	III
Teaching Hours/Week (L:T:P)	70 (3: 0 : 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL&TW	120 (42: 0 : 28 : 50)	SEE Marks	50
Credits	4	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Explain the classification, selection criteria, mechanical behaviour including testing of materials used in aerospace applications.

CO2: Apply the properties and processing characteristics of non-ferrous aerospace materials to select suitable materials for different aircraft components and applications.

CO3: Utilize the properties and characteristics of ferrous materials for appropriate material selection for structural and high-temperature applications.

CO4: Examine the relationship between processing techniques, material properties, and aerospace applications of ceramics and composite materials.

CO5: Apply relevant testing techniques to detect defects in materials, assess corrosion effects, and inspect aerospace components.

Module-1

Mechanical Behaviour of Engineering Materials: Introduction to aerospace materials and their classification, Material selection and design considerations for aircraft, Environmental challenges: High-temperature problems and aerodynamic heating, Toughness-Modules of resilience-Bauchinger's effect-Effect of notches-Testing and flaw detection of materials and components, knowledge of various material testing machines.

Number of Hours: 09

Module-2

Non-ferrous materials in aircraft construction: Aluminium and its alloys: Types and identification. Properties - Castings-Heat treatment processes -Surface treatments.

Magnesium and its alloys: Cast and Wrought alloys-Aircraft application, features specification, fabrication problems, Special treatments.

Titanium and its alloys: Applications, machining, forming, welding and heat treatment, Copper Alloys.

Wood and fabric in aircraft construction and specifications- Glues, Use of glass, plastics & rubber in aircraft, Transparent materials for aircraft canopies, Introduction to glass & carbon composite.

Number of Hours: 09

Module-3

Ferrous materials in aircraft construction: Steels: Plain and low carbon steels, various low alloy steels, aircraft steel specifications, corrosion and heat resistant steels, structural applications.

Maraging Steels: Properties and Applications.

Super Alloys: Use -Nickel base- Cobalt base- Iron base -Forging and Casting of Super alloys-Welding, Heat treatment.

Number of Hours: 08

Module-4
Ceramics and Composites: Introduction, modern ceramic materials, cermets, glass ceramic, production of semi-fabricated forms, Thermal barrier coatings and ceramic coatings, Carbon/Carbon composites, Fabrication processes and their aerospace applications involved in metal matrix composites, polymer composites.
Number of Hours: 08
Module-5
Material Testing: Corrosion, its detection and prevention. Protective finishes. Testing: Destructive and non - destructive testing techniques. Crack detection, inspection of parts by hot oil and chalk, dye-penetrate, fluorescent and magnetic particles, X-ray, ultrasonic, eddy current and acoustic emission methods.
Number of Hours: 08
PRACTICAL COMPONENTS OF IPCC
PART – A: FIXED SET OF EXPERIMENTS
1. To perform tensile, shear and compression tests of metallic / non-metallic specimens using a Universal Testing Machine. 2. To perform Izod and Charpy Tests on M.S. and C.I. Specimens 3. To perform Hardening and tempering of steel, followed by Hardness testing to evaluate the effects of the treatment. 4. To perform a dye penetration test to study the defects of cast and welded specimens 5. To fabricate a standard aerospace component utilising turning operations. 6. To utilise thread cutting operations during fabrication of a standard aerospace component 7. To employ drilling and boring operations during fabrication of a standard aerospace component
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. **Additive Manufacturing for UAV Components:** Students must design and 3D print lightweight, high-impact custom bracket by experimenting with infill patterns and layer orientations, destructively testing them to find the highest strength-to-weight ratio. 2. **Heat Treatment Optimization for Typical Aircraft Components:** Students must consider a typical aircraft metallic material and develop a custom hardening and tempering cycle to achieve a specific target hardness (Rockwell/Brinell) while maximizing impact energy absorption (Charpy test). 3. **Fabrication of Composite Laminates and Understanding the Effect of Lay-up Sequence:** Students will fabricate custom GFRP/CFRP laminates by varying fiber orientation or epoxy ratios, then conduct flexural tests to determine the configuration that sustains the highest stress before ply failure. 4. **Defect Propagation & Notch Sensitivity in Machined Alloys:** A scratched aluminum bracket requires safety verification for flight. Students will induce controlled notches of varying depths into aluminium specimens and perform tensile tests to map the strength reduction, determining the critical flaw size that leads to catastrophic failure. 5. **NDT (Non-Destructive Testing) Reliability Assessment:** Microscopic sub-surface cracks are not noticed during visual inspections. Students will inspect a defective welded joint using Dye Penetrant, Ultrasonic, and Magnetic Particle methods, comparing the reliability of each method for different defect types to create a standardized inspection protocol. 6. **Weight Optimization of Aircraft Components:** Since there are various materials/ material combinations that can be used for the construction of aircraft components, a standard aircraft component / sub-system is to be identified and develop a performance index based on strength, stiffness and cost.

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

Text books:

1. H Buhl, Advanced Aerospace Materials, Springer, Berlin 1992, ISBN-13: 978-3540558880
2. Titterton GF, Aircraft Material and Processes, English Book Store, New Delhi, 5th edition,1998, ISBN-13: 978-8175980136
3. Mouritz, A.P, Introduction to aerospace materials, Oxford 2012, Woodhead Publishing.
4. Avner, S.H, Introduction to physical metallurgy, New York: McGraw-Hill Education 2nd edition, 1997.
5. Campbell, F.C, Manufacturing processes for advanced composites. Oxford: Elsevier Science, 2004
6. Baldev, R., Jayakumar, T. and Thavasimuthu, M, Practical non-destructive testing. 3th edn. New Delhi: Narosa Publishing House, 2013

Reference books / Manuals:

1. Balram Gupta, Aerospace material Vol.1,2,3,4 ARDB, S Chand & Co , 2009, ISBN-13: 978-8121922005.
2. Parker ER, Materials for Missiles and Space, McGraw-Hill Inc., US, 1963.
3. Hill ET, The Materials of Aircraft Construction, Pitman London.
4. CG Krishnadas Nair, Hand book of Aircraft materials, Interline publishers, Bangalore, 1993
5. King and Butler, Principles of Engineering Inspection, Clever Humes Press.

Web links and Video Lectures (e-Resources):

- MIT OpenCourseWare — Unified Engineering: Materials and Structures, MIT OCW 16.001 Fall Portal
- NPTEL - Engineering Materials and Processing Techniques, https://nptel.ac.in/courses/112107086
- NPTEL - Advanced Materials and Processes, https://nptel.ac.in/courses/113105081

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. Problem-Based Learning (PBL)
3. Case-Based Teaching
4. Simulation and Virtual Labs
5. Partial Delivery of course by Industry expert/ industrial visits
6. ICT-Enabled Teaching
7. Role Play

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 each from both Part A and Part B.

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.	Seminar on topics drawn from different modules	5
2.	Case Study Presentation	5
3.	Tool/Software Exploration	5
4.	Micro Projects	10
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Online Courses	20
2.	Technical Literature Review and Summarizing	5

Rubrics for a Sample Activity - Case Study [Marking on a scale of 1-5]

	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
Problem Identification (weightage: 20 %)	Define problem clearly with background and objectives	Problem is well defined with minor omissions.	Problem is adequately identified.	Problem is defined vague with no clarity.	Problem is poorly, not defined
Review of Literature (weightage: 20 %)	Extensive, relevant, and current literature is used and summarized	Good use of relevant references.	Adequate literature with limited analysis.	Limited or outdated references	Little or no supporting literature
Critical Analysis (weightage: 15 %)	Demonstrates exceptional reasoning	Good analysis with logical reasoning	Basic analysis with limited depth	Weak analysis with limited critical assessment	No meaningful analysis
Scientific Advancement and Application (weightage: 15 %)	Scientific concepts are accurately applied and integrated effectively	Concepts are applied with minimal deviations	Adequate application of concepts	Limited understanding demonstrated	Concepts incorrectly applied
Innovation and recommendations (weightage: 15%)	Innovative, feasible recommendations	Recommendations are practical	Acceptable recommendations	Poorly justified recommendations	No meaningful recommendations

Support Data Availability and Presentation (weightage: 15 %)	Use of sufficient data, figures, tables, and evidence	Good use of supporting evidence.	Adequate evidence provided.	Limited evidence used	No supporting evidence.

Rubrics for CIE Examination

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Theory Tests	90–100%	75–89%	60–74%	40–59%	<40%
PI-2: Assignments & Record	Complete and submitted on time	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance	Independent execution without guidance	Minor guidance required	Moderate guidance required	Significant guidance required	Unable to perform the experiment
PI-4: Viva Voce	Excellent understanding and confident responses	Good understanding with minor errors	Basic understanding	Limited understanding	Unable to answer questions
PI-5: Participation	Excellent participation and initiative	Good participation	Average participation	Poor participation	No participation

Rubrics for SEE Examination

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge	Excellent understanding of fundamental concepts and principles.	Good understanding with minor gaps in concepts.	Adequate understanding of basic concepts.	Limited understanding of concepts; requires significant support.	Poor understanding of concepts.
PI-2: Problem Solving	Accurately identifies and solves problems independently using appropriate methods.	Solves problems with minor errors and minimal guidance.	Solves basic problems with acceptable accuracy.	Frequent errors in problem-solving; requires considerable guidance.	Unable to solve the given problems.
PI-3: Analytical Ability	Demonstrates excellent analytical and critical thinking skills.	Demonstrates good analytical ability with minor limitations.	Demonstrates basic analytical skills.	Limited analytical ability; struggles to interpret results.	No evidence of analytical ability.
PI-4: Application	Applies concepts effectively to practical situations and	Applies concepts correctly with minor guidance.	Demonstrates basic application of concepts.	Limited ability to apply concepts in practical situations.	Unable to apply concepts to solve problems.

	engineering problems.				
PI-5: Communication	Excellent communication with clear, organized, and professional presentation.	Good communication with minor improvements needed.	Satisfactory communication of ideas with acceptable clarity.	Poor communication; ideas are not presented clearly.	Communication is incomplete or ineffective.

Continuous Internal Evaluation (CIE)
(i)Theory component
1. The CIE marks of 25 shall be earmarked for two tests.
2. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.
3. 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
1. Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.
2. 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
3. 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.

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

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).

Mechanics of Materials			
Course Code	1BAS303 / 1BAE303	Scheme	2025
Type of Course	Professional Core Course (PCC)	Semester	III

Teaching Hours/Week (L:T:P)	70 (3 : 2 : 0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	120 (42 : 28 : 0 : 50)	SEE Marks	50
Credits	4	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Analyze stress, strain, and deformation in structural members subjected to different loading conditions.

CO2: Evaluate the torsional behavior of structural elements.

CO3: Determine shear and flexural stresses in beams and other engineering members.

CO4: Assess deflection in beams, combined stress conditions and pressure vessel behavior.

CO5: Examine the influence of end conditions and eccentric loading on the stability and load-carrying capacity of columns

Module-1

Stress, Strain and Axial Loading - Introduction to mechanics of materials, assumptions and idealizations, external and internal forces, normal stress and strain, shear stress and strain, stress–strain diagrams, Hooke’s law, Poisson’s ratio, elastic constants and their relations, factor of safety, thermal stresses and strains, axial deformation of stepped and composite bars, statically indeterminate members under axial loading.

Number of Hours:09

Module-2

Torsion of Circular Shafts - Theory of pure torsion, assumptions in torsion theory, derivation of torsion equation, torsional shear stress distribution, angle of twist, power transmission shafts, hollow and solid circular shafts, composite shafts, torsional rigidity, springs subjected to torsion.

Number of Hours:06

Module-3

Shear Force, Bending Moment and Stresses in Beams - Types of beams and loading, shear force and bending moment diagrams, relation between load, shear force and bending moment, theory of simple bending, flexure formula, section modulus, bending stresses in symmetric and unsymmetric sections, shear stresses in beams, composite beams.

Number of Hours:11

Module-4

Beam Deflection, Combined Loading and Pressure Vessels - Slope and deflection by double integration and moment-area methods, Macaulay’s method (simple problems), superposition principle, combined loading, stress transformation, principal stresses and maximum shear stresses, Mohr’s circle, thin cylindrical and spherical pressure vessels.

Number of Hours:08

Module-5

Columns and Stability - Columns and struts, Euler’s theory of buckling, effective length for different end conditions, Rankine’s formula, eccentric loading on columns, introduction to energy methods: strain energy, resilience, impact loading (basic concepts).

Number of Hours:08

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

Text books:

1. Mechanics of Materials - R. C. Hibbeler, *Mechanics of Materials*, Pearson Education, Latest Edition.
2. Strength of Materials - S. S. Rattan, *Strength of Materials*, McGraw Hill Education.

Reference books / Manuals:

1. Mechanics of Materials - Beer, Johnston, DeWolf & Mazurek, McGraw Hill.
2. Strength of Materials - R. K. Rajput, S. Chand Publications.
5. Advanced Mechanics of Materials - Boresi & Schmidt, Wiley.

Web links and Video Lectures (e-Resources):

- NPTEL – Strength of Materials by Prof. S. K. Bhattacharyya, IIT Kharagpur - https://elearn.nptel.ac.in/shop/nptel/strength-of-materials/?utm_source=chatgpt.com
- MIT OCW – Mechanics & Materials - https://ocw.mit.edu/courses/2-001-mechanics-materials-i-fall-2006/?utm_source=chatgpt.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.

1. Interactive Chalk-and-Talk Sessions supplemented with real engineering and aerospace structural examples.
2. Visualization Through Simulation Tools using software demonstrations for stress distribution, beam deflection, and deformation behavior.
3. Case Studies of Structural Failures in aircraft and engineering structures to relate theoretical concepts with practical applications.

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**.

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.	Two Assignments (RBL4) – One individual and One group Assignment (AI-assisted)	15
2.	Solving Numerical Problems Appearing in GATE / other competitive examinations	10

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Case Study on Structural Failures	5
2.	Tool/Software Exploration (FEA Exploration)	5
3.	Micro Projects involving Component analysis and Investigating Material Behavior	10
4.	Industry Visits / Virtual Laboratory Activities	10
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Exploring Design and Testing Standards	10
2.	Reviewing Research Articles and Summarizing the Findings	10

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Rubrics for a Sample Activity - Case Study [Marking on a scale of 1-5]

	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
Problem Identification (weightage: 20 %)	Define problem clearly with background and objectives	Problem is well defined with minor omissions.	Problem is adequately identified.	Problem is defined vague with no clarity.	Problem is poorly, not defined
Review of Literature (weightage: 20 %)	Extensive, relevant, and current literature is used and summarized	Good use of relevant references.	Adequate literature with limited analysis.	Limited or outdated references	Little or no supporting literature
Critical Analysis (weightage: 15 %)	Demonstrates exceptional reasoning	Good analysis with logical reasoning	Basic analysis with limited depth	Weak analysis with limited critical assessment	No meaningful analysis
Scientific Advancement and Application (weightage: 15 %)	Scientific concepts are accurately applied and integrated effectively	Concepts are applied with minimal deviations	Adequate application of concepts	Limited understanding demonstrated	Concepts incorrectly applied
Innovation and recommendations (weightage: 15%)	Innovative, feasible recommendations	Recommend ations are practical	Acceptable recommen dations	Poorly justified recommendations	No meaningful recommendati ons
Support Data Availability and Presentation (weightage: 15 %)	Use of sufficient data, figures, tables, and evidence	Good use of supporting evidence.	Adequate evidence provided.	Limited evidence used	No supporting evidence.

Rubrics for CIE Examination

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Theory Tests	90–100%	75–89%	60–74%	40–59%	<40%
PI-2: Assignments & Record	Complete and submitted on time	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance	Independent execution without guidance	Minor guidance required	Moderate guidance required	Significant guidance required	Unable to perform the experiment
PI-4: Viva Voce	Excellent understanding and confident responses	Good understanding with minor errors	Basic understanding	Limited understanding	Unable to answer questions
PI-5: Participation	Excellent participation and initiative	Good participation	Average participation	Poor participation	No participation

Rubrics for SEE Examination

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge	Excellent understanding of fundamental concepts and principles.	Good understanding with minor gaps in concepts.	Adequate understanding of basic concepts.	Limited understanding of concepts; requires significant support.	Poor understanding of concepts.
PI-2: Problem Solving	Accurately identifies and solves problems independently using appropriate methods.	Solves problems with minor errors and minimal guidance.	Solves basic problems with acceptable accuracy.	Frequent errors in problem-solving; requires considerable guidance.	Unable to solve the given problems.
PI-3: Analytical Ability	Demonstrates excellent analytical and critical thinking skills.	Demonstrates good analytical ability with minor limitations.	Demonstrates basic analytical skills.	Limited analytical ability; struggles to interpret results.	No evidence of analytical ability.
PI-4: Application	Applies concepts effectively to practical situations and engineering problems.	Applies concepts correctly with minor guidance.	Demonstrates basic application of concepts.	Limited ability to apply concepts in practical situations.	Unable to apply concepts to solve problems.
PI-5: Communication	Excellent communication with clear, organized, and professional presentation.	Good communication with minor improvements needed.	Satisfactory communication of ideas with acceptable clarity.	Poor communication; ideas are not presented clearly.	Communication is incomplete or ineffective.

