3rd Semester Syllabus

Probability and Statistics for Civil and Infrastructure Engineers			
Course Code	1BMAT301	Scheme	2025
Type of Course	Applied Science Course (ASC)	Semester	III
Teaching Hours/Week (L:T:P)	56(3:1:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW:	120 (56:0:0:64)	SEE Marks	50
Credits	4	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

1. CO1 (L2 – Understand): Explain basic statistical concepts, descriptive measures, and data visualisation relevant to civil and infrastructure engineering datasets.
2. CO2 (L3 – Apply): Apply probability rules, random variables, and common probability distributions to model variability in loads, material properties, hydrologic and traffic data.
3. CO3 (L3 – Apply): Use sampling distributions, estimation and hypothesis testing to draw inferences about civil-engineering population parameters from sample data.
4. CO4 (L4 – Analyze): Analyse relationships between civil engineering variables using correlation and regression and develop simple predictive models for design and planning.
5. CO5 (L3 – Apply): Formulate and solve reliability-style and risk-informed decision problems in structural, geotechnical, water resources and transportation contexts using basic probabilistic tools.
6. CO6 (L4 – Analyze/Evaluate): Interpret probabilistic results, discuss modelling assumptions and limitations, and comment on safety factors, characteristic values and code-based design choices.

Module-1

Descriptive Statistics and Data for Civil Systems

- Role of statistics in civil and infrastructure engineering: types of data (time series, spatial, grouped, ungrouped) from structures, materials, hydrology, traffic, and environment.
- Frequency distribution: histograms, bar diagrams, pie charts, box plots (civil examples: rainfall, traffic counts, strength tests).
- Measures of central tendency: mean, median, mode (grouped and ungrouped data).
- Measures of dispersion: range, variance, standard deviation, coefficient of variation, concept of skewness and kurtosis (qualitative: outliers and data quality).
- Introduction to sample vs. population; data acquisition and basic data-cleaning ideas for civil engineering studies.

Linked COs: **CO1, CO3** **Number of Hours Required (CI)**: **11 hours**

Module-2

Probability and Random Variables:

- Need for probability in civil engineering: uncertainties in loads, resistances, demand, climate, traffic, and material properties.
- Sample space, events, algebra of events, axioms of probability (classical, empirical, and subjective probability).
- Conditional probability, independence of events, total probability theorem, and Bayes' theorem.
- Multiple random variables: basic idea (joint, marginal, and conditional distributions, covariance, and correlation coefficient concept).
- Random variables: discrete and continuous (probability mass/density functions, cumulative distribution function (CDF), expectation, variance, and moments).

Linked COs: CO2, CO3, CO5 **Number of Hours Required (CI): 11 hours**

Module-3

Probability Distributions for Civil Applications:

- Discrete distributions: Bernoulli, Binomial, Geometric and Poisson -- definitions, parameters, mean and variance (statement), and engineering examples (arrival counts, failures, accidents).
- Continuous distributions: Uniform, Exponential and Normal -- PDFs, CDFs, key properties, civil examples (modelling measurement errors, inter-arrival times, material variability).
- Normal approximation to Binomial and Poisson (simple problems).

- Use of distributions for computing probabilities of exceedance, return periods and threshold crossings in structural safety and hydrologic/traffic problems (conceptual and numericals).

Linked COs: CO2, CO3, CO5 **Number of Hours Required (CI): 11 hours**

Module-4

Sampling, Estimation and Hypothesis Testing:

- Sampling concepts: population, sample, parameters and statistics; random sampling, bias, standard error.
- Sampling distributions of the mean (central limit idea -- qualitative); t, chi-square and F distributions (definitions and tables, no derivations).
- Point estimation and interval estimation; confidence intervals for means and proportions (single sample, simple two-sample cases).
- Hypothesis testing: null and alternative hypotheses, type I and II errors, p-value, one- and two-tailed tests.
- Basic tests for civil data: tests on mean/variance of strength, load, flow or travel-time data; chi-square test for goodness-of-fit of a distribution to observed data.

Linked COs: CO3, CO4, CO6 **Number of Hours Required (CI): 11 hours**

Module-5

Regression, Correlation

- Correlation: scatter diagrams, Pearson's correlation coefficient, interpretation of strength and direction of linear association for civil variables (e.g., rainfall--runoff, load--deflection).
- Standard error of estimate, Simple linear regression: least-squares line, slope and intercept, coefficient of determination R^2; use in basic prediction/forecasting for civil engineering data, Residential analysis and accuracy and limitations of regression models.
- Multiple linear regression (concept only); limitations, overfitting and extrapolation issues.

Linked COs: CO4, CO5, CO6 **Number of Hours Required (CI): 12 hours**

Suggested Learning Resources

Textbooks:

- Benjamin, J. R., & Cornell, C. A. (2014). *Probability, Statistics, and Decision for Civil Engineers*. Dover Publications, Inc. (Original work published 1970).
- Walpole, R. E., Myers, R. H., Myers, S. L., & Ye, K. (2012). *Probability & Statistics for Engineers & Scientists* (9th ed.). Pearson.

Reference Books:

- Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics* (12th ed.). Sultan Chand & Sons.
- Montgomery, D. C., & Runger, G. C. (2018). *Applied Statistics and Probability for Engineers* (7th ed.). Wiley.

Web links and e-Resources:

- Probability and Statistics for Civil Engineering (Lecture Notes), JNTU Anantapur: http://vemu.org/uploads/lecture_notes/17_02_2023_914719312.pdf.
- Ross, S. M. Introduction to Probability and Statistics for Engineers and Scientists (Supplementary Material), Elsevier.
- NPTEL (National Programme on Technology Enhanced Learning) - Probability and Statistics courses for Engineers: https://nptel.ac.in/.

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
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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.**

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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

As per National credit farmwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-52 hour) and Teamwork/ Selfe learning (TW/Sl-64 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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.	**Civil Data Analytics Mini-Project** : Collect or obtain a civil dataset (e.g., concrete strength, rainfall, traffic, settlement), perform descriptive statistics, fit distributions, and pose at least one reliability-style question with a short report.	32
2.	**Hydrologic/Traffic Case Study Portfolio**: Prepare concise case studies on extreme events or demand patterns (e.g., flood peaks, daily traffic), using probability plots, return-period calculations and risk statements with a short seminar.	32
3.	**Programming & Tools Workbook:** Develop a digital workbook in Excel/R/Python/MATLAB implementing core course computations: descriptive stats, distribution fitting, regression, confidence intervals and simple reliability metrics.	32

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	**MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil engineering, culminating in an integrated open-book test.	32
2.	Literature review on emerging tools; reflective learning journal	32

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

1. Sample Rubrics -Integrated Design Mini-Project

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Problem definition & data	Clear, relevant civil-engineering question; data source and limitations documented.	Mostly clear; minor gaps in context or data description.	Vague question or poorly documented data.	10%
Data processing & descriptive statistics	Correct cleaning, visualisation, and computation of key measures; patterns clearly highlighted.	Mostly correct; minor computational/formatting 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 beyond numbers.	20%
Report & communication	Well-structured report, clear figures/tables, reproducible calculations; effective brief presentation.	Acceptable structure; some clarity issues; presentation adequate.	Disorganised or incomplete report; weak presentation.	15%

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:

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

ii. 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.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

FLUID MECHANICS AND HYDRAULIC MACHINERY			
Course Code	**1BCV302**	Scheme	2025
Type of course	Integrated Professional Core Courses (IPCC)	Semester	III
Teaching Hours/Week (L: T:P)	70 (3:0:2)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	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:

1. CO1 (L2): Explain fluid properties, hydrostatic laws, and pressure measurement techniques.
2. CO2 (L3): Apply kinematics and dynamics principles to analyze fluid flow patterns and energy equations.
3. CO3 (L3): Compute discharges in pipes, notches, weirs, and design pipe networks with losses.
4. CO4 (L4): Design open channels for uniform/non-uniform flows and analyze hydraulic jumps.
5. CO5 (L4): Analyze performance of hydraulic turbines and pumps for hydropower applications.
6. CO6 (L5): Evaluate sustainable hydraulic systems integrating Industry 5.0 digital twins and flood modelling.