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).

Fluid Mechanics			
Course Code	1BAS304/ 1BAE304	Scheme	2025

Type of Course	Professional Core Course (PCC)	Semester	III
Teaching Hours/Week (L:T:P)	42 (3 : 0 : 0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90 (42 : 0 : 0 : 48)	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course outcome (Course Skill Set)

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

CO1: Explain the basic properties of fluids, pressure measurement, fluid statics on submerged surfaces

CO2: Interpret different types of fluid flow, fluid kinematics, continuity equation, and the governing conservation equations for fluid motion

CO3: Solve engineering problems involving Bernoulli's equation, Euler's equation, momentum equation, dimensional analysis, and similarity principle

CO4: Analyze the characteristics of boundary layer flow, drag and lift forces on immersed bodies, and the aerodynamic behavior of airfoils.

CO5: Apply the principles of compressible flow, shock waves, and boundary layer theory to analyze fluid flow problems.

Module-1

Basic Considerations:
Introduction, Dimensions- Modules and physical quantities, Continuum view of gases and liquids, Pressure and Temperature scales, Physical properties of fluids.
Fluid Statics:
Pressure distribution in a static fluid, Pressure and its measurement, hydrostatic forces on plane and curved surfaces, buoyancy, illustration by examples.

Number of Hours: 08

Module-2

Fluids in motion:
Methods of describing fluid motion, types of fluid flow, continuity equation in 3 dimensions, velocity potential function and stream function. Types of motion, Source sink, doublet, plotting of stream lines and potential lines Numerical problems.
Fluid Kinematics:
Kinematics of fluid motion and the constitutive equations, Integral (global) form of conservation equations (mass, momentum, energy) and applications, Differential form of conservation equations (continuity, Navier-Stokes equations, energy equation).

Number of Hours: 09

Module-3

Fluid Dynamics:
Equations of motion: Euler's and Bernoulli's equation of motion for ideal and real fluids. Momentum equation, Fluid flow measurements. Numerical problems.
Dimensional analysis and similarity:
Dimensional homogeneity, methods of dimensional analysis, model analysis, types of similarity and similitude. Dimensionless numbers. Model laws. Numerical problems.

Number of Hours: 08

Module-4

Flow past Immersed bodies:

Introduction to boundary layer, boundary layer thickness, Karman's integral momentum theory, drag on a flat plate for laminar and turbulent flow, Drag on immersed bodies. Expression for drag and lift. Kutta –Joukowsky theorem; Fundamentals of aerofoil theory, Numerical problems.

Number of Hours: 08

Module-5

Compressible flow and Boundary Layers theory:
Steady, one-dimensional gas dynamics, Propagation of pressure waves in a compressible medium, velocity of sound, Mach number, Mach cone, Stagnation properties, Bernoulli's equation for isentropic flow, normal shock waves. Numerical Problem; Laminar and turbulent boundary layers.

Number of Hours: 09

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

Text books:

1. Bansal, R.K, "Fluid Mechanics and Hydraulics Machines", Laxmi Publications (P) Ltd., New Delhi 2015,ISBN13: 978-8131808153.
2. Radhakrishnan. E, "Fluid Mechanics", Prentice-Hall of India Pvt. Ltd, 2010, ISBN 13: 9788120331839.
3. Frank M White, "Fluid Mechanics", Mc Graw Hill, 2009, ISBN 978-0-07-352934-9

Reference books / Manuals:

1. Ramamrutham. S "Hydraulic Fluid Mechanics and Fluid Machines", Dhanpat Rai&Sons, Delhi, 1988, ISBN 13: 9788187433804.
2. Kumar. K.L., "Engineering Fluid Mechanics" (VII Ed.) Eurasia Publishing House (P) Ltd., New Delhi, 1995, ISBN 13: 9788121901000.
3. Streeter. V. L., and Wylie, E.B., "Fluid Mechanics", McGraw Hill, 1983, ISBN 13: 9780070665781

Web links and Video Lectures (e-Resources):

- NPTEL – Introduction to Fluid Mechanic by Prof. Suman Chakraborty, IIT Kharagpur https://nptel.ac.in/courses/112105269
- MIT OCW – Fluid Mechanics - https://ocw.mit.edu/courses/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/pages/fluid-mechanics/

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. Interactive Chalk-and-Talk Sessions supplemented with real engineering and aerospace fluid mechanics examples with applications of aerodynamics.
2. Visualization Through Laboratory experiments and simulation tools using software demonstrations for streamlines, Boundary layer separation, Types of flows.
3. Case studies of Slow characteristics on various shapes of the body including cylinder, Flat plate, Airfoil and for aircraft wing.

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**.

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.	Two Assignments (RBL4) – One individual and One group Assignment / micro project	15
3.	Solving Numerical Problems Appearing in GATE / other competitive examinations	10

Rubrics for a Sample Activity – Micro Project (Scale of 1-5)

	Superior (5)	**Good (4)**	**Fair (3)**	**Needs Improvem ent (2)**	**Unacceptable (1)**
Problem Identification and definition (20 % Weightage)	Problem is clearly identified and objectives are stated	Problem clearly defined and objectives are stated with minor omissions	Problem is identified and objectives are generally clear	Objectives are partially defined or lack clarity	Problem and objectives are unclear or missing
Application of Engineering concepts / Innovative aspects (20 % Weightage)	Demonstrates exceptional understanding and accurate application of engineering principles.	Demonstrates strong understanding with only minor errors.	Demonstrates adequate understanding with some inaccuracies	Demonstrates limited understanding and application	Concepts are incorrectly applied or not demonstrated.
Implementation (25 % Weightage)	Solution is complete, functional, innovative, and fully meets objectives.	Solution is functional and meets most objectives.	Solution is functional but requires improvements.	Solution is partially functional.	Solution is incomplete or non-functional.
Testing and Results (20 % Weightage)	Exceptionally well-organized, technically accurate, and professionally formatted.	Well-written with only minor formatting or language errors	Adequately organized with some inconsistencies.	Basic report with several errors or omissions.	Poorly organized, incomplete, or difficult
Documentation and Presentation (15 % Weightage)	Clear, confident, engaging presentation with excellent demonstration and responses.	Effective presentation with good demonstration.	Clear presentation with satisfactory explanation	Basic presentation with limited clarity.	Poor presentation or demonstration.

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1.	Demonstration of Various types of flows over various shapes	5
2.	Tool/Software Exploration (CFD Related)	5
3.	Micro Projects involving the flow analysis and flow behavior by referring the papers from high quality journals	10
4.	Industry Visits / Virtual Laboratory Activities	10
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
3.	Recent developments of applications of fluid mechanics in aircraft and aerospace applications	10
4.	Reviewing Research Articles and Summarizing the Findings	10

Rubrics for CIE Examination:

Note: In case Lab Component Not present for the Subject – then the Rubrics can be suitably modified

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Theory Tests	90–100%	75–89%	60–74%	40–59%	<40%
PI-2: Assignments & Record	Complete and submitted on time	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance	Independent execution without guidance	Minor guidance required	Moderate guidance required	Significant guidance required	Unable to perform the experiment
PI-4: Viva Voce	Excellent understanding and confident responses	Good understanding with minor errors	Basic understanding	Limited understanding	Unable to answer questions
PI-5: Participation	Excellent participation and initiative	Good participation	Average participation	Poor participation	No participation

Rubrics for SEE Examination

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge	Excellent understanding of fundamental concepts and principles.	Good understanding with minor gaps in concepts.	Adequate understanding of basic concepts.	Limited understanding of concepts; requires significant support.	Poor understanding of concepts.
PI-2: Problem Solving	Accurately identifies and solves problems independently using	Solves problems with minor errors and minimal guidance.	Solves basic problems with acceptable accuracy.	Frequent errors in problem-solving; requires considerable guidance.	Unable to solve the given problems.

	appropriate methods.				
PI-3: Analytical Ability	Demonstrates excellent analytical and critical thinking skills.	Demonstrates good analytical ability with minor limitations.	Demonstrates basic analytical skills.	Limited analytical ability; struggles to interpret results.	No evidence of analytical ability.
PI-4: Application	Applies concepts effectively to practical situations and engineering problems.	Applies concepts correctly with minor guidance.	Demonstrates basic application of concepts.	Limited ability to apply concepts in practical situations.	Unable to apply concepts to solve problems.
PI-5: Communication	Excellent communication with clear, organized, and professional presentation.	Good communication with minor improvements needed.	Satisfactory communication of ideas with acceptable clarity.	Poor communication; ideas are not presented clearly.	Communication is incomplete or ineffective.

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).

Mechanisms and Machine Theory

Course Code	1BAS305	Scheme	2025
Type of Course	PCC	Semester	03
Teaching Hours/Week (L:T:P)	42:00:00	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	42:00:00:48	SEE Marks	50
Credits	**03**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Explain the fundamentals of mechanisms, kinematic pairs, kinematic chains, inversions of mechanisms, straight-line motion mechanisms, and intermittent motion mechanisms.

CO2: Analyze the velocity, acceleration, and static forces acting on four-bar, slider-crank, and simple mechanisms using graphical methods and principles of equilibrium.

CO3: Apply the principles of spur gears and gear trains to determine gear parameters, motion transmission characteristics, and torque relationships in simple, compound, reverted, and epicyclic gear trains.

CO4: Analyze the balancing of rotating and reciprocating masses in single-plane, multi-plane, multi-cylinder inline, and radial engine systems using graphical methods.

CO5: Evaluate the performance characteristics of governors and gyroscopes, including stability, sensitiveness, controlling force, gyroscopic couple, and their applications in engineering systems and aircraft.

Module-1

Introduction: Types of constrained motion, Link and its types, joints and its types, kinematic pair and its types, degrees of freedom, Grubler's criterion, Types of kinematic chains and inversions:

Inversions of Four bar chain: Beam engine, coupling rod of a locomotive, Watt's indicator mechanism. Inversions of Single Slider Crank Chain: Pendulum pump or Bull engine, Oscillating cylinder engine, Rotary internal combustion engine, Crank and slotted lever quick return motion mechanism, Whitworth quick return motion mechanism. Inversions of Double Slider Crank Chain: Elliptical trammels, Scotch yoke mechanism, Oldham's coupling. Straight line motion mechanisms: Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanism.

Number of Hours:09

Module-2

Velocity, Acceleration and static force analysis of Mechanisms (Graphical Methods): Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism and Simple Mechanisms by vector polygons.

Static force analysis: Introduction: Static equilibrium, Equilibrium of two and three force members. Members with two forces and torque. Free body diagrams, principle of virtual work. Static force analysis of four bar mechanism and slider-crank mechanism with and without friction

Number of Hours:09

Module-3

Spur Gears: Gear terminology, law of gearing, Path of contact, Arc of contact, contact ratio of spur gear, Interference in involute gears, Methods of avoiding interference.

Gear Trains: Simple gear trains, Compound gear trains, Reverted gear trains, Epicyclic gear trains, Analysis of epicyclic gear train (Algebraic and tabular methods), torques in epicyclic trains.

Number of Hours:08

Module-4

Balancing of Rotating Masses: Balancing of Several Masses Rotating in the Same Plane, Balancing of Several Masses Rotating in Different Planes (only Graphical Methods).

Balancing of Reciprocating Masses: Primary and Secondary Unbalanced Forces of Reciprocating Masses, Partial Balancing of Unbalanced Primary Force in a Reciprocating Engine, Balancing of Primary and secondary Forces of Multi-cylinder In-line Engines, Balancing of Radial Engines (only Graphical Methods)

Number of Hours:08

Module-5

Governors: Types of governors; force analysis of Porter and Hartnell governors, Controlling force, stability, sensitiveness, isochronism, effort and power of Porter and Hartnell governors.

Gyroscopes: Vectorial representation of angular motion, gyroscopic couple, effect of gyroscopic couple on plane disc and aeroplane.

Number of Hours:08

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

Text books:

1. Rattan S.S, "Theory of Machines", Tata McGraw-Hill Publishing Company Ltd., New Delhi, and 3rd edition -2009, ISBN: 007014477X, 9780070144774
2. R.S.Khurmi and J.K.Gupta, "*Theory of Machines*, *Machine Design*, *Thermal Engineering*, *Engineering Mechanics*" S. Chand Publishing, Revised Edition. ISBN 9788121925242
3. J.J. Uicker, G.R. Pennock, J.E. Shigley."Theory of Machines & Mechanisms", OXFORD 5th Ed. 2009, ISBN13: 978-0195371239

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

1. Sadhu Singh by Theory of Machines, Pearson Education India , 2nd Edition
2. Mechanism and Machine Theory, J. S. Rao and R. V. Dukkipati, 2nd Edition, New Age International Publishers.
4. Theory of Machines, Thomas Bevan, 3rd Edition, CBS Publishers & Distributors

Web links and Video Lectures (e-Resources):

1. NPTEL – National Programme on Technology Enhanced Learning Covers Theory of Machines, Kinematics of Machines, Gears, Governors, Gyroscopes, and Balancing., <u>NPTEL Official Website</u> . <u>https://nptel.ac.in/</u>
2. MIT Open Course Ware– Dynamics and Control, Lecture notes, assignments, and videos on kinematics, dynamics, virtual work, and gyroscopic effects. <u>MIT OpenCourseWare: Dynamics and Control I</u>.
3. NPTEL Video Lectures – Theory of Machines Complete lecture series on mechanisms, kinematic chains, gears, balancing, governors, and gyroscopes. <u>https://www.youtube.com/@nptelhrd?utm_source=chatgpt.com</u>.

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. Interactive Chalk-and-Talk Sessions supplemented with use of animations, videos, and simulations to explain mechanisms, kinematic chains, gears, governors, and gyroscopes.
2. Activity-Based Learning by the demonstration of working models of four-bar mechanisms, slider-crank mechanisms, Scotch yoke, Oldham coupling, and gear trains.
3. Simulation-Based Learning by the use of software tools such as MATLAB, MSC ADAMS, SolidWorks Motion, or ANSYS Motion for: Velocity and acceleration analysis, Gear train simulation Balancing of rotating and reciprocating masses , Gyroscopic motion analysis

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**.

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.	Two Assignments (RBL4) – One individual and One group Assignment (AI-assisted)	15
4.	Solving Numerical Problems Appearing in GATE / other competitive examinations	10

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.	Demonstration of Machines and links by various innovative methods	5
2.	Demonstration of Terminology and working of Gear and its	5
3.	Micro Projects involving creation of various machine components	10
4.	Industry Visits / Virtual Laboratory Activities	10
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Exploring Machines and its mechanisms using various lab components	10
2.	Reviewing Recent Research Articles, Summarizing the Findings and Developments in Mechanisms and Machines	10

Rubrics for CIE Examination

Note: In case Lab Component Not present for the Subject – then the Rubrics can be suitably modified

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Theory Tests	90–100%	75–89%	60–74%	40–59%	<40
PI-2: Assignments & Record	Complete and submitted on time	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance	Independent execution without guidance	Minor guidance required	Moderate guidance required	Significant guidance required	Unable to perform the experiment
PI-4: Viva Voce	Excellent understanding and confident responses	Good understanding with minor errors	Basic understanding	Limited understanding	Unable to answer questions
PI-5: Participation	Excellent participation and initiative	Good participation	Average participation	Poor participation	No participation

Rubrics for SEE Examination

Note: for Lab exam, the rubrics may be suitably modified

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge	Excellent understanding of fundamental concepts and principles.	Good understanding with minor gaps in concepts.	Adequate understanding of basic concepts.	Limited understanding of concepts; requires significant support.	Poor understanding of concepts.
PI-2: Problem Solving	Accurately identifies and solves problems independently using appropriate methods.	Solves problems with minor errors and minimal guidance.	Solves basic problems with acceptable accuracy.	Frequent errors in problem-solving; requires considerable guidance.	Unable to solve the given problems.
PI-3: Analytical Ability	Demonstrates excellent analytical and critical thinking skills.	Demonstrates good analytical ability with minor limitations.	Demonstrates basic analytical skills.	Limited analytical ability; struggles to interpret results.	No evidence of analytical ability.
PI-4: Application	Applies concepts effectively to practical situations and engineering problems.	Applies concepts correctly with minor guidance.	Demonstrates basic application of concepts.	Limited ability to apply concepts in practical situations.	Unable to apply concepts to solve problems.
PI-5: Communication	Excellent communication with clear, organized, and professional presentation.	Good communication with minor improvements needed.	Satisfactory communication of ideas with acceptable clarity.	Poor communication; ideas are not presented clearly.	Communication is incomplete or ineffective.

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).

Computer-Aided Aircraft Drawing

Course Code	1BASL306 / 1BAEL306	Scheme	2025
Type of Course	Professional Core Course Lab (PCCL)	Semester	III
Teaching Hours/Week (L:T:P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SLTW	30 (0:0:28:2)	SEE Marks	50
Credits	01	Total Marks	100
Examination type (SEE)	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: To draw and analyze orthographic views, sectional solids as per engineering drawing conventions.

CO2: To draw and analyze standard fasteners, riveted structural connections, and mechanical couplings following engineering drafting conventions.