Module-1

Fluid Properties & Hydrostatics:

Introduction to fluids, density, specific weight, viscosity (Newton's law), surface tension, capillarity, vapor pressure, compressibility. Hydrostatic law, Pascal's law, pressure measurement (manometers, piezometers, digital gauges). Total pressure and center of pressure on plane/curved surfaces. Buoyancy, metacenter, stability of floating bodies, metacentric height.

CO linkage: CO1. **Number of Hours (CI): 10 hours**:

Module-2

Fluid Kinematics & Dynamics:

Types of flow (steady/unsteady, uniform, laminar/turbulent, rotational/irrotational). Streamlines, path lines, continuity equation (Cartesian coordinates). Velocity potential, stream function, flow nets. Euler's equation, Bernoulli's theorem (applications: venturi meter, orifice meter, pitot tube). Momentum equation

CO linkage: CO2. **Number of Hours (CI): 8 hours**

Module-3

Flow Measurement & Pipe Flow:

Flow through orifices, mouthpieces, notches (rectangular/trapezoidal), weirs. Flow in pipes: Darcy-Weisbach equation, friction factor (Moody chart), minor losses, pipes in series/parallel, water hammer.

CO linkage: CO3. **Number of Hours (CI): 8 hours**

Module-4

Open Channel Flow

Geometrical properties, velocity distribution. Uniform flow: Chezy/Manning equations, most economical sections (rectangular/trapezoidal). Specific energy, critical flow. Non-uniform flow: gradually varied flow (GVF) equations, hydraulic jump.

CO linkage: CO4. **Number of Hours (CI): 8 hours**

Module-5

Hydraulic Turbines & Pumps:

Turbines: Classification, Pelton/Francis/Kaplan (components, velocity triangles, efficiencies). Pumps: Centrifugal/reciprocating (working, characteristics, NPSH, cavitation). Performance curves, selection for civil applications (dams, irrigation).

CO linkage: CO5, CO6. **Number of Hours (CI): 8 hours**

PRACTICAL COMPONENTS OF IPCC

PART – A: FIXED SET OF EXPERIMENTS

1. Determination of metacentric height.
2. Verification of Bernoulli's theorem.
3. Calibration of venturi meter/orifice meter.
4. Determination of friction factor in pipes.
5. Calibration of rectangular notch.
6. Hydraulic jump in open channel.
7. Performance testing of Pelton turbine.
8. Efficiency of centrifugal pump.

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 pipe network for campus water supply.
2. Model sustainable micro-hydel turbine.
3. Simulate GVF profile using software.
4. Compare pump/turbine efficiencies.
5. Open channel design for irrigation.

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

Textbooks:

1. Modi & Seth, *Fluid Mechanics*, Standard Book House.
2. Rajput, R. K. – *Fluid Mechanics and Hydraulic Machines*, S. Chand.
3. Bansal, R. K. – *A Textbook of Fluid Mechanics and Hydraulic Machines*, Laxmi Publications.
4. Subramanya, K. – *Flow in Open Channels*, McGraw-Hill

Reference books / Manuals:

1. White, F. M. – *Fluid Mechanics*, McGraw-Hill.
2. Cengel, Y. A. & Cimbala, J. M. – *Fluid Mechanics: Fundamentals and Applications*, McGraw-Hill.
3. Subramanya, K. – *Hydraulic Machines*, McGraw-Hill.

Web links and Video Lectures (e-Resources):

1. NPTEL: Fluid Mechanics for Civil Engineers (https://nptel.ac.in).
2. SWAYAM: Hydraulic Machines.
3. Autodesk/HEC-RAS tutorials for hydraulic modeling.

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. Concept-oriented lectures with frequent physical interpretations and small in-class demonstrations.
2. Problem-solving sessions focused on civil-engineering-type examples (pipes, channels, water-supply and drainage).
3. Flipped-classroom segments for selected topics (e.g., Bernoulli applications, pipe systems, hydraulic jump) using pre-class videos and in-class collaborative problem solving.
4. Mini-projects and open-ended lab tasks that integrate SDG-6, SDG-11, SDG-13, Industry 5.0 (digital tools) and NEP 2020 emphasis on experiential, multidisciplinary learning.

Assessment Structure:

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

The CIE 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**.

Students' activities for TW/SL under NCrF: Samples only: As per National credit farmwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/ Selfe learning (TW/Sl-50 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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.	**Activity 1 (CO2, CO3, CO6):** Mini-project on campus water-distribution/drainage line – data collection, simple hydraulic analysis, and sustainability recommendations (SDG-6, SDG-11, SDG-13).	25
2.	**Activity 2 (CO3, CO4):** Open-book assignment on pipe and open-channel problems using spreadsheets, including comparison of options for energy loss minimisation.	25
3.	**Activity 3 (CO5, CO6):** Short group task on pump/turbine selection for a given water supply or micro hydro context, considering technical and sustainability criteria (Industry 5.0 perspective).	25

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	**MOOC +GATE/Open- Book Track.:** Complete selected FM MOOC modules and GATE-style tests, plus at least one integrated open-book exam on conceptual/design problems.	25
2.	**Case Study & Literature Portfolio**: Prepare 3–4 case briefs on real FM systems/events plus short reviews of 3–5 papers/standards (e.g., drainage, floods, water supply).	25

Performance Indicator	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Problem understanding & SDG/NEP link (CO1, CO6)	Clear statement of system, objectives, constraints and explicit linkage to SDGs and NEP values.	Mostly clear; SDG/NEP link mentioned but not deep.	Basic description; weak SDG/NEP connection.	Vague or incorrect description; no SDG/NEP link.
Use of fluid-mechanics concepts & calculations (CO2–CO4)	Correct methods; appropriate assumptions; consistent units and checks.	Minor errors; overall reasonable application.	Several errors; partial application of concepts.	Major conceptual errors; little use of theory.
Sustainability / resilience analysis (CO6)	Insightful discussion of options and their sustainability/resilience; clear recommendations.	Some discussion with reasonable recommendations.	Limited or generic sustainability remarks.	No meaningful sustainability analysis.
Communication & teamwork (CO6)	Well-structured report/presentation; clear visuals; evidence of balanced participation.	Generally clear; some imbalance/minor issues.	Understandable but poorly structured or dominated by few.	Disorganised; weak teamwork evidence.