CO3: To model and draft 2D NACA airfoils, 3D wing surfaces, structural spars, ribs, and fuselage bulkheads using parametric surface modeling techniques.

CO4: To design and assemble complex aircraft propulsion hubs and landing gear assemblies while validating their geometric integration and kinematic operation.

CO5: To formulate and optimize open-ended aerospace projects for specific mission profiles.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 9 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills

PART – A
FIXED SET OF EXPERIMENTS

1. Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedra, Cones and Cylinders resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections
2. Orthographic Views: Conversion of pictorial views into orthographic projections of simple machine parts with or without section. Hidden line conventions. Precedence of lines.
3. Standard Fasteners and Threads: Thread terminology, sectional views of ISO Metric, BSW, Square and Acme threads. Assembly of Hexagonal/square-headed bolt and nut, flanged nut, slotted nut, and aerospace counter-sunk/flush screws.
4. Riveted Joints & Structural Connections: Single and double riveted lap joints, butt joints with single/double cover straps using snap head and standard aerospace flush/universal head rivets—Cotter joint and knuckle joint.
5. Power Transmission Components: Parallel key, Taper key, Woodruff key. Protected type flanged coupling, pin (bush) type flexible coupling, and universal coupling.
6. Introduction to Surface Modeling: Generation of 2D airfoil profiles using standard NACA coordinate data, and sweeping/lofting to create 3D wing surfaces.
7. Drafting of Aircraft Structural Components: 2D drafting and 3D modeling of typical aircraft wing ribs, wing spars, and fuselage bulkheads.
8. Design of propeller and hub assembly.
9. Design of Landing Gear Assembly.

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. **Design of UAV:** Integrate airframe geometry with propulsion and avionics constraints to optimize for a specific mission profile (e.g., endurance vs. payload).
2. **Design of Fuselage:** Develop a monocoque or semi-monocoque fuselage structure that balances aerodynamic efficiency, internal volume, and structural load-path integrity.
3. **Design of Wing:** Parametrically generate a high-lift wing system, incorporating NACA airfoil selection, twist distribution, and spar structural integration to meet defined stall-speed requirements.
4. **Propeller Performance and Hub Optimization:** Design and analyze a variable-pitch propeller hub assembly, focusing on minimizing vibrational torque loads and maximizing thrust efficiency at varying engine RPMs.
5. **Landing Gear Integration and Kinematics:** Formulate the landing gear retraction mechanism and strut geometry to ensure proper weight distribution and ground clearance while maintaining minimal weight penalty.
6. **Adaptive Thermal Management Systems:** Design an active or passive thermal management solution for engine cowlings or electronic bays to mitigate heat soak during high-speed cruise conditions.

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

Textbooks:

1. Machine Drawing, N.D. Bhatt and V.M. Panchal, Charotar Publishing House, 55th Edition, 2020.
2. Engineering Graphics and Design, P.S. Gill, S.K. Kataria & Sons, 2019.
3. Airframe Structural Design: Practical Design Information and Data on Aircraft Structures, Michael Chun-Yung Niu, Conmilit Press, 2nd Edition, 1998.

Reference books / Manuals:

1. Fundamentals of Aerospace Engineering: An Introductory Course to Aeronautical Engineering, Manuel Soler, Create space Independent Publishing, 2017.
2. Aircraft Design: A Conceptual Approach, Daniel P. Raymer, AIAA Education Series, 6th Edition, 2018.
3. Machine Drawing: Includes AutoCAD, Ajeet Singh, McGraw-Hill Education, 2012.

Web links and e-Resources:

- NPTEL - Computer Aided Engineering Design by Dr. Anupam Saxena, IIT Kanpur https://nptel.ac.in/courses/112104031
- NPTEL - Computer Aided Engineering Design by Prof. Anoop Chawla, Prof. P.V. Madhusudan Rao, IIT Delhi https://nptel.ac.in/courses/ 112102101
- MIT Open Course Ware - How to CAD Almost Anything: https://ocw.mit.edu/courses/res-16-002-how-to-cad-almost-anything-january-iap-2024/pages/learning-to-use-cad-software/

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 to improve practical understanding of drawing concepts
2. Use of reverse engineering concept - physical measurement of object and convert to drawings
3. AI-assisted interactive sessions

Self-Learning (SL) Activity	Number of Hours / Semester
Online tutorial(s)	02

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 for the all report 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**.

Sample Rubrics for Continuous Assessment (Lab Records) – Scale of 1-5

	Superior (5)	**Good (4)**	**Fair (3)**	**Needs Improvement (2)**	**Unacceptable (1)**
Completeness of Record (Weightage 25 %)	All sections complete and well-organized report	All sections complete and organized but with minor omissions	Details not sufficient / partially available in some sections	Insufficient details in sections	Report largely incomplete
Technical Content and Accuracy (Weightage 25 %)	Observations, results and plots are properly included and labeled	Minor errors in presenting the content and result accuracy	Some errors in calculations and plots	Significant deviation in results and observations not adequate	Technical content is largely inaccurate
Result Analysis (Weightage 25 %)	Excellent analysis of results, identification of experimental deviations and meaningful conclusions	Adequate analysis of results, listing of conclusions with minor omissions	Basic interpretation with limited discussion of results	Minimal result analysis with unsupported conclusions	No result analysis or presentation of conclusions
Presentation and Timeliness (Weightage 25 %)	Well structured presentation with on time submission	Well prepared presentation with minor deviations but on time	Acceptable presentation with minor time delay	Unclear presentation with omissions and poorly maintained timeline	Not legible, disorganized and difficult to comprehend; not submitted on time

Rubrics for CIE Examination

Note: In case Lab Component Not present for the Subject – then the Rubrics can be suitably modified

Performance Indicator	**Superior (5)**	**Good (4)**	**Fair (3)**	**Needs Improvement (2)**	**Unacceptable (1)**
PI-1: Theory Tests	90–100%	75–89%	60–74%	40–59%	<40
PI-2: Assignments & Record	Complete and submitted on time	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance	Independent execution without guidance	Minor guidance required	Moderate guidance required	Significant guidance required	Unable to perform the experiment

PI-4: Viva Voce	Excellent understanding and confident responses	Good understanding with minor errors	Basic understanding	Limited understanding	Unable to answer questions
PI-5: Participation	Excellent participation and initiative	Good participation	Average participation	Poor participation	No participation

Rubrics for SEE Examination

Note: for Lab exam, the rubrics may be suitably modified

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge	Excellent understanding of fundamental concepts and principles.	Good understanding with minor gaps in concepts.	Adequate understanding of basic concepts.	Limited understanding of concepts; requires significant support.	Poor understanding of concepts.
PI-2: Problem Solving	Accurately identifies and solves problems independently using appropriate methods.	Solves problems with minor errors and minimal guidance.	Solves basic problems with acceptable accuracy.	Frequent errors in problem-solving; requires considerable guidance.	Unable to solve the given problems.
PI-3: Analytical Ability	Demonstrates excellent analytical and critical thinking skills.	Demonstrates good analytical ability with minor limitations.	Demonstrates basic analytical skills.	Limited analytical ability; struggles to interpret results.	No evidence of analytical ability.
PI-4: Application	Applies concepts effectively to practical situations and engineering problems.	Applies concepts correctly with minor guidance.	Demonstrates basic application of concepts.	Limited ability to apply concepts in practical situations.	Unable to apply concepts to solve problems.
PI-5: Communication	Excellent communication with clear, organized, and professional presentation.	Good communication with minor improvements needed.	Satisfactory communication of ideas with acceptable clarity.	Poor communication; ideas are not presented clearly.	Communication is incomplete or ineffective.

Web Designing and App Development			
Course Code	1BASL307A / 1BAEL307A	Scheme	2025
Type of Course	Ability Enhancement Course Laboratory (AEC)	Semester	III
Teaching Hours/Week (L:T:P)	28 (0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SLTW	30 (0: 0: 28: 2)	SEE Marks	50
Credits	1	Total Marks	100
Examination type (SEE)	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Demonstrate the fundamentals of web technologies by creating structured web pages using HTML5 and styling them with CSS3.

CO2: Design and develop responsive and interactive web applications using HTML, CSS, and JavaScript.

CO3: Develop user-friendly mobile applications using Flutter by implementing widgets, layouts, navigation, and user interface components.

CO4: Implement data handling, form validation, and local storage techniques to develop functional mobile applications.

CO5: Design, develop, test, and demonstrate a complete web application and a mobile application to solve simple real-world engineering or personal productivity problems.

SET OF EXPERIMENTS

1. Design and develop a personal profile webpage using basic HTML5 elements.
2. Design and style a responsive webpage using CSS3.
3. Develop a responsive Aerospace Engineering Department website using HTML5 and CSS Flexbox.
4. Install and configure Flutter SDK and Android Studio and develop the first Flutter mobile application.
5. Design and develop a student profile mobile application using Flutter widgets.
6. Develop a multi-screen mobile application using Flutter navigation and routing.
7. Design and validate an online student registration form using HTML5 forms.
8. Develop an interactive web application using JavaScript (CGPA Calculator, Age Calculator, Unit Converter, or Simple Interest Calculator).
9. Design and develop a complete personal portfolio website using HTML5, CSS3, and JavaScript.
10. Develop a student registration mobile application with form validation using Flutter.
11. Develop a mobile application for storing and retrieving data using Shared Preferences in Flutter.
12. Design and develop an Aerospace utility mobile application using Flutter (Aircraft Unit Converter, Flight Checklist, Aircraft Maintenance Logbook, Aerospace Quiz, or CGPA Calculator).

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

Text books:

1. Jon Duckett, HTML & CSS: Design and Build Websites, John Wiley & Sons, 1st Edition, 2011.
2. Jon Duckett, JavaScript and jQuery: Interactive Front-End Web Development, John Wiley & Sons, 1st Edition, 2014.
3. Marco L. Napoli, Beginning Flutter: A Hands-On Guide to App Development, John Wiley & Sons, 1st Edition, 2019.

Reference books / Manuals:

1. Jennifer Robbins, Learning Web Design: A Beginner's Guide to HTML, CSS, JavaScript, and Web Graphics, O'Reilly Media, 6th Edition, 2025.
2. Thomas Bailey and Alessandro Biessek, Flutter for Beginners: An Introductory Guide to Building Cross-Platform Mobile Applications, Packt Publishing, 2nd Edition, 2022.
3. Google Developers, Flutter Documentation and Dart Language Guide, Google Developers Documentation (Latest Edition).

Web links and Video Lectures (e-Resources):

1. Flutter Official Documentation – https://docs.flutter.dev
2. Dart Programming Language – https://dart.dev
3. MDN Web Docs (HTML, CSS & JavaScript) – https://developer.mozilla.org
4. W3Schools Web Tutorials – https://www.w3schools.com
5. freeCodeCamp – https://www.freecodecamp.org
6. Google Codelabs – https://codelabs.developers.google.com
7. Flutter YouTube Channel – https://www.youtube.com/@flutterdev
8. freeCodeCamp YouTube Channel – https://www.youtube.com/@freecodecamp

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. Interactive hands-on laboratory sessions with live coding demonstrations.
2. Project-Based Learning (PBL) through the development of responsive websites and mobile applications.

Self-Learning (SL) Activity	**Number of Hours / Semester**
Online tutorial(s)	02 (minimum)

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 for the all report 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.

Experimental Fluid Mechanics

Course Code	1BASL307B / 1BAEL307B	Scheme	2025
Type of Course	Ability Enhancement Course Laboratory (AEC)	Semester	III
Teaching Hours/Week (L :T : P)	28 (0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L :T:P:SLTW	30 (0: 0: 28: 2)	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Conduct experiments to calibrate flow measuring devices such as Venturimeter, Orificemeter, and Rectangular Notch, and compare the experimental results with theoretical predictions.
CO2: Determine the hydraulic coefficients of orifices and evaluate fluid properties such as viscosity using standard experimental techniques.
CO3: Verify the fundamental principles of fluid mechanics, including Bernoulli's equation and Reynolds experiment, through laboratory investigations.
CO4: Analyze major and minor head losses in pipe flow systems, including losses due to fittings, sudden contraction, and friction, using experimental data.
CO5: Evaluate the characteristics of fluid flow and jet impact by interpreting experimental observations and comparing them with theoretical concepts.

SET OF EXPERIMENTS

1. Calibration of Venturimeter and Determination of the discharge of water using venturimeter and verify with the theoretical values.
2. Calibration of Orificemeter and Determination of the discharge of water using Orificemeter and verify with the theoretical values.
3. Determination of Coefficient of discharge for a small orifice by a constant head method.
4. Determination of Coefficient of discharge for a small orifice by a variable head method.
5. Determination of Viscosity of a Fluid.
6. Calibration of contracted Rectangular Notch.
7. Verification of Bernoulli’s equation.
8. Pipe friction apparatus with loss of head on pipe fittings.
9. Determination of Coefficient of loss of head in a sudden contraction and friction factor.
10. Estimation of Major loss/Minor losses for a given flow system.
11. Impact of Jet over a flat surface.
12. Determination of state of flow in a closed conduit using Reynolds Experiment.

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):
Text books:

1. R.K. Rajput, *Fluid Mechanics and Hydraulic Machines*, S. Chand Publishing, Latest Edition
2. P.N. Modi and S.M. Seth, Hydraulics and Fluid Mechanics including Hydraulic Machines, Standard Book House, Latest Edition.
3. Y.A. Çengel and J.M. Cimbala, Fluid Mechanics: Fundamentals and Applications, McGraw-Hill Education, Latest Edition.

Reference books / Manuals:

1. Frank M. White, *Fluid Mechanics*, McGraw-Hill Education, Latest Edition.
2. John F. Douglas, Janusz M. Gasiorek, John A. Swaffield, and Lynne B. Jack, Fluid Mechanics, Pearson Education.
3. Victor L. Streeter, E. Benjamin Wylie, and Keith W. Bedford, *Fluid Mechanics*, McGraw-Hill Education.

Web links and Video Lectures (e-Resources):

1. NPTEL – Introduction to Fluid Mechanic by Prof. Suman Chakraborty, IIT Kharagpur https://nptel.ac.in/courses/112105269
2. MIT OCW – Fluid Mechanics - https://ocw.mit.edu/courses/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/pages/fluid-mechanics/

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 fluid mechanics laboratory equipment such as Venturimeter, Orificemeter, Reynolds apparatus, Bernoulli's apparatus, and pipe friction setup, followed by hands-on experimentation.
2. Use of computational tools and simulation software (e.g., MATLAB, ANSYS Fluent, or OpenFOAM) to visualize fluid flow behavior and compare simulation results with experimental observations.
3. Flipped-classroom approach with pre-laboratory video demonstrations, laboratory manuals, and reading materials on flow measurement techniques, Bernoulli's principle, Reynolds number, and head loss before performing experiments.
4. Group-based laboratory exercises and mini-projects involving experimental analysis of flow systems, data acquisition, uncertainty analysis, and technical report preparation to enhance teamwork, analytical, and problem-solving skills.

Self-Learning (SL) Activity	Number of Hours / Semester
Online tutorial(s)	02 (minimum)

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 for the all report 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.

Drone Development and Operations			
Course Code	1BASL307C / 1BAEL307C	Scheme	2025
Type of Course	Ability Enhancement Course Laboratory (AEC)	Semester	III
Teaching Hours/Week (L :T : P)	28 (0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	30 (0: 0: 28: 2)	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Identify and classify drone/UAV components, subsystems, configurations, and their applications in aerospace engineering.

CO2: Perform flight simulator training exercises, including simulator familiarization, pre-flight checks, take-off, cruise, advanced manoeuvres, approach, landing, gimbal operations, and abnormal/emergency procedures in accordance with DGCA Remote Pilot Flight Simulator Training requirements.

CO3: Estimate the power, thrust, propulsion, and endurance requirements for drone/UAV systems using fundamental engineering principles.

CO4: Simulate drone flight dynamics, configure flight controller firmware, and calibrate on-board sensors using open-source simulation and ground control software.

CO5: Develop and execute autonomous flight missions, perform mission planning, and process aerial survey data using open-source mission-planning and photogrammetry tools.

SET OF EXPERIMENTS

1. Study and identification of drone/UAV components and subsystems (frame, motors, ESCs, propellers, flight controller, battery, sensors, GCS) and classification of UAVs (fixed-wing, multi-rotor, hybrid VTOL).
2. Assemble a simple quadcopter by integrating the different elements of the quadcopter system for demonstrating basic flying operations
3. Understand either through simulation / experiments drone communication and telemetry analysis by configuring telemetry modules and measurement of flight parameters
4. Demonstrate integration of a lightweight payload such as camera or a sensor to the quadcopter assembled and study the changes in stability, cg and endurance
5. Learn to Fly: Basic Simulator familiarization, controlled take off, hover, climb and descent Flight Maneuvers: Coordinated Left/right turns, rectangular circuit, figure of Eight.
6. Install firmware (PX4/ArduPilot), configure flight controller, calibrate accelerometer, gyroscope, compass, radio, and ESCs.
7. Investigate various aspects of propulsion systems and evaluate their performance such as measurement of motor rpm, thrust, current consumption and efficiency
8. Ground Control Operations: Mission Planning, Waypoint Navigation, Telemetry Monitoring
9. Flight-controller firmware configuration and IMU/compass/accelerometer sensor calibration using the open-source APM Planner 2 / Betaflight Configurator.
10. Autonomous mission programming and MAVLink command scripting using the open-source MAVSDK-Python / DroneKit-Python library with PX4 SITL.
11. Aerial image acquisition, photogrammetry and orthomosaic/3D-map generation using the open- source OpenDroneMap toolchain, with post-processing in QGIS.
12. Develop a report evaluating the performance characteristics of Li-ion and similar batteries measuring the voltage and discharge characteristics, flight endurance and charging procedures

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

Text books:

1. Reg Austin, "Unmanned Aircraft Systems: UAV Design, Development and Deployment", John Wiley & Sons, 2010.
2. Randal W. Beard and Timothy W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012.
3. Quan Quan, "Introduction to Multicopter Design and Control", Springer, 2017.

Reference books / Manuals:

1. ArduPilot Development Team, "ArduPilot Documentation" (Open-source Manual), ardupilot.org.
2. PX4 Development Team, "PX4 User Guide" (Open-source Manual), docs.px4.io.
3. Directorate General of Civil Aviation (DGCA), Government of India, "Remote Pilot Licence Examination & Syllabus – Category 1 (Flight Simulator Training)" (Official Document), Digital Sky Platform, digitalsky.dgca.gov.in.

Web links and Video Lectures (e-Resources):

1. PX4 Autopilot Official Documentation – https://docs.px4.io
2. ArduPilot Official Documentation – https://ardupilot.org/ardupilot
3. QGroundControl User Guide – https://docs.qgroundcontrol.com
4. OpenDroneMap Documentation – https://docs.opendronemap.org
5. NPTEL Online Course: Aeromechanics of Unmanned Aerial Vehicles / Drones by Prof. Abhishek, IIT Kanpur https://nptel.ac.in/courses/101104807
6. DGCA Remote Pilot Licence Syllabus – Flight Simulator Training (Official, DGCA/Digital Sky) – https://www.dgca.gov.in/digigov-portal/?dynamicPage=CivilAviationReqContent/6/256/viewDynamicRuleContLvl2/html&maincivilAviationRequirements/6/0/viewDynamicRulesReq

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 drone hardware components followed by hands-on assembly sessions in the laboratory.
2. Use of open-source simulation software (PX4 SITL, Gazebo, QGroundControl) for virtual experimentation prior to hardware trials.
3. Flipped-classroom approach with pre-lab video lectures/reading on drone subsystems and flight principles.
4. Group-based mini-project involving autonomous mission execution and aerial data analysis/reporting.

Self-Learning (SL) Activity	Number of Hours / Semester
Online tutorial(s)	02 (minimum)

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 for the all report 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.

Spreadsheet for Engineers with VBA Basics			
Course Code	1BASL307D / 1BAEL307D	Scheme	2025
Type of Course	Ability Enhancement Course Laboratory (AEC)	Semester	III
Teaching Hours/Week (L :T : P)	28 (0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	30 (0: 0: 28: 2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2Hrs

Course outcome (Course Skill Set)

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

CO1: Apply spreadsheet functions, formulas, and charting techniques to organize, analyze, and visualize engineering data effectively.
CO2: Develop engineering solutions using logical, conditional, lookup, and mathematical functions in spreadsheets for data analysis and decision-making.
CO3: Analyze engineering datasets using regression analysis, curve fitting, optimization, iterative methods, and matrix operations in spreadsheets.
CO4: Develop VBA programs, user-defined functions, macros, and user forms to automate engineering computations and spreadsheet operations.
CO5: Implement numerical methods such as numerical integration and differential equation solvers using spreadsheets and VBA for solving engineering problems.

SET OF EXPERIMENTS

1. Charting: Create an XY scatter graph, XY chart with two Y-Axes, add error bars to your plot, and 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: Trend line, Slope and Intercept, Interpolation and Forecast, The LINEST Function, Multi linear Regression, Polynomial Fit Functions, Residuals Plot, Slope and Tangent, Analysis Tool Pack.
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, Non-Linear 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. Develop spreadsheets for beam stress, deflection, factor of safety and design of springs. VBA to be used for automation
10. Design and develop a spreadsheet application for engineering analysis (e.g., material selection, cost estimation, project scheduling, flight performance estimation etc.) using formulas, charts, Solver, and VBA.

11. Numerical Integration Using Excel: The Rectangle Rule, The Trapezoid Rule, The Simpson's Rule, creating a User-Defined Function Using the Simpson's Rule.
12. Differential Equations: Euler's Method, Modified Euler's Method, The Runge, Kutta Method, Solving a Second Order Differential Equation.

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

Text books:

1. Excel Resources - 600+ Self Study Guides, Articles & Tools (wallstreetmojo.com).
2. Mc Fedries Paul Microsoft Excel 2019 Formulas and Functions Microsoft Press, U.S, 2019 Edition.
3. John Walkenbach, Excel 2019 Bible, Wiley Publications, 2019.

Reference books / Manuals:

1. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw-Hill Education, 8th Edition, 2021.
2. David M. Bourg, Excel Scientific and Engineering Cookbook, O'Reilly Media, 2006.
3. Michael Alexander and Richard Kusleika, Excel 2019 Power Programming with VBA, Wiley Publications, 2019.

Web links and Video Lectures (e-resources):

1. Microsoft Learn: Excel Training - https://support.microsoft.com/en-us/excel
2. Microsoft Learn: Get Started with VBA in Office - https://learn.microsoft.com/en-us/office/vba/library-reference/concepts/getting-started-with-vba-in-office
3. Excel Easy – Free Excel Tutorials https://www.excel-easy.com/
4. NPTEL: Decision Making with Spreadsheet by Prof. Ramesh Anbanandam, IIT Roorkee - https://nptel.ac.in/courses/110107157

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 Laboratory Sessions: Students perform spreadsheet-based engineering computations and VBA programming through guided laboratory exercises.
2. Demonstration-Based Learning: Instructor demonstrations of Excel functions, data analysis tools, Solver, Goal Seek, and VBA programming followed by student implementation.
3. Case Study Approach: Analysis of engineering datasets from civil, mechanical, electrical, aerospace, and manufacturing applications using Excel and VBA.

Self-Learning (SL) Activity	Number of Hours / Semester
Online tutorial(s)	02 (minimum)

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 for the all report 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.

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)	0:0:0	CIE Marks	50
Total Hours of Pedagogy CI(L :T):LI(P):SL:TW	30 (0:0:0:30)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	02

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:

CO1 (L2 – Understand): Identify and analyse societal problems through field interaction and technical assessment.
CO2 (L3 – Apply): Develop skills in project planning, field survey, data collection, implementation, documentation and reporting.
CO3 (L4 – Analyse): Formulate feasible engineering problem statements and solutions considering practical constraints and sustainability aspects.
CO4 (L3 – Apply): Apply principles of environmental responsibility, ethics and societal welfare in engineering practice through community-oriented interventions.
CO5 (L4 – Analyse): Exhibit multidisciplinary learning and problem-solving ability based on collected data, user feedback and baseline conditions.
CO6 (L5 – Evaluate): 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:

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

Sl. No.	Project title	Measurable engineering outcome	Mapped POs	SDGs
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		Deliver a structured mentoring activity and measure participation, engagement, and skill/awareness improvement.	PO6, PO8, PO9, PO10, PO11	SDG 4, SDG 10,

Sl. No.	Project title	Measurable engineering outcome	Mapped POs	SDGs
	Youth mentoring programmes			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:

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.

Web links and Video Lectures (e-Resources):

1. NPTEL courses on Engineering Geology (IIT Roorkee, IIT Kharagpur).
2. NPTEL courses on Soil Mechanics and Foundation Engineering (IIT Delhi, IIT Bombay).
3. Virtual Labs – Geotechnical Engineering Virtual Lab (IIT Kanpur): https://vlab.co.in
4. Geological Survey of India (GSI) – Maps, reports, and publications: https://www.gsi.gov.in
5. YouTube channels: Civil Engineering Essentials, The Engineering Classroom (soil mechanics experiments).
6. American Society of Civil Engineers (ASCE) – Geotechnical resources and standards

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

Week / Phase	Teaching–Learning Activity	Faculty Role	Student Activity	Output / Evidence
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 (Full marks)	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.

Additional Mathematics -I (Common to all Branches)			
Course Code	1BMATDIP310	Scheme	2025
Type of Course	NCMC	Semester	III
Teaching Hours/Week (L: T: P)	(3:0:0)	MCQ online exam Marks	50
Total Hours of Pedagogy per semester CI (L /T):LI(P):SL&TW:	42 (2:0:0:0)		
Credits	0	Total Marks	100
Total Hours of Pedagogy	42	Exam Hours	--

Course objectives (COS):

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

CO1: Provide the requisite and relevant background necessary to understand the other important engineering mathematics courses offered for Engineers and Scientists

CO2: Apply the knowledge of the co-ordinate system to analyze the polar co-ordinate system.

CO3: Familiarize the importance of calculus associated with one variable and multivariable for all branches of the engineering.

CO4: Analyze the importance of the integral calculus and their application to real-world problems.

CO5: Emphasize the knowledge of the vector calculus to all branches of engineering.

CO6: Develop the knowledge of Linear Algebra to solve the system of equations.

Module-1: Polar Curves and Curvature

Polar coordinates, Polar curves, angle between the radius vector and the tangent, angle between two curves. Pedal equations. Indeterminate forms: L'Hospital's rule ($\frac{\infty}{\infty}, \infty-\infty, 0^0, 1^\infty$).

(RBT Levels: L1, L2 and L3) Number of Hours: 08

Module-2: Partial Differentiation

Introduction: Partial derivatives, total derivative - differentiation of composite functions, Jacobian and problems. Taylor's and Maclaurin's series expansion for one variable (Statement only) – problems

(RBT Levels: L1, L2 and L3) Number of Hours: 09

Module-3: Integral Calculus

Statement of reduction formulae for $\sin^n(x), \cos^n(x)$ and $\sin^m(x)\cos^n(x)$ and illustrative problems.
Evaluation of double integrals and triple integrals-Simple examples.
Applications: Area of the region.

(RBT Levels: L1, L2 and L3) Number of Hours: 09

Module-4: Vector Calculus

Differentiation of vector functions: Velocity and acceleration of a particle moving on a space curve. Scalar and vector point functions. Gradient, Divergence and Curl, Solenoidal and irrotational vector fields-Problems.

(RBT Levels: L1, L2 and L3) Number of Hours: 09

Module-5: Linear Algebra

Introduction to linear algebra:
Elementary row transformation of a matrix, Rank of a matrix. Consistency and Solution of system of linear equations - Gauss-elimination method, Gauss Siedel method. Eigenvalues and Eigenvectors (2 x 2).

(RBT Levels: L1, L2 and L3) Number of Hours: 09

Suggested Learning Resources
Textbooks:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Ed., 2021
2. Gilbert Strang, Linear Algebra and its Applications, Cengage Publications, 4th Ed., 2022.
3. Erwin Kreyszig . Advanced Engineering Mathematics, wiley

Reference Books:

1. H K Das and Rajaneesh Varma, Higher Engineering Mathematics, S. Chand.
2. B. V. Ramana, Higher Engineering Mathematics, McGraw Hill.
3. Mangey Ram, Mathematics in Engineering Sciences, CRC Press
4. N. P. Bali, Manish Goyal - A Textbook of Engineering Mathematics, Laxmi Publications
5. David Poole, Linear Algebra, Cengage Learning India Pvt Ltd.

Web links and e-Resources:

- NPTEL (National Programme on Technology Enhanced Learning) – Mathematics: https://nptel.ac.in/..
- SWAYAM learning modules on Engineering mathematics.
- https://www.coursera.org/ Mathematics for Engineering Specialization

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.

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- ICT-Enabled Teaching.

Assessment Structure:

For courses offered by the Department of Mathematics, the **Continuous Internal Evaluation (CIE)** shall be conducted by the concerned course teacher. The CIE may comprise tests, assignments, quizzes, seminars, or other academic activities, as decided by the concerned teacher. The distribution of marks among these activities shall be determined by the course teacher. The total marks awarded for all CIE activities shall be **100 marks.**

The concerned teacher shall upload the CIE marks to the VTU web portal whenever notified by the University.

Online Mode of Offering for 1BMATDIP301 and 1BMATDIP401

The lecture sessions for 1BMATDIP301 and 1BMATDIP401 shall also be made available through the **vtu.online.ac.in** platform.

1. If all the students admitted to the 3rd and 4th semesters of a college opt to pursue these courses in online mode, the entire course shall be offered online. In such cases, the Centre for Online Education, Mysuru shall conduct the **Continuous Internal Evaluation (CIE)** for **100 marks** and submit the CIE marks to the University, with a copy to the concerned college.
2. Within the **same college/department**, all admitted students shall follow a single mode of learning for these courses. A situation where a part of the students opts for the online mode and the remaining students opt for the offline mode **shall not be permitted**.
3. A college intending to offer these courses through the online mode shall submit the **list of eligible students** to the Registrar, Visvesvaraya Technological University (VTU), Belagavi, for approval. Only after obtaining the approval of the University shall the students be permitted to enrol for the online course through the vtu.online.ac.in platform.

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

BE Aerospace Engineering
Fourth Semester Syllabus Academic Year 2026-2027

Complex Analysis and Probability Distributions

Course Code	1BAS401 / 1BAE401	Scheme	2025
Type of Course	Applied Science Course (ASC)	Semester	IV
Teaching Hours/Week (L: T: P)	42 (3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T):LI(P):SL&TW:	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

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

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

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

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

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

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

Module-1: Complex Analysis

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

Number of Hours:**08**

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 ordina differential equations using Laplace transforms.

Number of Hours:**08**

Module-3: Probability Distributions

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

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

Number of Hours:**09**

Module-4: Sampling theory

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

Number of Hours:**09**

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:**08**

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

Textbooks:

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

Reference books / Manuals:

1. B.V. Ramana, Higher Engineering Mathematics, Mc Graw-Hill Education,11th Ed., 2017
2. M.R.Spiegel, J. Schiller, and R.A. Srinivasan, Schaum's Outline of Probability and Statistics, McGraw Hill.
3. S. C. Gupta, Statistical Methods, S. Chand Publishing.
4. V. K. Rohatgi and A. K. Md. Ehsanes Saleh , An Introduction to Probability and Statistics, Wiley.

Web links and e-Resources:

http://academicearth.org/

VTUe-ShikshanaProgram

VTUEDUSATProgram

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 proce 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 E Examination (SEE), with each carrying 50% weightage.

The CIE Theory component consists of average of TWO IA tests for 25 marks and Continuous Comprehensive Assessmen (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 at least 40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation C

[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 students**. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
	Assignment (at RBL3 or RBL4 levels) for Team Work	10
	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 / Semeste**
1.	Seminar on Complex Analysis	5
2.	MATLAB/Python Simulation of Laplace-Transform problems	5
3.	Mini Project on statistical Models in Engineering Applications	5
4.	Case Study on Signal Processing using Transform Techniques	5

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 civil-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%
Civil engineering insight / risk framing	Clear link to design/assessment decisions, safety and uncertainty; limitations discussed.	Some discussion of implications; limited treatment of limitations.	Minimal civil 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 Cour instructions (CI-70 hour) and Teamwork/ Self learning (TW/Sl-50 hours). Hence, students must complete minimum of t activities as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities v be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinat 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).

Engineering Thermodynamics

Course Code	1BAS402 / 1BAE402	Scheme	2025
Type of course	Integrated Professional Core Course (IPCC)	Semester	IV
Teaching Hours/Week (L:T:P)	70 (3: 0 : 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL&TW	120 (42: 0 : 28 : 50)	SEE Marks	50
Credits	4	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Explain the fundamental concepts of thermodynamics, including heat, and work interactions, with reference to aerospace applications.

CO2: Apply the First Law of Thermodynamics to evaluate energy interactions in closed and open systems,

CO3: Apply Second Law and entropy principles to evaluate heat engines, refrigerators, and reversible/irreversible thermodynamic processes

CO4: Apply thermodynamic relations and equations of state to determine the properties of pure substances and gases.

CO5: Explain the working principles, processes, and performance characteristics of gas and vapour power cycles using P–V and T–S diagrams.

Module-1

Fundamental Concepts & Definitions:

Introduction, Microscopic and macroscopic approaches. Applications in aerospace/ aeronautical systems such as engines, compressors, and turbines. Thermodynamic systems and properties: intensive and extensive. Concepts of thermodynamic state, process, cycle. Zeroth law of thermodynamics. Temperature scales and measurement.

Work and Heat:

Definitions, displacement work, expressions for displacement work in various processes through p-v diagrams shaft work, electrical work, heat, and sign conventions

Number of Hours: 09

Module-2

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, pure substance; definition, two-property rule, Specific heat at constant volume, enthalpy, specific heat at constant pressure. Extension of the First law to control volume; steady state-steady flow energy equation, important applications

Number of Hours: 08

Module-3

Second Law of Thermodynamics and Entropy:

Heat engines and refrigerators with relevance to Brayton cycle. Kelvin-Planck and Clausius statements. Equivalence of the two statements, PMM I and PMM II, Carnot cycle and Carnot Principles, reversible heat engine, reversible and irreversible processes. factors that make a process irreversible.