Rubric – Mini-Project - (sample)

Criterion	**Exemplary (3)**	**Proficient (2)**	**Basic (1)**
Problem definition & scope	Clear objective, realistic hydraulic system, complete data and assumptions documented.	Objective mostly clear; minor gaps in data/assumptions.	Vague problem; key data/assumptions missing or inconsistent.
Fluid mechanics calculation s	Correct, consistent application of FM principles with clear steps and units.	Mostly correct with a few non-critical errors; reasoning generally sound.	Frequent conceptual/arithmetica l errors; reasoning unclear.
Design decisions & justificatio n	Pipe/channel sizes, components, and operating conditions well-justified using results.	Most design choices linked to results; some justification qualitative or brief.	Design choices arbitrary or unsupported by analysis.
Use of diagrams/tools	Neat schematics and, where used, digital tools (Excel/MATLAB/EPANET) applied appropriately.	Diagrams or tools used but with minor omissions or limited integration.	Poor or missing diagrams; tools misused or not used when expected.
Documentation & reflection	Well-structured report with clear tables/figures and focused reflection on learning and limits.	Report understandable but uneven; reflection brief or descriptive.	Disorganized report; little or no reflection on learning.

Suggested rubrics 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. (7-8)	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)

Note: Can add Engineering & IT tool usage based on the nature of the course

Continuous Internal Evaluation (CIE):

(i) Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus. The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

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**

i. To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

Passing requirement in SEE:

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

Mechanics of Solids			
Course Code	1BIF303	Scheme	2025
Type of Course	Professional Core Course (PCC)	Semester	III
Teaching Hours/Week (L: T:P)	56(3:1:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T): LI(P):SL&TW:	120 (56:0:0:64)	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:

1. CO1 (L2 – Understand): Explain fundamental concepts of stress, strain, elastic constants and factor of safety for common civil engineering materials.
2. CO2 (L3 – Apply): Apply equilibrium and deformation relations to determine stresses and elongations in axially loaded members and circular shafts under torsion.
3. CO3 (L3 – Apply): Construct shear force and bending moment diagrams for statically determinate beams and determine bending and shear stresses for standard cross sections.
4. CO4 (L4 – Analyze): Analyze two-dimensional stress states, determine principal stresses and maximum shear using transformation equations and Mohr's circle, and interpret their significance.
5. CO5 (L3 – Apply): Apply column buckling concepts to estimate critical loads and assess the stability of compression members under idealized end conditions.
6. CO6 (L4 – Analyze/Evaluate): Use strain energy and combined loading ideas to check safety and serviceability of simple civil engineering components and comment on the effect of modelling assumptions.

Module-1

Introduction, stress–strain and axial members:

- Concepts of rigid and deformable bodies; elastic and plastic behavior; normal and shear stresses; normal and shear strains.
- Stress–strain curves for ductile and brittle materials (qualitative); proportional limit, yield point, ultimate and failure.
- Hooke's law for uniaxial stress; elastic constants: E, G, K, ν and their relationships (isotropic, homogeneous material).
- Axially loaded members: bars of uniform and varying cross-section; stepped bars; temperature stresses (simple cases with/without constraints).
- Factor of safety and working stress concept (introductory).

Linked COs: CO1, CO2 **Number of Hours (CI)= 11hrs**

Module-2

Shear force, bending moment and stresses in beams:

- Types of loads and supports; concept of shear force (SF) and bending moment (BM).
- SF and BM diagrams for statically determinate beams: simply supported, cantilever and overhanging beams with point loads, UDL/UVL and simple combinations. Relationship between load, SF and BM diagrams.
- Flexural (bending) stresses: assumptions of simple bending theory; flexure formula $\sigma = \frac{My}{I}$ (statement and use); section modulus; bending stresses in rectangular, circular and I-sections (no built-up complex cases).
- Shear stresses in beams: shear formula $\tau = \frac{VQ}{Ib}$ (statement and use); shear stress distribution in rectangular and I-sections (qualitative curves + numericals).

Linked COs: CO2, CO3 **Number of Hours (CI)= 11hrs**

Module-3

Torsion and combined stresses:

- Torsion of circular shafts: assumptions; torsion formula $\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$ (statement and application); Solid and hollow shafts, strength and stiffness comparisons.
- Power transmitted by shafts; design-style numericals (within course level).
- Combined axial and bending stresses in members (qualitative introduction + simple numericals).
- Introduction to thin cylindrical shells under internal pressure: hoop and longitudinal

stresses (formulae and simple problems).

Linked COs: CO2, CO3, CO6 **Number of Hours (CI)= 11 hrs**

Module-4

Two-dimensional stress analysis and Mohr's circle:

- Plane stress at a point: normal and shear stresses on inclined planes; transformation equations (no full derivation needed at length).
- Principal planes and principal stresses; maximum shear stress; orientation of principal planes.
- Construction and use of Mohr's circle for plane stress – determination of principal stresses and maximum shear; interpretation in terms of material failure.
- Plane strain (basic idea); brief mention of 3D generalization (qualitative).

Linked COs: CO1, CO4, CO6 **Number of Hours (CI)= 11 hrs**

Module-5

Columns, buckling and strain energy:

- Columns and struts: classifications; slenderness ratio; Euler's buckling theory for ideal columns (pinned–pinned, fixed–free, fixed–pinned, fixed–fixed).
- Critical load, effective length and factor of safety in compression members; limitations of Euler theory.
- Introduction to empirical/Rankine or IS-based formula (statement and awareness).
- Strain energy: concept of energy stored in axially loaded members and in members under bending and torsion (formulae and simple numericals).
- Qualitative use of strain-energy methods for deflection and impact (no lengthy derivations); link to stiffness and serviceability checks.

Linked COs: CO5, CO6 **Number of Hours (CI)= 12 hrs**

Suggested Learning Resources Text books:

1. Beer, F. P., Johnston, E. R., DeWolf, J. T., & Mazurek, D. F. *Mechanics of Materials*. McGraw-Hill Education. Latest edition.
2. Hibbeler, R. C. *Mechanics of Materials*. Pearson. Latest edition.
3. Punmia, B. C., Jain, A. K., & Jain, A. K. *Strength of Materials*. Laxmi Publications.

Reference books / Manuals:

1. Ramamrutham, S. *Strength of Materials*. Dhanpat Rai Publishing.
2. Gere, J. M., & Goodno, B. J. *Mechanics of Materials*. Cengage.
3. Timoshenko, S., & Young, D. H. *Elements of Strength of Materials*.

Web links and e-Resources:

- NPTEL (IITs): "Strength of Materials", "Mechanics of Materials", "Solid Mechanics" – full lecture series, worked examples and assignments aligned to Indian civil curricula.
- MIT OCW / other MOOCs: Open course materials on "Solid Mechanics" and "Mechanics of Materials" for additional concept explanation and problem practice.