Entropy: Clausius inequality, entropy as a property, entropy change, principle of increase in entropy, TdS relations, Available and unavailable energy.

Number of Hours: 09

Module-4

Pure Substances and Properties of Gases

p-v, p-T, T-s and h-s diagrams for a pure substance, Equation of State of a gas, Ideal and real gases, Specific heats, internal energy and enthalpy of an ideal gas, compressibility factor and generalized compressibility chart

Thermodynamic relations

Maxwell's equations, Tds relations, ratio of heat capacities, evaluation of thermodynamic properties from an equation of state.

Number of Hours: 08

Module-5

Single stage Reciprocating compressors:
Operation, Work input, Efficiency
Gas Power and Vapour Power Cycles:
Efficiency of air standard cycles, Carnot, Otto, Diesel cycles, Brayton cycle, P-V & T-S diagram, calculation of efficiency, Simple Rankine cycle, Analysis and performance of Rankine Cycle

Number of Hours: 08

PRACTICAL COMPONENTS OF IPCC

PART – A: FIXED SET OF EXPERIMENTS

1. Determining the thermal conductivity of metal bar/ rod
2. Experimental determination of thermodynamic properties and specific heat of a gas using a gas calorimeter
3. Determination of heating value of solid / liquid fuel using bomb calorimeter
4. Determination of isothermal and volumetric efficiency of a reciprocating compressor
5. Determining the flash point and fire point of different fuels using Pensky-Martens apparatus
6. Performance testing of a four-stroke petrol engine
7. Performance testing of a diesel engine

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. Virtual Labs may be used to perform experiments.

1. Determine the relationship between heat supplied, work interaction, and change in internal energy for a closed system.
2. Verification of the first law of thermodynamics using an electrical heating system by checking the equivalence of work and heat by varying voltage and measuring temperature rise.
3. Investigate the effect of compression ratio on Otto cycle performance
4. Study a practical thermodynamic process, quantify entropy generation and lost work, and identify parameters that can improve system efficiency
5. Conduct an experimental study to compare the performance of Otto and Diesel cycles
6. Determine thermal efficiency of a heat engine and compare the experimental performance with the Carnot-efficiency limit
7. Perform energy balance on a device such as turbine, compressor, pump or a nozzle to investigate the effect of operating conditions on the total energy conversion.
8. Students can design experiments to demonstrate their understanding of first and second law of thermodynamics

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

Text books:

1. P K Nag, Basic and Applied Thermodynamics, 2nd Edition, Tata McGraw Hill, 2002.
2. A Venkatesh, Basic Engineering Thermodynamics, Universities Press, India, 2007
3. G. J. Van Wylen and R.E Sonntag, Fundamentals of Classical Thermodynamics, Wiley Eastern, 1985.

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

1. Yunus A. Cenegal and Michael A. Boles, Thermodynamics: An Engineering Approach,Tata McGraw Hill, 2002
2. J.B. Jones and G.A. Hawkins, Engineering Thermodynamics, John Wiley and Sons, Wiley 1986
3. Y.V.C. Rao, An Introduction to Thermodynamics, Wiley Eastern 1993
4. Holman, J. P, Thermodynamics, 4th Edition by Tata McGraw Hill, New Delhi, 2015.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112105123
2. https://ocw.mit.edu/courses/16-050-thermal-energy-fall-2002/
3. https://ht-amrt.vlabs.ac.in/
4. https://nptel.ac.in/courses/127106135

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. Virtual labs
3. Problem-Based Learning (PBL)
4. Case-Based Teaching
5. 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 each from both Part A and Part B.

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.	Seminars / Case Studies / Software tools exploration / Micro projects	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Online Courses / Research paper review	25

Rubrics for a Sample Activity - Case Study [Marking on a scale of 1-5]

	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
Problem Identification (weightage: 20 %)	Define problem clearly with background and objectives	Problem is well defined with minor omissions.	Problem is adequately identified.	Problem is defined vague with no clarity.	Problem is poorly, not defined
Review of Literature (weightage: 20 %)	Extensive, relevant, and current literature is used and summarized	Good use of relevant references.	Adequate literature with limited analysis.	Limited or outdated references	Little or no supporting literature
Critical Analysis (weightage: 15 %)	Demonstrates exceptional reasoning	Good analysis with	Basic analysis with	Weak analysis with limited	No meaningful analysis

		logical reasoning	limited depth	critical assessment	
Scientific Advancement and Application (weightage: 15 %)	Scientific concepts are accurately applied and integrated effectively	Concepts are applied with minimal deviations	Adequate application of concepts	Limited understanding demonstrated	Concepts incorrectly applied
Innovation and recommendations (weightage: 15%)	Innovative, feasible recommendations	Recommendations are practical	Acceptable recommendations	Poorly justified recommendations	No meaningful recommendations
Support Data Availability and Presentation (weightage: 15 %)	Use of sufficient data, figures, tables, and evidence	Good use of supporting evidence.	Adequate evidence provided.	Limited evidence used	No supporting evidence.

Rubrics for CIE Examination

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Theory Tests	90–100%	75–89%	60–74%	40–59%	<40%
PI-2: Assignments & Record	Complete and submitted on time	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance	Independent execution without guidance	Minor guidance required	Moderate guidance required	Significant guidance required	Unable to perform the experiment
PI-4: Viva Voce	Excellent understanding and confident responses	Good understanding with minor errors	Basic understanding	Limited understanding	Unable to answer questions
PI-5: Participation	Excellent participation and initiative	Good participation	Average participation	Poor participation	No participation

Rubrics for SEE Examination

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge	Excellent understanding of fundamental concepts and principles.	Good understanding with minor gaps in concepts.	Adequate understanding of basic concepts.	Limited understanding of concepts; requires significant support.	Poor understanding of concepts.
PI-2: Problem Solving	Accurately identifies and solves problems independently using appropriate methods.	Solves problems with minor errors and minimal guidance.	Solves basic problems with acceptable accuracy.	Frequent errors in problem-solving; requires considerable guidance.	Unable to solve the given problems.
PI-3: Analytical Ability	Demonstrates excellent analytical and critical thinking skills.	Demonstrates good analytical ability with minor limitations.	Demonstrates basic analytical skills.	Limited analytical ability; struggles to interpret results.	No evidence of analytical ability.

PI-4: Application	Applies concepts effectively to practical situations and engineering problems.	Applies concepts correctly with minor guidance.	Demonstrates basic application of concepts.	Limited ability to apply concepts in practical situations.	Unable to apply concepts to solve problems.
PI-5: Communication	Excellent communication with clear, organized, and professional presentation.	Good communication with minor improvements needed.	Satisfactory communication of ideas with acceptable clarity.	Poor communication; ideas are not presented clearly.	Communication is incomplete or ineffective.

Continuous Internal Evaluation (CIE)

(i)Theory component

1. The CIE marks of 25 shall be earmarked for two tests.
2. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.
3. 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

1. Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.
2. 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
3. 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.

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

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).

Aerodynamics

Course Code	1BAE403 / 1BAS403	Scheme	2025
Type of Course	PCC	Semester	IV
Teaching Hours/Week (L:T:P)	70 (3 : 1 : 0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	120 (42: 28:00:50)	SEE Marks	50
Credits	04	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

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

CO1: Explain the fundamental concepts of potential flow theory and apply thin airfoil theory to analyze the aerodynamic characteristics of two-dimensional airfoils.

CO2: Analyze the aerodynamic performance of finite wings using lifting line theory, lifting surface theory, and vortex-based methods to determine lift, drag, and moment characteristics.

CO3: Evaluate the aerodynamic effects of wing configurations, high-lift devices, compressibility, and transonic phenomena on aircraft performance.

CO4: Apply the principles of compressible flow to analyze isentropic flows, nozzles, diffusers, and determine the influence of Mach number on flow properties.

CO5: Analyze supersonic flow phenomena involving normal shocks, oblique shocks, and expansion waves, and interpret experimental aerodynamic data obtained from wind tunnel testing.

Module-1

Potential Flows: Governing Equation: Laplace Equation, Uniform flow, Source flow, Sink flow, Combination of a uniform flow with source and sink, Doublet flow, Non-lifting flow over a circular cylinder, Vortex flow, Lifting flow over a circular cylinder, Kutta-Joukowski theorem and generation of Lift, D'Alembert's paradox.

Incompressible Flow over Airfoils: Airfoil characteristics, Vortex Sheet, The Kutta Condition, Kelvin's circulation theorem and the starting vortex, Classical thin airfoil theory for symmetric Airfoil and cambered airfoil, Effect of Airfoil Thickness, Camber on the Airfoil Aerodynamic Characteristics

Number of Hours: 09

Module-2

Incompressible Flow Over Finite Wings: Downwash and induced drag on wings, Vortex Filament, Biot-Savart law and Helmholtz's theorems, Infinite and semi-infinite vortex filament, Prandtl's classical lifting line theory, Limitations of Prandtl's lifting line theory, Elliptical and modified elliptical lift distribution. Lifting surface theory: Extended lifting line theory lifting surface theory, vortex lattice method for wings. Lift, drag and moment characteristics of complete airplane.

Number of Hours: 08

Module-3

Applications of Finite Wing Theory & High Lift Systems

Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane, ground effects. Swept wings: Introduction to sweep effects, swept wings, pressure coefficient, typical aerodynamic characteristics, Subsonic and Supersonic leading edges. Introduction to high-lift systems, flaps, leading-edge slats and typical high – lift characteristics. Critical Mach numbers, Lift and drag divergence, shock induced separation, Effects of thickness, camber and aspect ratio of wings, Transonic area rule, Tip effects. Introduction to Source panel & vortex lattice method.

Number of Hours: 09

Module-4

Basics of Compressible Flow

Basics of thermodynamics-definition and basic relation, Energy Equation- For flow and non-flow process, adiabatic energy equation, stagnation pressure, temperature, density, reference velocities, Bernoulli's equation, Effect of Mach number on Compressibility, Isentropic flow with variable area-Area ratio as a function of Mach number, Impulse function, Mass flow rate, Flow through nozzles and diffusers

Number of Hours: 08

Module-5

Normal, Oblique Shocks and Expansion Waves

Governing Equations of Normal Shock Wave. Prandtl relation and Rankine - Hugoniot equation. Oblique shocks and corresponding relations. Shock polar & Hodograph plane. Supersonic flow over a wedge. Supersonic compression and supersonic expansion. Detached shocks. Mach reflection. Intersection of waves of same and opposite families.

Number of Hours: 08

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

Textbooks:

1. Fundamentals of Aerodynamics, Anderson J .D, 5th Edition, 2011, McGraw-Hill International Edition, New York ISBN:9780073398105
2. Aerodynamics for Engineering Students, E. L. Houghton, P.W, Carpenter 5th Edition, 2010, Elsevier, New York. ISBN: 9780080493855
3. Yahya, S.M., "Fundamentals of Compressible flow",Wiley Eastern, 2003

Reference books / Manuals:

1. Aerodynamics, Clancy L. J., Sterling book house, 5th Edition, 2006, New Delhi. ISBN: 9788175980570
2. Theoretical Aerodynamics, Louis M. Milne-Thomson, Imported Edition,. 4th Edition, 2011, Dover Publications, USA, ISBN: 080-075961980.
3. Low-Speed Wind Tunnel Testing, Jewel B Barlow, William H Rae, Alan Pope. 3rd Edition, 1999, John Wiley & Sons, ISBN-10: 0471557749 ISBN-13: 978-0471557746.

Web links and Video Lectures (e-Resources):

- Introduction to Aerodynamics (edX) Offered by MIT- https://www.mooc-list.com/course/16101x-introduction-aerodynamics-edx
- NPTEL – Introduction to Aerodynamics by Prof. Dr. K.P. Sinhamahapatra , IIT Kharagpur - https://nptel.ac.in/courses/101105059

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. ICT-enabled teaching using CFD simulations, flow visualization videos, MATLAB demonstrations, and virtual aerodynamic experiments to explain complex aerodynamic phenomena.
2. Problem-Based Learning (PBL) and Case-Based Teaching involving aircraft wing design, high-lift systems, compressible flow applications, and wind tunnel data interpretation with industry-relevant examples.

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**.

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.	CFD/Software Exploration and Aerodynamic Analysis using XFOIL, OpenVSP, AVL or ANSYS Fluent (Mini Project/Simulation Study)	15
2.	Case Study Presentation / Assignment on Aircraft Aerodynamic Design, Compressible Flow or Wind Tunnel Testing	10

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
Problem formulation and aerodynamic understanding (CO1, CO2)	Demonstrates excellent conceptual understanding with correct formulation	Minor conceptual errors	Adequate understanding	Limited understanding	Unable to explain concepts

Analysis using aerodynamic principles/tools (CO2, CO3, CO4)	Accurate analysis with appropriate methodology	Mostly accurate analysis	Moderate analysis	Incomplete analysis	Incorrect analysis
Interpretation of results and engineering reasoning (CO3, CO5)	Excellent interpretation with engineering justification	Good interpreta tion	Basic interpretation	Weak justification	No meaningful interpretation
Presentation, report quality and communication (PO10)	Excellent technical presentation and documentation	Good document ation	Average presentation	Poor documentation	Incomplete submission
Innovation, teamwork and professional conduct (PO9, PO11)	Highly innovative with excellent teamwork	Good participati on	Moderate participation	Minimal contribution	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.	Tutorial Assignments on Potential Flow, Airfoil Theory and Finite Wing Theory	25
2.	Mini Project/Software Exploration using XFOIL, AVL, OpenVSP or CFD Software	
3.	Case Study Presentation on Aircraft Aerodynamic Design or High-Lift Devices	
4.	Technical Seminar/Quiz/Report Preparation	

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	Completion of NPTEL/MOOC modules on Aerodynamics or Compressible Flow	25
2.	Literature Review of Recent Aircraft Wing Designs, UAV Aerodynamics or Wind Tunnel Studies	
3.	Practice Problems using Textbooks and GATE Previous Year Questions	
4.	Independent Learning using Online Simulators, Video Lectures and Technical Articles	

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).

Space Mechanics

Course Code	1BAS404	Scheme	2025
Type of Course	PCC	Semester	IV
Teaching Hours/Week (L: T: P)	42 (3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T):LI(P):SL&TW:	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

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

CO1: Assess the characteristics of the space environment and its effects on spacecraft materials, astronauts, manned space missions, and satellite lifetime.

CO2: Apply the principles of celestial mechanics, Kepler's laws, Newton's law of gravitation, and the two-body problem to determine orbital parameters and classify different orbit types.

CO3: Analyze satellite injection techniques, orbital transfer maneuvers, injection errors, and orbital perturbations using appropriate perturbation methods.

CO4: Apply the concepts of interplanetary trajectory design, Lambert's theorem, and sphere of influence to analyze spacecraft transfer trajectories between planets.

CO5: Analyze ballistic missile trajectories by evaluating the boost, ballistic, and re-entry phases to determine flight characteristics and impact parameters.

Module-1

Space Environment: Peculiarities of space environment and its description, effect of space environment on materials of spacecraft structure and astronauts, manned space missions, effect on satellite lifetime.

Number of Hours:**08**

Module-2:

Basic Concepts and Two body Problem: The solar system, reference frames and coordinate systems, terminology related to the celestial sphere and its associated concepts, Kepler's laws of planetary motion and proof of the laws, Newton's universal law of gravitation, motion of body under central force field, two body problem, relations between position and time, orbital elements, orbit types.

Number of Hours:**09**

Module-3

Satellite Injection and Satellite Perturbations: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach.

Number of Hours:**09**

Module-4

Interplanetary Trajectories: Two-dimensional interplanetary trajectories, fast interplanetary trajectories, three dimensional interplanetary trajectories, launch of interplanetary spacecraft, trajectory estimation about the target planet, concept of sphere of influence, Lambert's theorem.

Number of Hours:**08**

Module-5

Ballistic Missile Trajectories: Introduction to ballistic missile trajectories, boost phase, the ballistic phase, trajectory geometry, optimal flights, time of flight, re-entry phase, the position of impact point, influence coefficients.

Number of Hours:**08**

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

Textbooks:

1. Cornelisse, J.W., Rocket Propulsion and Space Dynamics, W.H. Freeman&co,1984.
2. Thomson, Introduction to Space Dynamics, Dover Publications, Revised edition,2012

Reference books / Manuals:

1. Vande Kamp, P., "Elements of Astromechanics", Pitman,1979
2. Willian E. Wiesel, Space Flight Dynamics, Create Space Independent Publishing Platform, 3rd Edition ,2010, ISBN-13: 978-1452879598
3. George P. Sutton and Oscar Biblarz, Rocket Propulsion Elements, Wiley India Pvt Ltd,7th edition, 2010, ISBN-13: 978-8126525775.

Web links and e-Resources:

- NPTEL – Space Flight Mechanics by Prof. Manoranjan Sinha, IIT Kharagpur - https://nptel.ac.in/courses/101105083
- NPTEL – Space Environment and its Effects on Orbital Spacecrafts by Prof. Soumyabrata Chakrabarty, IIT Kanpur https://nptel.ac.in/courses/101105083

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 develop students' conceptual understanding and problem-solving skills in Space Mechanics.

2. State the significance of Space Mechanics in satellite missions, space exploration, launch vehicle design, and interplanetary missions by providing real-world examples from ISRO, NASA, ESA, and other space agencies.

3. Support and guide the students for self-study through standard textbooks, research articles, NPTEL courses, simulation software, and recent advancements in orbital mechanics.

4. You will also be responsible for assigning numerical problems, case studies, quizzes, and assignments related to orbital mechanics, satellite trajectories, and space mission analysis, and for documenting student's progress.

5. Encourage the students to work in groups to solve complex orbital mechanics problems, analyze satellite missions, and improve their analytical, computational, and teamwork skills.

6. Show short subject-related video lectures in the following ways:

1. As demonstrations of satellite launches, orbital maneuvers, and interplanetary missions (post-lecture activity).
2. As supplementary material for challenging topics such as orbital perturbations, Lambert's theorem, and interplanetary trajectory design (pre- and post-lecture activity).
3. As worked examples for solving numerical problems related to two-body motion, orbital transfers, and ballistic trajectories (post-lecture activity).

7. Motivate students to study recent space missions and analyze mission profiles involving satellite injection, orbit transfers, planetary exploration, and re-entry trajectories through seminars and technical presentations.

8. Encourage students to undertake mini-projects, case studies, or literature reviews on contemporary topics such as reusable launch vehicles, satellite constellation deployment, deep-space missions, and space debris mitigation to strengthen their understanding of Space Mechanics.

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**.

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 Team Work	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 Recent Advances in Space Missions and Orbital Mechanics	24
2.	MATLAB/Python Simulation of Two-Body Problem and Orbital Trajectories	
3.	Mini Project on Satellite Orbit Design and Transfer Maneuvers	
4.	Case Study on Satellite Injection, Orbital Perturbations, or Interplanetary Mission Analysis	

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	NPTEL/MOOC modules / Literature Review / Solving Questions from previous GATE exam Papers / Use of Online tools	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 & mission objectives	Clearly defines the space mission/problem with well-defined objectives, assumptions,	Objectives are mostly clear; minor gaps in assumptions or problem description.	Problem statement is vague or objectives are poorly defined.	10%

	and constraints.			
Orbital analysis & computational approach	Correct application of orbital mechanics principles, accurate calculations/simulations, and logical methodology.	Mostly correct analysis with minor computational or methodological errors.	Significant errors in orbital analysis or inappropriate computational approach.	25%
Application of Space Mechanics concepts	Appropriate use of Kepler's laws, orbital elements, perturbations, trajectory design, or related concepts with sound justification.	Reasonable application of concepts with limited justification or interpretation.	Inappropriate or incorrect application of space mechanics concepts.	30%
Engineering analysis & interpretation	Results are critically analyzed with clear engineering insights, limitations, and mission relevance.	Adequate interpretation with limited discussion of engineering implications.	Minimal interpretation; conclusions are unsupported or lack engineering significance.	20%
Report & presentation	Well-structured report, clear figures/tables, reproducible calculations/simulations, and effective presentation.	Acceptable report with minor clarity or formatting issues; presentation is satisfactory.	Poorly organized report with inadequate documentation and weak presentation.	15%

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions and Teamwork/ Self learning. 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 following sample activities are listed below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

1. Seminar on Recent Advances in Space Missions and Orbital Mechanics
2. MATLAB/Python Simulation of Two-Body Problems and Orbital Trajectories
3. Mini Project on Satellite Orbit Design and Transfer Maneuvers
4. Case Study on Satellite Injection, Orbital Perturbations, or Interplanetary Mission Analysis

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).

Aerodynamics Lab			
Course Code	1BASL405/ 1BAEL405	Scheme	2025
Type of Course	Practical	Semester	IV
Teaching Hours/Week (L:T:P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SLTW	30 (0:0:28:2)	SEE Marks	50
Credits	01	Total Marks	100
Examination type (SEE)	Practical	Exam Hours	02

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

CO1: Conduct wind tunnel experiments to measure and analyze aerodynamic parameters such as pressure distribution, lift, drag, and flow characteristics using standard aerodynamic instrumentation.

CO2: Analyze and interpret flow characteristics around airfoils and bluff bodies, including pressure distribution, flow separation, vortex formation, effects of angle of attack, and high-lift devices.

CO3: Design and perform open-ended aerodynamic experiments, validate experimental results using analytical/CFD predictions, and effectively communicate engineering findings through technical reports and presentations.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
    1. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
    2. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills

PART – A
FIXED SET OF EXPERIMENTS

1. Calibration of a subsonic wind tunnel: test section static pressure and total head distributions.
2. Smoke flow visualization studies on a two-dimensional circular cylinder and airfoil at low speeds and different angles of attack (Only for Airfoil)
3. Smoke flow visualization studies on a two-dimensional multi element airfoil with flaps and slats at different angles of incidence at low speeds.
4. Surface pressure distributions on a two-dimensional smooth and rough circular cylinder at low speeds and calculation of pressure drag.
5. Surface pressure distributions on a two-dimensional symmetric airfoil.
6. Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence and calculation of lift and pressure drag.

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. Experimental investigation of lift and drag characteristics of different airfoil profiles using wind tunnel measurements.
2. Effect of angle of attack on pressure distribution and lift coefficient of cambered and symmetric airfoils.
3. Comparative flow visualization study of flow separation over bluff bodies of different cross-sections (circular, square, elliptical).
4. Experimental investigation of aerodynamic characteristics of high-lift devices (flaps/slats) under different operating conditions.
5. Validation of experimental aerodynamic coefficients with analytical or CFD-based predictions.
6. Design and conduct an aerodynamic experiment for a chosen engineering application (UAV wing, automobile body, wind turbine blade, etc.) and analyze the obtained results.

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

1. Anderson, J.D., Fundamentals of Aerodynamics, 5th Edition, McGraw-Hill Education, 2011.
2. Houghton, E.L. and Carpenter, P.W., Aerodynamics for Engineering Students, 6th Edition, Elsevier, 2017.
3. Barlow, J.B., Rae, W.H., Pope, A., Low-Speed Wind Tunnel Testing, 3rd Edition, Wiley India, 1999.

Reference books / Manuals:

1. Clancy, L.J., Aerodynamics, Sterling Book House, 5th Edition, 2006.
2. Pope, A. and Goin, K.L., High-Speed Wind Tunnel Testing, Wiley, 1965.
3. Laboratory Manual on Aerodynamics Laboratory, Department of Aerospace Engineering (Institute Manual).

Web links and e-Resources:

- NPTEL - Fundamentals of Theoretical and Experimental Aerodynamics by Prof. Arnab Roy, IIT Kharagpur https://nptel.ac.in/courses/101105088
- NPTEL - Experimental Gas/Aerodynamics by Prof. Job Kurian, IIT Madras https://nptel.ac.in/courses/101106040
- MOOC Course by MIT - Introduction to Aerodynamics (edX) https://www.mooc-list.com/course/16101x-introduction-aerodynamics-edx
- NASA's Learning Technologies - NASA Glenn Research Center - https://www.grc.nasa.gov/www/k-12/airplane/

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 wind tunnel experimentation integrated with flow visualization, pressure measurement techniques, and experimental data acquisition.
2. Inquiry-based laboratory learning through open-ended experiments, CFD validation studies, group discussions, and technical presentations.

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 for the all report 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.

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

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

Performance Indicator	Superior	Good	Fair	Needs Improvement	Unacceptable
Experimental setup and instrument handling (CO1, PO1)	Independently performs setup with complete accuracy	Minor guidance required	Performs with moderate guidance	Significant guidance required	Unable to perform
Data acquisition and observations (CO2, PO4)	Accurate measurements with complete observations	Minor recording errors	Adequate observations	Incomplete observations	Incorrect data
Data analysis and interpretation (CO2, CO3, PO2)	Excellent engineering analysis with correct conclusions	Good analysis	Moderate analysis	Weak interpretation	Unable to analyze
Laboratory report quality (CO4, PO10)	Well-organized report with excellent discussion	Good report	Average documentation	Poor documentation	Incomplete report
Professional conduct and teamwork (CO4, PO9)	Excellent teamwork and laboratory ethics	Good participati on	Average participation	Minimal contribution	No participation

least 40 out of 100 marks.

Rubrics for CIE – Continuous assessment:

Rubrics for SEE / CIE Test:

Performance Indicator	Superior	Good	Fair	Needs Improvement	Unacceptable

Understanding of experimental principles (CO1, PO1)	Excellent conceptual clarity	Good understanding	Basic understanding	Limited understanding	Poor understanding
Execution of experiment (CO1, CO2, PO2)	Performs independently with accuracy	Minor assistance	Moderate assistance	Significant assistance	Unable to complete
Calculations and result analysis (CO2, CO3, PO4)	Accurate calculations with engineering interpretation	Minor computational errors	Basic calculations	Incomplete calculations	Incorrect analysis
Experimental observations and conclusions (CO3, PO4)	Excellent interpretation with technical justification	Good conclusions	Moderate conclusions	Weak conclusions	No valid conclusions
Viva-voce and communication (CO4, PO10)	Excellent technical communication	Good communication	Average communication	Poor communication	Unable to answer

Rubrics suggested for Practical continuous assessment				
Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output. (3)	Student will be able to run the program but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth.	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

	(7-8)			

GenAI Enabled Python Programming			
Course Code	1BASL406A / 1BAEL406A	Scheme	2025
Type of course	Ability Enhancement Course (Laboratory)	Semester	IV
Teaching Hours/Week (L:T:P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30 (0:0:28:2)	SEE Marks	50
Credits	01	Total Marks	100
Type of Examination (IPCC):	Practical	Exam Hours	02

Course outcome (Course Skill Set)

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

CO1: Apply Python programming constructs, NumPy, and pandas to develop basic data processing pipelines and applications.
CO2: Perform data preprocessing, visualization, feature engineering, and basic machine learning model development using appropriate data science tools.
CO3: Apply natural language processing techniques, embeddings, semantic search, and vector-based retrieval for handling and analyzing text data.
CO4: Demonstrate responsible GenAI practice by applying evaluation, safety, privacy and bias mitigation techniques.
CO5: Implement RAG and parameter-efficient fine-tuning workflows, evaluate GenAI systems, and address ethical, safety, privacy, bias, and deployment considerations.

SET OF EXPERIMENTS

1. GenAI-Assisted Python Programming: Functions, Modules and Exception Handling - Use an LLM to generate, explain, debug and optimize Python code
2. Numerical Data Processing using NumPy and Pandas - Generate Python code and prompts for data transformation; compare AI-generated and student-written solutions
3. Data Cleaning, Feature Engineering and Visualization - Employ GenAI to obtain cleaning strategies and visualization code; critically validate suggestions
4. Building and Evaluating a Machine Learning Pipeline - Generate basic ML code using AI and iteratively improve prompts
5. Text Preprocessing and TF-IDF Based Text Classification - Use GenAI to create preprocessing functions and explain errors/edge cases
6. Semantic Search using Sentence Embeddings- Generate embedding and retrieval code; use GenAI to formulate and refine search queries
7. Building a Python Application using an LLM API and Prompt Engineering - Design zero-shot/few-shot prompts; compare prompt versions and structured outputs
8. Structured LLM Outputs and AI-Assisted Data Analysis - Ask LLM to return responses and use Python to process them
9. Build a Mini RAG (Retrieval-Augmented Generation) Application using Python - Use GenAI to generate chunks, prompts and RAG code and then compare RAG vs direct LLM responses
10. Deploying and Evaluating a GenAI Application using a suitable technique – Use AI-assisted code generation/debugging, evaluation-prompt design and hallucination testing
11. Design prompts and evaluation datasets to test factuality, bias, consistency and robustness
12. Use a small pretrained language model and fine-tune selected parameters using Parameter-Efficient Fine-Tuning (PEFT) or Low-Rank Adaptation (LoRA)

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

Text books:

1. A. Geron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow"
2. S. Bird, E. Klein, E. Loper, "Natural Language Processing with Python".

Reference books / Manuals:

1. K. Venkata Reddy, K. Shailendra, “Machine Learning and Deep Learning Using Python and TensorFlow”, McGraw Hill Publications, 2021
2. Provider SDK docs (OpenAI, Hugging Face)
3. Faiss/Annoy/Milvus docs
4. Articles/tutorials on RAG, LoRA, adapters.

Web links and Video Lectures (e-Resources):

1. Hugging Face course (https://huggingface.co/learn) ; FAISS tutorials; OpenAI docs; sentence-transformers tutorials; selected YouTube lecture series on NLP and GenAI.
2. NPTEL – Programming with Generative AI by Prof. Viraj Kumar, IISc Bangalore https://nptel.ac.in/courses/112105269

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 prerecorded demos for labs.
2. Project-based learning (mini RAG project) and peer code reviews.

Self-Learning (SL) Activity	Number of Hours / Semester
Online tutorial(s)	02 (minimum)

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 for the all report 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.

VR and AR in Aerospace Engineering

Course Code	1BASL406B / 1BAEL406B	Scheme	2025
Type of Course	Ability Enhancement Course (Laboratory)	Semester	IV
Teaching Hours/Week (L :T : P)	28 (0 : 0 : 2)	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	30 (0 : 0 : 28 : 02)	SEE Marks	50
Credits	01	Total Marks	100

Type of Examination	Practical	Exam Hours	03

Course outcome (Course Skill Set)

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

CO1: Understand the concepts, hardware and software components of Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) technologies used in aerospace engineering

CO2: Demonstrate and visualize fundamental aerodynamic concepts, aircraft components, flight control systems, and aircraft stability using VR/AR-based interactive simulations.

CO3: Identify aircraft components, engine parts, cockpit instruments, and aerospace safety symbols using AR-based visualization techniques.

CO4: Develop AR-based applications for aerospace operations, including pre-flight inspection checklists and interactive visualization modules using open-source AR frameworks.

CO5: Apply VR technologies to simulate basic aircraft and drone flight operations for enhancing understanding of aerospace systems and flight mechanics.

SET OF EXPERIMENTS

1. VR Visualization of Airfoil and Lift: interactive VR visualization of airflow, pressure distribution and lift generation over an airfoil.
2. AR-Based Aircraft Parts Identification: marker-based AR labelling and identification of aircraft parts.
3. VR Flight Control Demonstration: VR demonstration of the primary flight control surfaces (aileron, elevator, rudder) and their effect on aircraft attitude.
4. AR Pre-Flight Checklist: AR-based interactive pre-flight inspection checklist overlay.
5. VR Aircraft Stability Demonstration: VR demonstration of longitudinal, lateral and directional stability of an aircraft.
6. AR Engine Parts Visualization: AR-based exploded-view visualization of aircraft engine components.
7. VR Basic Instrument Panel Demo: VR demonstration of a basic aircraft instrument panel (ASI, altimeter, VSI, attitude indicator).
8. AR Bernoulli Principle Demonstration: AR-based interactive demonstration of Bernoulli's principle and its relation to lift generation.
9. VR Basic Drone Flight Simulation: basic VR/desktop simulation of drone flight.
10. AR Aircraft Safety Symbols Display: AR-based interactive display of standard aircraft safety and marshalling symbols.

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

Text books:

1. Alan B. Craig, "Understanding Augmented Reality: Concepts and Applications", Morgan Kaufmann, 2013.
2. Doug A. Bowman, Ernst Kruijff, Joseph J. LaViola Jr., Ivan Poupyrev, "3D User Interfaces: Theory and Practice", Addison-Wesley, 2004.
3. Steve Aukstakalnis, "Practical Augmented Reality: A Guide to the Technologies, Applications and Human Factors for AR and VR", Addison-Wesley, 2016.

Reference books / Manuals:

1. Blender Foundation, "Blender Reference Manual" (Open-source Manual), docs.blender.org.
2. Godot Engine Community, "Godot Engine Documentation" (Open-source Manual), docs.godotengine.org.
3. Khronos Group, "OpenXR Specification and Developer Guide" (Open Standard), khronos.org/openxr.

Web links and Video Lectures (e-Resources):

1. NPTEL: Foundation for Virtual and Augmented Reality Systems by Prof. Samit Bhattacharya, IIT Guwahati https://nptel.ac.in/courses/106103842
2. Godot Engine (XR/VR) Documentation – https://docs.godotengine.org
3. AR.js Documentation – https://ar-js-org.github.io/AR.js-Docs
4. WebXR Device API (W3C Standard) – https://www.w3.org/TR/webxr/
5. Mozilla Hubs (Open-source Social VR) Documentation – https://hubs.mozilla.com/docs

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 VR headsets and AR-enabled devices, followed by hands-on hardware sessions.
2. Use of open-source engines (Blender, Godot) for guided 3D model-building and interactive scene-creation exercises.
3. Flipped-classroom approach with pre-lab tutorials on VR/AR SDKs, APIs and the WebXR standard.
4. Group-based mini-project on developing an aerospace VR/AR training, assembly or inspection application.