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
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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.**

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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

As per National credit farmwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-52 hour) and Teamwork/ Selfe learning (TW/Sl-64 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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.	**Integrated Design Mini-Project**: Design a small structural system (beam–column–tank) using all five modules with hand calculations, basic drawings, and a short report.	32
2.	**Case Study & Literature Portfolio**: Prepare a few concise case studies on real beam/column/tank failures or successes, with simple mechanics checks and a short seminar.	32
3.	**Programming & Tools Workbook:** Develop a digital workbook using MATLAB/Python and one analysis tool to automate key computations from each module.	32

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	**MOOC + GATE/Open-Book Track**: Complete mapped NPTEL/MOOC content, solve GATE-style tests, and attempt at least one integrated open-book exam covering all modules.	32
2.	Literature review on emerging tools; reflective learning journal	32

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

1. Sample Rubrics -Integrated Design Mini-Project

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Problem definition & data (loads, materials, geometry)	Clear, realistic, well-documented; all modules scoped.	Mostly clear; minor data gaps.	Vague or incomplete; key data missing.	10%
Mechanics calculations (M1–M5)	Correct, consistent, covers stress, SFD/BMD, bending/shear, buckling, failure checks coherently.	Generally correct; a few minor errors; most modules covered.	Frequent errors or major omissions; weak linkage across modules.	40%
Use of tools/software	Appropriate selection and correct use; results cross-checked with hand calculations.	Tools used with minor setup/interpretation issues.	Minimal or incorrect use; no meaningful comparison.	20%

SDG / design insight (safety, efficiency)	Clear discussion of safety, material saving, and resilience; explicit SDG 9/11 links.	Some discussion of safety/efficiency; SDG links implied or brief.	Little or no discussion beyond raw numbers.	15%
Report & communication	Well-structured report, neat drawings, clear figures and references; confident brief presentation.	Acceptable structure; minor clarity issues; presentation adequate.	Disorganized or incomplete; weak or missing presentation.	15%

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:

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

ii. 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.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail

Construction Materials and Techniques			
Course Code	1BIF304	Scheme	2025
Type of Course	PEC	Semester	III
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. **CO1 (L2 – Understand):** Explain properties, classification, and selection criteria of traditional construction materials like stones, bricks, and timber. SDG9, SDG11.
2. **CO2 (L3 – Apply):** Apply manufacturing processes and testing methods for cement, aggregates, and concrete mixes relevant to industry standards. SDG9.
3. **CO3 (L3 – Apply):** Design basic masonry, formwork, and finishing techniques using modern materials like polymers and green composites. SDG11.
4. **CO4 (L4 – Analyze):** Analyze sustainable materials such as recycled aggregates, geopolymers, and smart materials for durability and environmental impact. SDG9, SDG11, SDG12.
5. **CO5 (L5 – Evaluate):** Evaluate advanced construction techniques including prefabrication, 3D printing, and quality control for industrial projects. SDG9, SDG13.

Module-1

Traditional Building Materials:

- Stones: Classification (granite, limestone, sandstone), quarrying, dressing, properties (strength, durability, weathering), tests (compressive strength, water absorption), preservation techniques, uses in foundations and masonry.
- Bricks: Composition of good brick earth, manufacturing (clay preparation, molding, drying, burning in clamps/Hoffman kilns), classification (common, refractory, perforated), field/lab tests (dimension, water absorption, efflorescence, compressive strength), defects. Tiles:
- Roofing/flooring types (mangalore, clay, concrete), manufacturing, properties.
- Lime: Types (fat, hydraulic), production, properties, uses in mortar.

Linked COs: CO1. **Number of Hours (CI): 8 hrs.**

Module-2

Cement, Aggregates & Concrete Aggregates:

- Cement: Types (OPC, PPC, rapid hardening, sulfate resisting, low heat), manufacture (dry/wet process), chemical composition, properties, tests (fineness, setting time, compressive strength).
- Aggregates: Classification (fine/coarse), properties (shape, texture, specific gravity, absorption), sieve analysis, bulking, deleterious materials.
- Concrete: Ingredients, water-cement ratio, workability (slump, compaction factor), mix design (IS method), admixtures (plasticizers, super-plasticizers), properties of fresh/hardened concrete, quality control tests (compressive, tensile, flexural strength.

Linked COs: CO2. **Number of Hours (CI): 8 hrs**

Module-3

Timber, Metals & Finishing Materials:

- Timber: Classification (soft/hard wood), structure, seasoning (air/oven), defects (knots, shakes), preservation (ASCU, creosote), tests (moisture content, compressive strength), engineered wood (plywood, laminates).
- Metals: Ferrous (mild steel, HYSD bars, stainless steel) and non-ferrous (aluminum, copper), properties, corrosion prevention, uses in reinforcement.
- Finishing: Paints (types, constituents), varnishes, distempers; Bitumen/asphalt: Properties, uses in roads/waterproofing; Glass: Types (float, laminated), uses.

Linked COs: CO1, CO3. **Number of Hours (CI): 8 hrs.**

Module-4

Modern & Sustainable Materials:

- Polymers & Plastics: Thermoplastics/thermosets, PVC, FRP, applications in pipes/formwork.
- Composites: Fiber-reinforced (GFRP, CFRP), geopolymer concrete, self-healing concrete.
- Green Materials: Fly ash bricks, AAC blocks, recycled aggregates, bamboo, rice husk ash in concrete; Geosynthetics (geotextiles, geomembranes) for soil stabilization.
- Smart Materials: Phase change materials, self-compacting concrete, nano-modified materials for enhanced durability.
- Industry relevance: Sustainability, waste reduction, life-cycle assessment.

Linked COs: CO4. **Number of Hours (CI): 8 hrs.**

Module-5

Construction Techniques & Practices:

- Masonry: Brick/stone masonry bonds (English, Flemish), joints, damp-proof courses.
- Formwork: Types (timber, steel, plastic), design principles.
- Prefabrication: Elements (panels, beams), advantages.
- Advanced Techniques: Slipform, tunnel form, 3D printing in construction, robotics for material handling.
- Quality Control: Non-destructive tests (rebound hammer, ultrasonic pulse), codal provisions (IS 456, IS 383).
- Industrial Practices: Lean construction, modular building for rapid urbanization.

Linked COs: CO3, CO5. **Number of Hours (CI): 10 hrs..**

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

Text books:

1. S.C. Rangwala, Engineering Materials, Charotar Publishing House, latest edition.
2. M.L. Gambhir, Concrete Technology, Dhanpat Rai & Sons, latest edition.
3. B.C. Punmia, Building Construction, Laxmi Publications, latest edition.

Reference Books:

1. P.C. Varghese, Building Materials, PHI Learning.
2. S.K. Duggal, Building Materials, New Age International.
3. NPTEL lectures on Building Materials and Construction.

Web links and Video Lectures (e-Resources):

1. VTU/NIT/IIT NPTEL courses on Construction Materials.
2. IS Codes: 456:2000 (Concrete), 383:2016 (Aggregates), 1077:1992 (Bricks).