Self-Learning (SL) Activity	Number of Hours / Semester
Online tutorial(s)	02 (minimum)

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 for the all report 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.

Measurements and Instrumentation

Course Code	1BASL406C / 1BAEL406C	Scheme	2025
Type of Course	Ability Enhancement Course (Laboratory)	Semester	IV
Teaching Hours/Week (L :T : P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	30 (0:0:28:02)	SEE Marks	50
Credits	1	Total Marks	100

Type of Examination	Practical	Exam Hours	2Hrs

Course outcome (Course Skill Set)

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

CO1: Apply appropriate principles and devices to measure aerospace engineering parameters such as pressure, temperature and force.
CO2: Apply calibration, signal-conditioning and data-acquisition techniques for obtaining reliable measurements from aerospace instrumentation systems.
CO3: Analyze experimental data obtained from aerospace sensors and instrumentation systems to determine performance parameters such as airspeed, altitude and thrust.
CO4: Analyze measurement errors, uncertainty, sensitivity, linearity and repeatability to assess the reliability of experimental results.
CO5: Apply appropriate instrumentation and experimental techniques to investigate the performance of aircraft, UAV and propulsion-system components using laboratory and low-cost digital measurement systems.

SET OF EXPERIMENTS

1. Calibration of Pressure Transducers
2. Measurement of Temperature Using Different Sensors
3. Measurement of Air Flow characteristics (total pressure, static pressure, velocity) Using Pitot-Static System
4. Calibration and Performance Testing of a Load Cell
5. Measurement of Strain Using Strain Gauges and Strain Gauge rosettes
6. Measurement of Engine/Airframe Vibration Using Accelerometers
7. Measurement of Propeller/Engine Thrust Using a Load Cell
8. Measurement of Rotational Speed and Torque
9. Data Acquisition and Signal Conditioning - sampling, filtering, amplification, DAQ and LabVIEW/Python-based acquisition
10. Measurement of Aircraft Flight Parameters Using Accelerometer, gyroscope, attitude sensors
11. Investigate sensor response time and dynamic characteristics
12. Compare analog and digital signal-conditioning techniques for a simple sensor

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

Text books:

1. S. P. Venkateshan, Mechanical Measurements, Ane Books, New Delhi.
2. E. O. Doebelin and D. N. Manik, Measurement Systems: Application and Design, McGraw-Hill Education.

Reference books / Manuals:

1. R. P. Benedict, Fundamentals of Temperature, Pressure and Flow Measurements, John Wiley & Sons
2. J. P. Holman, Experimental Methods for Engineers, McGraw-Hill Education.

Web links and Video Lectures (e-Resources):

1. NPTEL Course - Measurement and Instrumentation by Prof. Ravindra Kumar Jha, IIT Guwahati https://nptel.ac.in/courses/112104031
2. NPTEL Course - Mechanical Measurement Systems by Prof. Ravi Kumar, IIT Roorkee https://nptel.ac.in/courses/ 112107242

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. **Interactive hands-on laboratory sessions** involving calibration, operation, and performance evaluation of measurement instruments and sensors.
2. **Demonstration-based learning** through real-time experiments on pressure, temperature, flow, displacement, strain, and vibration measurement systems.
3. **Simulation-assisted learning** using MATLAB/LabVIEW/Proteus or other virtual instrumentation software to visualize measurement principles and signal acquisition.
4. **Project-Based Learning (PBL)** involving the design and development of simple instrumentation and data acquisition systems for engineering applications.
5. **Inquiry-based and problem-solving experiments** where students analyze measurement errors, calibrate instruments, interpret experimental data, and recommend suitable measurement techniques for practical engineering problems.

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 for the all report 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.

Smart Manufacturing and Robotics

Course Code	1BASL406D / 1BAEL406D	Scheme	2025
Type of Course	Ability Enhancement Course (Laboratory)	Semester	IV
Teaching Hours/Week (L :T : P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy L :T:P:SL:TW	30 (0:0:28:02)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	Practical	Exam Hours	2Hrs

Course outcome (Course Skill Set)

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

CO1: Apply working principles and use basic sensors, actuators and microcontrollers to develop simple automated manufacturing systems
CO2: Apply programming and control techniques for robotic and automated mechanisms.
CO3: Analyze the performance of robotic and automated manufacturing systems using experimental data.
CO4: Analyze sensor and machine-vision data for monitoring and inspection of manufactured components

CO5: Apply smart manufacturing technologies to aerospace component manufacturing applications.

SET OF EXPERIMENTS

Simple equipment including Arduino/ESP32, servo motors, stepper motors, sensors and desktop machines with Python/OpenCV and basic CAD software to be employed to conduct the experiments

1. Automatic Object Detection Using IR Sensor, Arduino unit and LED
2. Automatic Conveyor Belt Control demonstration
3. Servo Motor Position Control experiment
4. Stepper Motor Speed and Position Control
5. Mini Robotic Arm – Pick and Place using simple equipment
6. Obstacle Avoiding Mobile Robot
7. Automatic Sorting of Components
8. Ultrasonic-Based Dimensional Measurement
9. Control a set of LEDs using proximity sensor
10. 3D Printing of a Simple Aerospace Component
11. Combine sensors and actuators into a miniature automated cell
12. Sort objects using a color sensor

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

Text books:

1. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson Education, 2024
2. S. R. Deb and Sankha Deb, Robotics Technology and Flexible Automation, McGraw-Hill Education, 2017

Reference books / Manuals:

1. MacDougall, W., Industrie 4.0: Smart Manufacturing for the Future, Germany Trade & Invest (GTAI), 2014.
2. Lamb, F., Industrial Automation: Hands On, 1st Edition, McGraw-Hill Education, 2013.

Web links and Video Lectures (e-Resources):

1. https://www.nptel.ac.in/courses/112103293
2. https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_me32
3. https://professionalprograms.mit.edu/online-program-smart-manufacturing/?utm_campaign=mpe-sm-eng&utm_source=school&utm_medium=nonpaid&utm_content=mitpe-web
4. https://www.nptel.ac.in/courses/112105910

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. Challenge-Based Learning – “Build an Aerospace Smart Cell”
2. Digital Twin + Physical Twin Learning
3. Flipped Laboratory + “Predict–Build–Test–Analyze”

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 for the all report 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.

Biology for Engineers

Course Code	1BAS407/ 1BAE407	Scheme	2025
Type of Course	Professional Core Course (PCC)	Semester	IV
Teaching Hours/Week (L:T:P)	42 (3 : 0 : 0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90 (42 : 0 : 0 : 48)	SEE Marks	50
Credits	2	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course outcome (Course Skill Set)
At the end of the course, the student will be able to:
CO1: Develop fundamental understanding of biological systems relevant to aerospace and space environments.
CO2: Explain the effects of atmospheric flight and microgravity on the human body.
CO3: Understand biological requirements for life-support systems and long-duration space missions.
CO4: Explore astrobiology and the biological aspects of extraterrestrial environments.
CO5: Apply biological principles to aerospace engineering through biomimetics, bio-inspired design and emerging space biotechnology.

Module-1

Introduction - Scope of biology in aerospace engineering, Interdisciplinary relationship between biology, aerospace engineering and medicine, Biological systems as engineering systems, Applications in aerospace engineering
Cell Biology - Structure and functions of cells, Cell membrane and transport mechanisms, Cellular metabolism, Energy production: mitochondria and ATP, Cell growth, division and repair
Biological Responses to Environmental Changes - Temperature, pressure and humidity, Oxygen availability Radiation, Acceleration and vibration, Biological adaptation and stress

Number of Hours: 08

Module-2

Atmosphere and Human Physiology - Atmospheric composition and pressure, Altitude and reduced atmospheric pressure, Partial pressure of oxygen, Hypoxia and its physiological effects, Time of useful consciousness
Acceleration and G-Forces - Effects of acceleration on the human body, Positive and negative G, Blood redistribution, G-induced loss of consciousness, Anti-G suits and protection systems
Pressure and Decompression - Decompression sickness, Nitrogen absorption and elimination, Rapid decompression Cabin pressurization requirements
Human Performance in Flight - Spatial disorientation, Motion sickness, Fatigue and sleep, Circadian rhythm, Cognitive performance and workload, Human factors in aviation safety, Life-Support Requirements in Aircraft

Number of Hours: 09

Module-3

Space Environment - Microgravity and weightlessness, Vacuum, Radiation environment, Extreme temperature
Effects of Microgravity on the Human Body - Cardiovascular adaptation, Fluid redistribution, Muscle atrophy, Bone loss and osteoporosis, Changes in vision, Immune system changes
Space Radiation Biology - Types of space radiation, Solar radiation and galactic cosmic rays, Biological effects of ionizing radiation, DNA damage, Cancer and radiation risks, Radiation shielding concepts
Human Adaptation and Countermeasures - Exercise in space, Nutrition, Artificial gravity, Space suits and physiological protection, Psychological effects of isolation

Number of Hours: 08

Module-4

Biological Requirements for Human Life - Oxygen requirements, Carbon dioxide removal, Water requirements Food and nutrition, Waste management, Temperature and humidity requirements
Bio-regenerative Life-Support Systems - Closed-loop life-support systems, Biological oxygen generation, Carbon dioxide fixation, Water recycling, Microbial systems, Algae and plant-based life-support systems
Plants in Space - Plant growth under microgravity, Photosynthesis in space, Controlled environment agriculture Space greenhouses, Food production for long-duration missions
Microbiology in Space - Microorganisms in spacecraft, Microbial contamination, Biofilms, Human microbiome, Microbial monitoring and control
Planetary Environments – Mars, Moon, Europa and icy moons, Titan, Habitability of exoplanets

Number of Hours: 08

Module-5

Biomimetics and Bio-Inspired Engineering - Concept of biomimetics, Biological systems as engineering models, Nature-inspired optimization, Structural efficiency in biological systems
Bio-Inspired Aerodynamics - Bird and insect flight, Wing morphology, Flapping-wing flight, Leading-edge adaptations Bio-inspired flow control, Unmanned aerial vehicles inspired by biological flyers
Bio-Inspired Materials and Structures - Lightweight biological structures, Honeycomb structures, Bone-inspired structures, Hierarchical materials, Self-healing materials
Synthetic Biology for Space Exploration - Genetically engineered microorganisms, Biological production of materials

In-situ resource utilization using biological systems, Biological recycling, Future applications in Moon and Mars habitats

Number of Hours: 09

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

Text books:

1. Campbell, N. A., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V. and Reece, J. B., Campbell Biology, Pearson.
2. Nicogossian, A. E., Huntoon, C. L., and Pool, S. L., Space Physiology and Medicine, 4th/5th ed., Lea & Febiger / Springer.
3. Sullivan, W. T. III and Baross, J. A. (Eds.), Planets and Life: The Emerging Science of Astrobiology, Cambridge University Press.

Reference books / Manuals:

1. Biology for Engineers, Rajendra Singh C and Rathnakar Rao N, Rajendra Singh C and Rathnakar Rao
2. N Publishing, Bengaluru, 2023.
3. Barratt, M. R. and Baker, E. C., Principles of Clinical Medicine for Space Flight, Springer.
4. Schulze-Makuch, D. and Irwin, L. N., Life in the Universe: Expectations and Constraints, Springer.
5. National Academies of Sciences, Engineering, and Medicine, An Astrobiology Strategy for the Search for Life in the Universe, National Academies Press, 2018.

Web links and Video Lectures (e-Resources):

- https://openstax.org/books/biology-2e/
- https://www.nasa.gov/hrp/
- https://science.nasa.gov/biological-physical/programs/space-biology/
- https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Research/The_SciSpacE_White_Papers
- https://astrobiology.nasa.gov/

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. Case studies: different space missions
2. Problem-based learning
3. Mini projects
4. Bio-inspired design
5. Virtual laboratories

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**.

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.	Individual and group Assignments / micro projects/ case studies / research paper review	25

Rubrics for a Sample Activity – Micro Project (Scale of 1-5)

	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)

Problem Identification and definition (20 % Weightage)	Problem is clearly identified and objectives are stated	Problem clearly defined and objectives are stated with minor omissions	Problem is identified and objectives are generally clear	Objectives are partially defined or lack clarity	Problem and objectives are unclear or missing
Application of Engineering concepts / Innovative aspects (20 % Weightage)	Demonstrates exceptional understanding and accurate application of engineering principles.	Demonstrates strong understanding with only minor errors.	Demonstrates adequate understanding with some inaccuracies	Demonstrates limited understanding and application	Concepts are incorrectly applied or not demonstrated.
Implementation (25 % Weightage)	Solution is complete, functional, innovative, and fully meets objectives.	Solution is functional and meets most objectives.	Solution is functional but requires improvements.	Solution is partially functional.	Solution is incomplete or non-functional.
Testing and Results (20 % Weightage)	Exceptionally well-organized, technically accurate, and professionally formatted.	Well-written with only minor formatting or language errors	Adequately organized with some inconsistencies.	Basic report with several errors or omissions.	Poorly organized, incomplete, or difficult
Documentation and Presentation (15 % Weightage)	Clear, confident, engaging presentation with excellent demonstration and responses.	Effective presentation with good demonstration.	Clear presentation with satisfactory explanation	Basic presentation with limited clarity.	Poor presentation or demonstration.

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Bio-inspired Projects / Model Development / Design of conceptual experiments	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Case study analysis / Research summary preparation / Seminars / Virtual lab experiments	24

Rubrics for CIE Examination:

Note: In case Lab Component Not present for the Subject – then the Rubrics can be suitably modified

Performance Indicator	**Superior (5)**	**Good (4)**	**Fair (3)**	**Needs Improvement**	**Unacceptable (1)**

				(2)	
PI-1: Theory Tests	90–100%	75–89%	60–74%	40–59%	<40%
PI-2: Assignments & Record	Complete and submitted on time	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance	Independent execution without guidance	Minor guidance required	Moderate guidance required	Significant guidance required	Unable to perform the experiment
PI-4: Viva Voce	Excellent understanding and confident responses	Good understanding with minor errors	Basic understanding	Limited understanding	Unable to answer questions
PI-5: Participation	Excellent participation and initiative	Good participation	Average participation	Poor participation	No participation

Rubrics for SEE Examination

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge	Excellent understanding of fundamental concepts and principles.	Good understanding with minor gaps in concepts.	Adequate understanding of basic concepts.	Limited understanding of concepts; requires significant support.	Poor understanding of concepts.
PI-2: Problem Solving	Accurately identifies and solves problems independently using appropriate methods.	Solves problems with minor errors and minimal guidance.	Solves basic problems with acceptable accuracy.	Frequent errors in problem-solving; requires considerable guidance.	Unable to solve the given problems.
PI-3: Analytical Ability	Demonstrates excellent analytical and critical thinking skills.	Demonstrates good analytical ability with minor limitations.	Demonstrates basic analytical skills.	Limited analytical ability; struggles to interpret results.	No evidence of analytical ability.
PI-4: Application	Applies concepts effectively to practical situations and engineering problems.	Applies concepts correctly with minor guidance.	Demonstrates basic application of concepts.	Limited ability to apply concepts in practical situations.	Unable to apply concepts to solve problems.
PI-5: Communication	Excellent communication with clear, organized, and professional presentation.	Good communication with minor improvements needed.	Satisfactory communication of ideas with acceptable clarity.	Poor communication; ideas are not presented clearly.	Communication is incomplete or ineffective.

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).

Environmental Science Project			
Course Code	1BEP408	Scheme	**2025**
Type of Course	Societal Development Course (SDC)	Semester	IV
Teaching Hours/Week (L:T:P)	0:0:0	CIE Marks	50

Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	30 (0:0:0:30)	SEE Marks	50
Credits	1	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course Objectives:

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. **CO1 (L2 – Understand):** Identify and analyse environmental problems through field interaction and technical assessment.
2. **CO2 (L3 – Apply):** Develop skills in project planning, field survey, data collection, implementation, documentation and reporting.
3. **CO3 (L4 – Analyze):** Formulate feasible environmental problem statements and solutions considering practical constraints and sustainability aspects.
4. **CO4 (L3 – Apply):** Apply principles of environmental responsibility, ethics and societal welfare in engineering practice through community-oriented interventions.
5. **CO5 (L4 – Analyze):** Exhibit multidisciplinary learning and problem-solving ability based on collected data, user feedback and baseline conditions.
6. **CO6 (L5 – Evaluate):** 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; and, after selecting a broad topic, collect data, conduct a feasibility survey, estimate timelines and resources, approximate expenditure, and 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 daocument 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

Particulars	Titles and Publishers
Textbooks	1. Phadke, N. D., *Community Engagement and Social Innovation*, Oxford University Press, New Delhi. 2. Garg, N. R., *Project-Based Learning in Engineering Education*, Pearson India Education Services, Noida. 3. Gupta, A. and P. Singh, *Service Learning and Community Projects*, McGraw-Hill Education

	(India), New Delhi. 4. Wilson, G., *Practical Guide to Community Development Projects*, Routledge, London.
Reference books	1. NPTEL courses on Project-Based Learning and Social Innovation. 2. SWAYAM courses on community engagement and sustainability. 3. UN Sustainable Development Goals portal. 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.
Web links and Video Lectures (e-Resources)	1. NPTEL courses on Engineering Geology. 2. NPTEL courses on Soil Mechanics and Foundation Engineering. 3. Virtual Labs – Geotechnical Engineering Virtual Lab. 4. Geological Survey of India. 5. YouTube channels on civil engineering experiments. 6. American Society of Civil Engineers (ASCE) – Geotechnical resources and standards.

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 (Full marks)	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	10	Precise statement; sound, innovative, feasible approach.	Adequate statement;	Partial statement;	Missing or infeasible.

approach, innovation & feasibility			feasible with minor gaps.	marginal feasibility.	
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-	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.

solving demonstrated					
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.
- Awareness Campaign on Single-Use Plastic and E-Waste Management

Suggested Learning Resources:

Text Books:

1. Benny Joseph, *Environmental Studies*, Tata McGraw-Hill, 2nd Edition.
2. R. Rajagopalan, *Environmental Studies: From Crisis to Cure*, Oxford University Press, 2005.
3. Erach Bharucha, *Textbook of Environmental Studies*, University Press, latest edition as available in library.
4. M. P. Poonia and S. C. Sharma, *Environmental Studies*, Vikas Publishing House, latest edition as available

Reference Books:

1. R. Sivakumar, Principles of Environmental Science and Engineering, Cengage Learning, 2nd Edition.
2. G. Tyler Miller Jr., Environmental Science: Working with the Earth, Thomson Brooks/Cole, 11th Edition.
3. Pratibha Singh, Anoop Singh, and Piyush Malaviya, Text Book of Environmental and Ecology, Acme Learnin 1st Edition.
4. S. M. Prakash, Environmental Studies, Elite Publishing House, Mangalore, 3rd Edition, 2018.

Web links and Video Lectures (e-Resources):

1. VTU e-Learning Centre: http://elearning.vtu.ac.in
2. VTU e-Resources / e-Content: http://elearning.vtu.ac.in/e-Res.php
3. VTU e-Shikshana Lecture Videos: http://elearning.vtu.ac.in/esk3.php
4. VTU Consortium Digital Resources: https://access.vtuconsortium.com/msec
5. VTU e-Learning Centre: http://elearning.vtu.ac.in
6. VTU e-Resources / e-Content: http://elearning.vtu.ac.in/e-Res.php
7. VTU e-Shikshana Lecture Videos: http://elearning.vtu.ac.in/esk3.php
8. VTU Consortium Digital Resources: https://access.vtuconsortium.com/msec

Assessment Structure:

Continuous Internal Evaluation (CIE) shall be conducted by the Departmental Project Review Committee consisting of a Senior Professor, the Project Guide, and one additional faculty member nominated by the Head of the Department. Semester End Evaluation (SEE) shall be conducted by university-appointed examiners. The evaluation shall be based on rubrics designed to assess the attainment of NBA-defined graduate attributes, including problem analysis, investigation, design of solutions, communication, teamwork, and professionalism.

The weightage of marks for CIE and SEE is 50% each.

Pass Criteria: A candidate shall secure a minimum of 40% of the total marks prescribed for Project Work, subject to the required minimum in Continuous Internal Evaluation and Semester End Evaluation as per VTU regulations.

Sample Rubrics for Campus water-quality and development of a water-conservation plan.

Criterion	Weight (%)	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs improvement
Problem definition and campus context	10	Clearly defines campus water issue, boundaries, water sources, and purpose.	Defines issue and context with minor gaps.	Basic problem stated, but scope is incomplete.	Vague or incorrect problem definition.
Water-quality data collection	15	Uses appropriate sampling points, methods, and frequency; data are well documented.	Methods are mostly appropriate with minor omissions.	Limited methods or incomplete documentation.	Weak or unclear data collection.
Water-quality parameters and analysis	20	Correctly analyzes key physical, chemical, and microbiological parameters and interprets results.	Analyzes most parameters correctly with minor interpretation gaps.	Some parameters analyzed, but interpretation is weak.	Minimal or incorrect analysis.
Evidence and standards comparison	15	Compares results against relevant standards/guidelines and draws valid conclusions.	Compares most results with reasonable conclusions.	Comparison is partial or uneven.	No meaningful comparison with standards.
Diagnosis of issues and causes	10	Identifies likely causes of poor quality or water loss using evidence.	Identifies main causes with some support.	Causes are mentioned, but weakly supported.	Causes are speculative or absent.
Conservation plan objectives and measures	15	Plan includes clear goals, realistic measures, prioritization, and campus suitability.	Plan is relevant and mostly realistic.	Plan has some useful measures but limited prioritization.	Plan is generic or impractical.
Feasibility and implementation	10	Addresses resources, responsibilities, timeline, and implementation steps clearly.	Covers most implementation aspects.	Implementation is partial or underdeveloped.	Little or no implementation planning.
Cost, savings, and sustainability	5	Provides reasonable cost-benefit thinking and expected savings.	Includes some cost or savings discussion.	Limited financial/savings analysis.	No cost or savings consideration.
Presentation and documentation	0–10	Clear structure, tables/figures, references, and professional report quality.	Well organized with minor issues.	Acceptable but uneven formatting or writing.	Poorly organized and difficult to follow.

Manufacturing Techniques			
Course Code	1BAS409	Scheme	2025
Type of Course	Professional Core Course (PCC)	Semester	IV
Teaching Hours/Week (L:T:P)	42 (3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90 (42:0:0:48)	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

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

CO1: Acquire knowledge of different processes of casting and welding materials & their defects.

CO2: Understand the stress strain rate, deformation and sheet metal working.

CO2: Characteristics and Applications of different machine tools and advanced machining systems.

CO4: Illustrate the programming for CNC machines, CIM and understand the concepts of additive manufacturing methods.

CO5: Analyse limits, fits, and tolerances for manufacturing applications

Module-1

Metal Casting & Joining

Casting Processes: Patterns, core making, molding sands, and sand testing. Special casting methods (Die casting, Centrifugal, Investment, Shell molding) and casting defects.

Welding & Joining: Arc welding, gas welding, and modern techniques (Laser beam, Electron beam, Plasma arc, Friction welding). Brazing, soldering, and non-destructive testing (NDT) methods.

Number of Hours: 08

Module-2

Metal Forming

Deformation Mechanics: Hot and cold working, yield criteria, flow stress, and strain rate.

Bulk Deformation: Forging operations (open and closed die), rolling mills, wire drawing, and extrusion.

Sheet Metal Working: Shearing, bending, deep drawing, and forming limits

Number of Hours: 08

Module-3

Machining & Machine Tools

Conventional Machining: Theory of metal cutting, tool geometry, and cutting fluids. Mechanics of turning, drilling, milling, shaping, and grinding processes. Special purpose machines (Capstan and Turret lathes).

Advanced Machining (Non-Conventional): Electrical Discharge Machining (EDM), Electro-Chemical Machining (ECM), Ultrasonic Machining (USM), and Laser Beam Machining

Number of Hours: 08

Module-4

Advanced Manufacturing & Automation

CNC Technology: Introduction to Computer Numerical Control, G-codes, M-codes, and manual part programming.

Computer-Integrated Manufacturing (CIM): Group technology, flexible manufacturing systems (FMS), and robotics.

Additive Manufacturing: 3D printing, rapid prototyping, and digital manufacturing processes

Number of Hours: 09

Module-5

Metrology & Quality Control

Measurement Standards: Linear and angular measurements, comparators, and limits, fits, and tolerances.

Surface Finish & Inspection: Surface texture measurement, gear and thread measurement, and Coordinate Measuring Machines (CMM)

Number of Hours: 09

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

Text books:

1. Ghosh, A. and Mallik, A. K., (2017), Manufacturing Science, East-West Press.
2. Parmar R. S., (2007), Welding Processes and Technology, Khanna Publishers.
3. Little R. L. – 'Welding and Welding Technology' – Tata McGraw Hill Publishing Company Limited, New Delhi – 1989
4. Grong O. – 'Metallurgical Modelling of Welding' – The Institute of Materials – 1997 – 2nd Edition
5. Kou S. – 'Welding Metallurgy' – John Wiley Publications, New York – 2003 – 2nd Edition.
6. Serope Kalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' – Prentice Hall – 2013 – 7th Edition
7. Non Traditional Manufacturing Processes, by Gary F Benedict, Taylor & Francis

Reference books / Manuals:

1. Mikell P. Groover, (2019), Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley Publications.
2. Rao P. N., Manufacturing Technology I & II, Tata McGraw Hill.
3. Mechanical Measurements Beckwith Marangoni and Lienhard Pearson Education 6th Ed.,
4. Instrumentation, Measurement and Analysis B C Nakra, K K Chaudhry McGraw–Hill 4th Edition
5. Engineering Metrology R.K. Jain Khanna Publishers 2009
6. New Technology, Dr. Amitabha Bhattacharyya, The Institute of Engineers (India), 2000

Web links and Video Lectures (e-Resources):

- NPTEL Course - Manufacturing Processes II by Prof. A.B. Chattopadhyay, Prof. A.K. Chattopadhyay, Prof. S. Paul, IIT Kharagpur http://nptel.ac.in/courses/112105127
- Manual on Drilling, Sampling, and Analysis of Coal, Compiled by ASTM Subcommittees D05.18 and D05.23 - http://www.astm.org/DIGITAL_LIBRARY/MNL/SOURCE_PAGES/MNL11.htm
- ASTM Paper - Cutting, Machining, and Drilling of Composites http://www.astm.org/DIGITAL_LIBRARY/JOURNALS/COMPTECH/PAGES/CTR10654J.htm
- NPTEL Course - Computer Aided Design and Manufacturing II by Prof. P.V. Madhusudan Rao, IIT Delhi https://nptel.ac.in/courses/112102103
- NPTEL Course - Fundamentals of Additive Manufacturing Technologies by Prof. Sajan Kapil, IIT Guwahati https://nptel.ac.in/courses/112103306
- Book Chapter - Nontraditional Machining Processes - http://www.springer.com/us/book/9781447151784

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.

Teaching-Learning Process (General Instructions) These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

• Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
• Chalk and Talk method for Problem Solving.
• Adopt flipped classroom teaching method.
• Adopt collaborative (Group Learning) learning in the class.
• Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

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**.

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.	Assignments – Group or Individual / Mini projects / Quiz / Research Paper Review / Case Studies	25

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 Hour Semester**
1.	Seminars / Mini Projects / Case Studies	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	NPTEL/MOOC modules / Literature Review / Use of Virtual Labs	24

Rubrics for a Sample Activity - Case Study [Marking on a scale of 1-5]

	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
Problem Identification (weightage: 20 %)	Define problem clearly with background and objectives	Problem is well defined with minor omissions.	Problem is adequately identified.	Problem is defined vague with no clarity.	Problem is poorly, not defined
Review of Literature (weightage: 20 %)	Extensive, relevant, and current literature is used and summarized	Good use of relevant references.	Adequate literature with limited analysis.	Limited or outdated references	Little or no supporting literature
Critical Analysis (weightage: 15 %)	Demonstrates exceptional reasoning	Good analysis with logical reasoning	Basic analysis with limited depth	Weak analysis with limited critical assessment	No meaningful analysis
Scientific Advancement and Application (weightage: 15 %)	Scientific concepts are accurately applied and integrated effectively	Concepts are applied with minimal deviations	Adequate application of concepts	Limited understanding demonstrated	Concepts incorrectly applied
Innovation and recommendations (weightage: 15%)	Innovative, feasible recommendations	Recommendations are practical	Acceptable recommendations	Poorly justified recommendations	No meaningful recommendations
Support Data Availability and Presentation (weightage: 15 %)	Use of sufficient data, figures, tables, and evidence	Good use of supporting evidence.	Adequate evidence provided.	Limited evidence used	No supporting evidence.

Continuous Internal Evaluation (CIE)

(i)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.

(ii)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.

(iii) 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.

(iv) 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

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).

Additional Mathematics -II (Common to all Branches)

Course Code	**1BMATDIP410**	Scheme	2025
Type of Course	NCMC	Semester	03
Teaching Hours/Week (L: T: P)	28 (2:0:0)	MCQ online exam Marks	100
Total Hours of Pedagogy per semester CI (L /T):LI(P):SL&TW:	42 (3:0:0:0)		
Credits	0	Total Marks	100
Total Hours of Pedagogy	42	Exam Hours	--

Course objectives:

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

CO1: Provide the requisite and relevant background necessary to understand the other important engineering mathematics courses offered for the Engineers and Scientists.

CO2: Familiarize the importance of calculus associated with higher order differential equation with constant coefficients for all branches of the engineering.

CO3: Apply the knowledge to find nonlinear differential equations and their respective solutions.

CO4: Develop the knowledge of numerical methods to solve equations.

CO5: Analyze the numerical methods by applying Ordinary Differential Equations.

CO6: Understand and explain basic probability concepts.

Module-1: Ordinary Differential Equations

Higher order ODE's: Linear differential equations of second and higher order equations with constant coefficients. Homogeneous and non-homogeneous equations. Inverse differential operators $e^{ax}, \sin(bx+c), \cos(bx+c)$ and polynomials. Solutions to the initial value problems.

(RBT Levels: L1, L2 and L3) Number of Hours: 09

Module-2: Non-linear differential equations

Non-linear differential equations: Introduction to general and singular solutions, solvable for p. Clairaut's equations, reducible to Clairaut's equations.

(RBT Levels: L1, L2 and L3) Number of Hours: 08

Module-3: N**umerical methods-1**

Introduction to the numerical methods (All formulae without proof)**:** Finite differences, Problems on Interpolation using Newton's forward and backward difference formulae, Newton's divided difference formula and Lagrange's interpolation formula.

Numerical integration: Problems on Trapezoidal, Simpson's (1/3)rd and Simpson's (3/8)th rules.

(RBT Levels: L1, L2 and L3) Number of Hours: 09

Module-4: Numerical Methods-2

Solutions of algebraic and transcendental equations: Problems on Regula-Falsi and Newton-Raphson methods (only formulae).

Numerical Solution of Ordinary Differential Equations (ODE's): Numerical solution of ordinary differential equations of first order and first degree - Taylor's series method, Modified Euler's method, Runge-Kutta method of fourth order (No derivations) and problems.

(RBT Levels: L1, L2 and L3) Number of Hours: 08

Module-5: Probability

Probability: Introduction. Sample space and events. Axioms of probability. Addition and multiplication theorems. Conditional probability – illustrative examples. Bayes's theorem examples.

(RBT Levels: L1, L2 and L3) Number of Hours: 08

Suggested Learning Resources

Textbooks:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Ed., 2021
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, 8thEd., 2022.

Reference Books:

1. H K Das and Rajaneesh Varma, Higher Engineering Mathematics, S. Chand.
2. B. V. Ramana Higher Engineering Mathematics, McGraw Hill.
3. Mangey Ram, Mathematics in Engineering Sciences, CRC Press
4. N. P. Bali, Manish Goyal - A Textbook of Engineering Mathematics, Laxmi Publications
5. Erwin Kreyszig. Advanced Engineering Mathematics, Wiley.

Web links and e-Resources:

1. NPTEL Course – Numerical Methods for Engineers by Prof. Niket Kaisare, IIT Madras https://nptel.ac.in/courses/127106019
2. NPTEL Course – Ordinary Differential Equations and Applications by A. K. Nandakumaran, P. S. Datti, Raju K. George , IISc Bangalore https://nptel.ac.in/courses/111108081
3. NPTEL Course - Introduction to Probability Theory and Statistics Prof. S Dharmaraja, IIT Delhi https://nptel.ac.in/courses/111102160

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.

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- ICT-Enabled Teaching.

Assessment Structure:

For courses offered by the Department of Mathematics, the **Continuous Internal Evaluation (CIE)** shall be conducted by the concerned course teacher. The CIE may comprise tests, assignments, quizzes, seminars, or other academic activities, as decided by the concerned teacher. The distribution of marks among these activities shall be determined by the course teacher. The total marks awarded for all CIE activities shall be **100 marks.**

The concerned teacher shall upload the CIE marks to the VTU web portal whenever notified by the University.

Online Mode of Offering for 1BMATDIP301 and 1BMATDIP401

The lecture sessions for 1BMATDIP301 and 1BMATDIP401 shall also be made available through the **vtu.online.ac.in** platform.

1. If all the students admitted to the 3rd and 4th semesters of a college opt to pursue these courses in online mode, the entire course shall be offered online. In such cases, the Centre for Online Education, Mysuru shall conduct the **Continuous Internal Evaluation (CIE)** for **100 marks** and submit the CIE marks to the University, with a copy to the concerned college.
2. Within the **same college/department**, all admitted students shall follow a single mode of learning for these courses. A situation where a part of the students opts for the online mode and the remaining students opt for the offline mode **shall not be permitted**.
3. A college intending to offer these courses through the online mode shall submit the **list of eligible students** to the Registrar, Visvesvaraya Technological University (VTU), Belagavi, for approval. Only after obtaining the approval of the University shall the students be permitted to enrol for the online course through the vtu.online.ac.in platform.

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