Teaching-Learning Process (Innovative Delivery Methods):

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

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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:

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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.	Material Testing Mini-Project: Select and test local construction materials (e.g., bricks, concrete cubes) for properties like strength and absorption; prepare report with IS standards compliance.	24
2.	Sustainable Material Case Study: Analyze a green building project using recycled materials; compute environmental impact, cost-benefit, and suggest optimizations.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Self-learning modules on NPTEL/SWAYAM; completion of online certification courses.	24
2.	Literature review on emerging technologies; reflective learning journal.	24

Rubrics for Students learning activities -TW/SL - (Samples)

1. Integrated Design Mini-Project – Rubric

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Conceptual Understanding (CO1)	Exemplary grasp of stones/bricks/cement properties with strong classification links.	Proficient; mostly correct, minor errors.	Partial gaps in material basics.	15%
Testing/Design Coverage (CO2)	In-depth lab tests/mix design with sketches, full procedures.	Some errors, partial coverage.	Partial test descriptions.	20%
Analysis Depth (CO3, CO4)	Deep analysis of concrete durability/sustainability metrics.	Some quantitative explanations.	Descriptive properties only.	20%
Sustainability Links (CO4)	Strong SDG links (e.g., recycled aggregates, low-carbon cement).	Brief green material mentions.	No sustainability focus.	15%
Innovative Techniques (CO5)	Well-structured prefab/3D print modules with novel ideas.	Generally organized outputs.	Disorganized technique notes.	15%

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).

Engineering Geology for Infrastructure Projects			
Course Code	1BIF305	Scheme	2025
Type of Course	PEC	Semester	III
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. **CO1 (L2 – Understand):** Explain the origin, classification and properties of rocks and soils relevant to civil engineering infrastructure.
2. **CO2 (L3 – Apply):** Interpret geological maps, structures and subsurface information for siting and planning of foundations, tunnels, dams and highways.
3. **CO3 (L3 – Apply):** Identify and describe engineering significance of geological structures such as joints, faults, folds and unconformities.
4. **CO4 (L4 – Analyze):** Analyze unstable slopes and mass-movement conditions qualitatively and suggest suitable stabilization and drainage measures.
5. **CO5 (L3 – Apply):** Apply basic principles of groundwater occurrence and movement in planning wells, dewatering and seepage control measures.
6. **CO6 (L4 – Analyze/Evaluate):** Assess geological hazards and geo-environmental issues, and relate them to resilient and sustainable infrastructure in line with SDG 6, SDG 9, SDG 11 and SDG 13.

Module-1

Introduction, minerals and rocks

- Scope of engineering geology in planning, design and construction of infrastructure.
- Internal structure of the earth and rock cycle (qualitative).
- Minerals – physical properties of important rock-forming minerals (quartz, feldspar, mica, calcite etc.).
- Rocks – classification into igneous, sedimentary and metamorphic; textures and structures; engineering significance of common rock types (granite, basalt, sandstone, limestone, shale, gneiss, schist).

Linked COs: CO1, partial CO2, CO6 **Number of Hours (CI): 8 hrs**

Module-2

Geological structures and engineering significance

- Primary and secondary structures; bedding, laminations and joints – types, spacing, infilling and their effect on strength and permeability.
- Folds – terminology, classification based on attitude; impact on tunnels, slopes and foundations.
- Faults – elements, types and recognition in field and maps; engineering problems due to faults.
- Unconformities and their recognition; importance in site selection and groundwater.
- Interpretation of simple geological maps and sections (qualitative).

Linked COs: CO2, CO3, CO6 **Number of Hours (CI): 8 hrs**

Module-3

Weathering, soil profile and site investigation

- Weathering of rocks – physical, chemical and biological processes; residual and transported soils; engineering implications.
- Soil profile, laterites and black cotton soils – occurrence and problems for foundations (qualitative).
- Concept of bearing strata, overburden, rock mass quality (awareness of RQD).
- Role of engineering geologist in reconnaissance and detailed site investigations.

Linked COs: CO1, CO2, CO4, CO6. **Number of Hours (CI): 8 hrs**

Module-4

Groundwater and subsurface conditions

- Groundwater occurrence – aquifers, aquitards, water table and piezometric surface.
- Concept of porosity, permeability and transmissivity at qualitative level.
- Springs, wells and boreholes; influence of geological formations on groundwater yield.
- Seepage and leakage issues in foundations, underground structures and slopes; basic drainage and grouting concepts (qualitative).

Linked COs: CO2, CO5, CO6. **Number of Hours (CI): 8 hrs**

Module-5

Slopes, landslides, dams, tunnels and geo-hazards

- Natural slopes in rock and soil, factors affecting stability – material, structure, groundwater and external loading.
- Landslides – types, causes, warning signs and basic preventive measures (drainage, retaining structures, bioengineering – qualitative).
- Geological considerations in dam and reservoir sites – suitable and unsuitable conditions, seepage and uplift issues.
- Tunnels and underground constructions – influence of rock type, joints, faults and water; concept of rock support systems (awareness).
- Earthquakes, seismic zoning (India – awareness), geotechnical amplification and resilient infrastructure; linkage to SDG 11 and SDG 13.

Linked COs: CO2, CO4, CO5, CO6. **Number of Hours (CI): 10 hrs..**

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

Text books:

1. Parbin Singh. Engineering and General Geology.
2. Krynine & Judd. Principles of Engineering Geology.
3. Venkat Reddy, D. Engineering Geology.

Reference Books:

1. Goodman, R. E. Engineering Geology – Rock in Engineering Construction.
2. IS code extracts on subsurface exploration and site investigation – awareness.

Web links and Video Lectures (e-Resources):

1. NPTEL courses on Engineering Geology and Rock Engineering.

Teaching-Learning Process (Innovative Delivery Methods):

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

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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**.
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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:

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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	Local Geology Portfolio: Document local rock/soil types, structures and slope features with photos and short notes	24
2	Infrastructure Case Study: Short case on dam/tunnel/highway influenced by geology, with simple qualitative stability and seepage comments	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Self-learning modules on NPTEL/SWAYAM; completion of online certification courses.	24
2	Literature review on emerging technologies; reflective learning journal.	24

Rubrics for Students learning activities -TW/SL - (Samples)

1. Integrated Design Mini-Project – Rubric

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Field data collection & coverage (rocks, soils, structures, slopes)	Visits multiple representative sites; records rock/soil types, structures and slope features systematically with locations and dates; safety considered.	Visits at least two sites; records main rock/soil types and some structures/slopes; minor gaps in documentation.	Limited sites or desk-based only; observations incomplete or unsystematic.	20%
Geological description & accuracy (CO1, CO3)	Correct identification of major rock/soil types and simple structures; clear descriptions of texture, colour, weathering and slope condition using appropriate terms.	Mostly correct identification; minor misclassification or weak terminology, but intent is clear.	Frequent misidentification; very limited or incorrect terminology.	25%
Engineering interpretation (foundations, slopes, drainage) (CO2, CO4)	Clearly relates local geology to foundations, slope stability, drainage and simple infrastructure suitability; gives realistic qualitative comments.	Provides some links to foundations or slopes; comments partly relevant but not always well-justified.	Little/no engineering interpretation; mostly descriptive.	25%
SDG linkage & reflection (SDG 9, 11, 13; CO6)	Explicitly connects observations to sustainable/resilient infrastructure (e.g., hazard awareness, land-use, climate impacts) with thoughtful reflection.	Mentions sustainability or hazard issues briefly; links somewhat general.	No or very superficial mention of sustainability or resilience.	15%
Portfolio organisation & presentation	Well-structured document (or digital portfolio) with clear sections, labelled photos/figures, maps and references; language clear.	Generally organised; some missing labels or minor clarity issues.	Disorganised, hard to follow, photos/figures poorly labelled or missing.	15%

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).

Auto CAD and 3D Modelling of Buildings and Infrastructure		Scheme	2025
Course Code	**1BIFL306**	Semester	III
Teaching Hours/Week (L:T:P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy CI(L:T):LI(P):SLTW	30 (0:0:2:2)	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:

1. CO1: Describe CAD interface, units, layers, snaps, and aids for building drafting. (L2)
2. CO2: Create detailed 2D plans, elevations, sections of institutional buildings using layers, hatches, dimensions. (L3)
3. CO3: Develop 3D models of buildings, generate multi-views, and apply basic rendering. (L3)
4. CO4 : Organize complex drawings with blocks, XREFs, layouts for collaboration and standards compliance. (L4)
5. CO5: Export models for estimation, BIM intro, presentations; reflect on civil applications. (L3)

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.
   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 (LI =20 hours)

FIXED SET OF EXPERIMENTS

1. CAD basics: Interface setup, units (metric), limits, layers (walls, doors, dimensions), OSNAPs, modify commands; draw simple room shapes, annotate.
2. Residential plan: Detailed plan with rooms, doors/windows (standard sizes: doors 900x2100mm, windows 1200x1200mm), furniture blocks, dimensions 1:100 scale.
3. Residential elevation/section: Matching elevation, cross-section with hatching (walls 230mm brick, slab 150mm), stairs, roof.
4. School building plan: Ground +1 floor plan (classrooms 7x8m, staff room, hall 20x10m, toilets, corridors), doors/windows, ramps for accessibility, grid lines, 1:100 scale.
5. School elevation/sections: Front/side elevations, longitudinal section showing plinth (750mm), parapet, solar panels; hatches for materials.
6. Office building plan: G+2 commercial office (reception, cabins 4x4m, open workstations, conference 10x6m, parking layout), lifts, services ducts, 1:100.
7. Office elevations/sections: Multi-level elevations, sections with column grids (6x6m bay), beam details, glazing.
8. Primary health center (PHC) plan: OPD rooms, waiting area, lab, pharmacy, wards (4 beds), admin, generator backup, circulation for patients, 1:100 scale.
9. PHC elevations/sections: Elevations with ramps (1:12), sections showing ventilation, septic tank stub, green features.
10. Structural details: RCC footing (1.5x1.5x0.6m), columns (400x400mm), beams/slabs for above buildings; grid/centerlines.

PART – B (LI = 8 hours)
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. Complete working drawings (plan, 2 elevations, 2 sections) for school/office/PHC variant; advanced layers, dynamic blocks, title block with BOM.
2. 3D modeling: Extrude school/office/PHC plans to full model (floors, roof, doors/windows), UCS views, section planes, basic materials/rendering (Revit/AutoCAD 3D).
3. Collaborative set: XREF plans/elevations/3D from peers, assemble layout sheets, plot PDFs; BIM export intro (IFC format).
4. Quantity takeoff: Area/volume from 3D model (floors, walls), Excel link; sustainability check (green area >20%)

Suggested Learning Resources:

Text books:

1. MG Shah, CM Kale, SY Patki, "Building Drawing with an Integrated Approach to Built Environment Drawing", Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. S.S. Bhavikatti and M.V. Chitawadagi, "Building Planning and Drawing", I K International Publishing House Pvt. Ltd., New Delhi.
3. Gurucharan Singh, "Building Construction", Standard Publishers & Distributors, New Delhi.
4. RS Malik and GS Meo, "Civil Engineering Drawing", Asian Publishers / Computech Publications Pvt. Ltd., New Delhi.
5. Sham Tickoo. AutoCAD 2024 for Engineers and Designers (or latest edition) – 2D drafting and 3D modelling with civil/architectural examples.
6. Munir Hamad. AutoCAD for Architectural Drawing and Design – building plans, elevations and basic 3D for buildings.
7. Elise Moss. Introducing AutoCAD Civil 3D – site, road and basic infrastructure modelling using Civil 3D.

Reference books / Manuals:

1. Dodge F.W., *"Time Saver Standards for Building Types"*, F.W. Dodge Corp., New York.
2. IS: 962 – 1989 – *"Code of Practice for Architectural and Building Drawing"*, BIS, New Delhi.
3. *"National Building Code of India"*, BIS, New Delhi.
4. Prof. Anil A. Patil. Computer Aided Building Drawing
5. Louisa Jahn, Dustin Manning. Mastering Autodesk Civil 3D – advanced corridor, grading and infrastructure workflows.

Web links and Video Lectures (e-Resources):

1. NPTEL: Computer Aided Design – Introductory CAD concepts and 3D modelling (lecture series by IIT Delhi / IITs).
2. NPTEL / IIT Hyderabad: Computer Aided Engineering Drawing and Design – 2D/3D CAD, drafting standards, projections useful before AutoCAD practice.
3. NPTEL / BIM-related courses: Building Information Modeling (BIM) – conceptual and workflow understanding for 3D model-based building/infrastructure projects (IITM Pravartak / similar)

NCrF – TWSL Activities for Lab (2 hours) -Any one Activity

- Watching and summarising selected CAD video tutorials (commands, good practices).
- Self-paced practice problems assigned weekly (additional building/road/utility drawings).
- Short reflection note on how CAD outputs can integrate with quantity estimation/BIM/digital site layout.

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.

Eligibility for SEE:

- 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**.

Rrubrics for CIE- Continuous Assessment for practical courses

Performance Indicator	CO/PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
P1: Regularity & Participation	CO1/PO5 (Lab discipline)	Always punctual, fully engaged, leads peers.	Regular, actively participates.	Moderately regular, some participation.	Irregular, minimal effort.	Absent/frequent disruptions.
P2: Understanding Objectives & Setup	CO2/PO2 (Problem analysis)	Fully comprehends, independently sets up accurately.	Good grasp, sets up with minor help.	Partial understanding, basic setup.	Struggles with setup/aims.	No understanding, incorrect setup. scribd+1
P3: Execution & Results	CO3/PO4 (Investigation)	Flawless conduction, precise results with error analysis.	Correct execution, accurate results.	Partial success, some errors.	Major errors in procedure/results.	Fails to conduct properly.
P4: Record Writing	CO4/PO10 (Communication)	Neat, complete, analytical beyond requirements.	Complete, neat, includes calculations.	Basic record, some omissions.	Incomplete/untidy.	Not submitted/illegible

P5: Viva Voce & Presentation	CO5/PO12 (Lifelong learning)	Confident, deep insights, relates to applications.	Answers most questions correctly.	Basic responses, some hesitation.	Few correct answers.	Unable to respond.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
PI-1: Experimental Skill / Technique (CO-x / PO-y)	Executes procedure flawlessly, handles equipment with confidence, completes work within time, and shows initiative in troubleshooting.	Performs procedure correctly; equipment handling is safe but with minor hesitation; completes most steps on time.	Follows procedure but with intermittent errors; needs frequent guidance; time management is poor.	Makes repeated procedural errors; unsafe handling; requires continuous supervision; incomplete work.	Fails to follow basic steps; unsafe practices; work not attempted or abandoned.
PI-2: Observation & Data Recording (CO-x / PO-y)	Records all required observations systematically; data is accurate, well-labeled, and presented in prescribed format. scribd+1	Records most observations correctly; data is readable but with minor omissions or formatting issues.	Records incomplete or inconsistent data; units/labels missing; entries are disorganized.	Data recording is haphazard; major omissions; units/labels largely absent.	No meaningful data recorded; or copied/incorrect entries without any understanding.
PI-3: Computation / Analysis (CO-x / PO-y)	Applies correct formulas, computes results accurately, interprets	Computes results correctly with minor arithmetic errors; graph/plot	Uses correct method but makes significant calculation errors; graph/plot is	Incorrect method or formula; computations are mostly wrong; no clear	No attempt at computation/analysis; blank or nonsensical entries.

	graphs/tables meaningfully, and identifies sources of error.	is acceptable; interpretation is partial.	poorly drawn; interpretation is weak. i	interpretation.	
PI-4: Safety, Discipline & Professionalism (CO-x / PO-y)	Maintains strict adherence to lab safety, SOPs, and instructions; respects peers and equipment; works independently.	Generally follows safety rules and instructions; acceptable conduct; needs minimal supervision.	Occasionally ignores minor safety precautions; requires reminders on discipline.	Repeated lapses in safety/behavior; disturbs others; needs constant monitoring.	Gross violation of safety norms; disruptive or negligent behavior; unsafe for self/others.
PI-5: Viva-Voce / Conceptual Understanding (CO-x / PO-y)	Demonstrates deep understanding of concepts, objectives, and methodology; answers questions confidently and precisely. nsec+1	Shows clear understanding of key concepts; answers most questions satisfactorily.	Understands basics but struggles with detailed or application-based questions.	Limited understanding; answers are vague or incorrect on fundamental points.	Unable to answer basic questions; shows no understanding of the experiment.

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. (7-8)	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)

Ability Enhancement Course (Laboratory) Syllabus

MATLAB & Spreadsheet Applications for Civil Engineering			
Course Code:	**1BIFL307A**	Scheme	2025
Type of Course	Ability Enhancement Course (Laboratory)	Semester	III
Teaching Hours/Week (L: T:P)	28(0:0:2)	CIE Marks	50
Total Hours of Pedagogy CI(L:T):LI(P):SL:TW	30 (0:0:2:2)	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:

1. CO1 (L2 – Understand): Describe the MATLAB and spreadsheet environment, basic syntax, data types, formulas and charting relevant to civil computations.
2. CO2 (L3 – Apply): Use MATLAB and spreadsheets for basic numerics, matrix operations, unit conversions and simple civil data handling (tables, plots, statistics).
3. CO3 (L3 – Apply): Develop simple MATLAB programs and spreadsheet templates for standard civil problems in structures, geotech, transport and water.
4. CO4 (L4 – Analyze): Analyze and visualize engineering data (curve fitting, regression, interpolation, basic optimization) and interpret results for design decisions.
5. CO5 (L3 – Apply): Build reusable, well-documented computational tools for routine civil design/check calculations aligned with IS codes.
6. CO6 (L4 –Evaluate): Judge the pros, cons and best practices of using MATLAB/spreadsheets in civil engineering, including error checks, documentation and sustainable digital workflows.

SET OF EXPERIMENTS (L1=28 hours)

1. Introduction to MATLAB & spreadsheets – basic interface, arithmetic, matrices, formulas and simple plots.
2. Matrix operations & linear systems – solve small structural systems in MATLAB and verify in Excel.
3. Civil data & descriptive statistics – import data, compute basic stats, create histograms/time-series.
4. Curve fitting & regression – fit material/load data and generate trendlines and design charts.
5. Geotechnical templates – Excel sheets for index properties and consolidation/settlement.
6. Structural design aids – simple RC checks and load calculations in MATLAB/Excel.
7. Hydrology applications – rainfall–runoff/streamflow processing and hydrographs/frequency plots.
8. Transport data analysis – traffic volume/speed data, peak-hour factors and speed–flow plots.
9. Numerical methods – root finding, interpolation, numerical integration for civil problems.
10. Visualization & dashboard – compact civil “mini-dashboard” with charts, tables and plots.
11. Mini-project – small integrated MATLAB + spreadsheet tool for a realistic civil problem.

Suggested Learning Resources

Textbooks:

1. MATLAB – A Practical Introduction to Programming and Problem Solving (Stormy Attaway) – civil examples added.
2. Excel for Engineers and Scientists (S. Narayan) – data analysis, optimization.

Reference Books:

1. MATLAB for Engineering Applications (William Palm III).
2. Engineering Computation with MATLAB (David M. Smith).

Web links and Video Lectures (e-Resources):

1. NPTEL: MATLAB Programming for Numerical Computations (IIT Madras).
2. NPTEL: Scientific Computing using MATLAB (IIT Kharagpur).
3. MathWorks MATLAB Onramp (free tutorials).

NCrF – TWSL Activities for Lab

1. **Video + Hands-On Reflection:** Watch a tutorial, reproduce one example with own data, and write a brief reflection on learning and limitations.
2. **Digital Lab Portfolio:** Compile scripts, spreadsheets, plots and short engineering comments for at least three experiments.
3. **Mini-Case Study:** Document use of MATLAB/spreadsheets in a real civil project, noting benefits, risks and good practices.
4. **Error & Good-Practice Audit:** Analyze a given sheet/script with known issues, fix errors, add checks and list best-practice guidelines.

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 marks for report and test shall be out of 50 marks.

Eligibility for SEE:

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

Rubrics for CIE – Continuous Assessment for practical courses

Perf. Indicator	**CO–PO Mapping**	**Superior (5)**	**Good (4)**	**Fair (3)**	**Needs Improvement (2)**	**Unacceptable (1)**
P1 Regularity & Participation	CO1, CO6 – PO8, PO9	Always punctual; actively engaged in all MATLAB/Excel tasks; frequently helps peers and contributes ideas.	Regular and attentive; participates in discussions and lab work with minimal prompting.	Moderately regular; participates occasionally; sometimes distracted or off-task.	Irregular attendance; low participation; often off-task or waiting for answers.	Frequently absent or disengaged; disrupts lab or shows no interest in work.
P2 Understanding of	CO1, CO2 –	Clearly explains aim of each experiment/mi	States aim in own words; sets	Has partial idea of aim; needs step-by-step	Confused about aim; struggles to follow setup	Cannot state objective;

Objectives & Setup	PO1, PO2	ni-task; independently sets up MATLAB scripts and spreadsheet templates correctly.	up environment with minor guidance.	help to set up scripts or sheets.	instructions even with support.	unable to set up MATLAB/Excel files meaningfully.
P3 Implementation & Execution of Tasks	CO2, CO3 – PO2, PO3	Implements scripts and formulas correctly; uses appropriate MATLAB functions and spreadsheet features; runs multiple test cases without errors.	Mostly correct implementation; small syntax/formula errors corrected after hints; runs a few valid test cases.	Basic implementation works only for simple cases; frequent errors; limited testing.	Incomplete or largely incorrect implementation; depends heavily on peers/teacher.	No meaningful implementation; code/formulas copied without understanding or do not run.
P4 Result Analysis & Visualisation	CO3, CO4 – PO4	Produces correct results; uses clear plots/tables; interprets trends and links them to the civil-engineering context (e.g., settlement, load, flow).	Results mostly correct; plots/tables present; gives some explanation of engineering meaning.	Results partially correct; plots/graphs cluttered or mislabeled; interpretation vague.	Major numerical/plotting errors; little or no attempt to interpret results.	No valid results; no plots/tables; cannot relate outputs to engineering problem.
P5 Documentation & Professional Presentation	CO5, CO6 – PO9, PO10	Lab record/portfolio is complete, well organized with headings, comments in code, labeled figures; work is reproducible and references (codes/texts) are noted.	Record mostly complete; basic structure present; some comments and labels; minor gaps in clarity.	Record has several missing steps or explanations; limited commenting/labeling.	Record is poorly organized or largely incomplete; hard to follow workflow.	Record not submitted or largely copied; no evidence of student's own work.
P6 Viva-Voce & Conceptual Understanding	CO1–CO4 – PO1, PO12	Demonstrates strong understanding of MATLAB/Excel concepts and civil applications; answers "why this method" questions confidently and connects to theory.	Answers most questions correctly; shows reasonable understanding of methods used.	Can answer basic "what did you do" questions but struggles with "why/how".	Very limited understanding; guesses or cannot explain own scripts/spreadsheets.	Unable to answer even basic questions; no grasp of either tools or applications.
Rubrics for SEE / CIE Test:						

Performance Indicator	CO–PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1 Experimental Skill & Tool Handling	CO2, CO3 – PO2, PO3	Navigates MATLAB and spreadsheet confidently; sets up scripts, functions and linked sheets correctly; handles file import/export and plotting without guidance; completes required task within time.	Uses MATLAB/Excel correctly with minor hesitation; setup mostly correct; completes most parts of task in allotted time.	Basic commands/formulas known but frequent errors; needs prompts for setup; struggles with time management.	Significant difficulty using tools; requires continuous guidance; large parts of task incomplete.	Unable to operate MATLAB/Excel correctly; key steps not attempted or abandoned.
PI-2 Observation & Data Recording (Inputs/Outputs)	CO1, CO2 – PO1	Clearly and systematically records given data, assumptions, and generated outputs (tables, intermediate values) in the prescribed format; units and labels are correct.	Records most data and outputs; minor omissions or inconsistent units/labels.	Partial recording of inputs/outputs; missing steps; some units/labels absent or incorrect.	Observations are disorganised; major omissions; format not followed.	No meaningful data/outputs recorded; copied/guessed values with no link to work.
PI-3 Computation, Logic & Result Accuracy	CO3, CO4 – PO2, PO4	Applies correct logic, formulas and functions; results are accurate for the test cases; checks reasonableness and comments on errors/limitations.	Overall method correct; minor numerical or referencing errors; limited but sensible checking of results.	Uses broadly correct approach but with several calculation or logic mistakes; little checking of reasonableness.	Method largely incorrect or incomplete; results mostly wrong; no error checking.	No valid computation; wrong or missing formulas/scripts; outputs meaningless.
PI-4 Visualisation & Engineering Interpretation	CO3, CO4 – PO3, PO4	Produces clear, well-formatted plots and tables; interprets trends correctly and relates them to the civil-engineering problem (e.g., settlement vs time, load vs deflection).	Plots/tables mostly correct and readable; gives some correct engineering interpretation.	Plotting attempted but poorly formatted or partially wrong; interpretation vague or superficial.	Minimal or incorrect visualisation; little or no explanation of what results imply.	No plots/tables; cannot explain any engineering meaning of outputs.
PI-5 Viva-Voce & Professionalism	CO1, CO5, CO6 – PO9,	Explains objectives, methods and code/formulas clearly; answers	Answers most questions correctly; shows	Can describe steps taken but struggles with “why” questions or	Limited understanding; many incorrect or incomplete	Unable to answer basic questions; shows no

	PO10, PO12	conceptual and application questions confidently; reflects on advantages/limitations of MATLAB/Excel in civil practice; displays good lab etiquette.	reasonable understanding of tools and underlying concepts; behaviour professional.	deeper concepts; professionalism acceptable.	answers; hesitant; professionalism marginal.	grasp of objectives or methods; unprofessional conduct.

Rubrics suggested for Practical continuous assessment

Performance Indicator	CO–PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1 Experimental Skill & Tool Handling	CO2, CO3 – PO2, PO3	Navigates MATLAB and spreadsheet confidently; sets up scripts, functions and linked sheets correctly; handles file import/export and plotting without guidance; completes required task within time.	Uses MATLAB/Excel correctly with minor hesitation; setup mostly correct; completes most parts of task in allotted time.	Basic commands/formulas known but frequent errors; needs prompts for setup; struggles with time management.	Significant difficulty using tools; requires continuous guidance; large parts of task incomplete.	Unable to operate MATLAB/Excel correctly; key steps not attempted or abandoned.
PI-2 Observation & Data Recording (Inputs/Outputs)	CO1, CO2 – PO1	Clearly and systematically records given data, assumptions, and generated outputs (tables, intermediate values) in the prescribed format; units and labels are correct.	Records most data and outputs; minor omissions or inconsistent units/labels.	Partial recording of inputs/outputs; missing steps; some units/labels absent or incorrect.	Observations are disorganised; major omissions; format not followed.	No meaningful data/outputs recorded; copied/guessed values with no link to work.
PI-3 Computation, Logic & Result Accuracy	CO3, CO4 – PO2, PO4	Applies correct logic, formulas and functions; results are accurate for the test cases; checks reasonableness and comments on errors/limitations.	Overall method correct; minor numerical or referencing errors; limited but sensible checking of results.	Uses broadly correct approach but with several calculation or logic mistakes; little checking of reasonableness.	Method largely incorrect or incomplete; results mostly wrong; no error checking.	No valid computation; wrong or missing formulas/scripts; outputs meaningless.
PI-4 Visualisation &	CO3, CO4 –	Produces clear, well-formatted plots and tables;	Plots/tables mostly correct and	Plotting attempted but poorly	Minimal or incorrect visualisatio	No plots/tables; cannot

Engineering Interpretation	PO3, PO4	interprets trends correctly and relates them to the civil-engineering problem (e.g., settlement vs time, load vs deflection).	readable; gives some correct engineering interpretation.	formatted or partially wrong; interpretation vague or superficial.	n; little or no explanation of what results imply.	explain any engineering meaning of outputs.
PI-5 Viva-Voce & Professionalism	CO1, CO5, CO6 – PO9, PO10, PO12	Explains objectives, methods and code/formulas clearly; answers conceptual and application questions confidently; reflects on advantages/limitations of MATLAB/Excel in civil practice; displays good lab etiquette.	Answers most questions correctly; shows reasonable understanding of tools and underlying concepts; behaviour professional.	Can describe steps taken but struggles with “why” questions or deeper concepts; professionalism acceptable.	Limited understanding; many incorrect or incomplete answers; hesitant; professionalism marginal.	Unable to answer basic questions; shows no grasp of objectives or methods; unprofessional conduct.

AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR) LABORATORY IN CIVIL ENGINEERING			
Course Code	1BIFL307B	Scheme	2025
Type of Course	Ability Enhancement Course (Laboratory)	Semester	III
Teaching Hours/Week (L :T : P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy CI(L :T):LI(P):SL:TW	30 (0:0:2:2)	SEE Marks	50
Credits	1	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:

1. CO1 (L2 – Understand): Describe AR/VR fundamentals, hardware, software tools, and their applications in civil engineering visualization, construction, and inspection.
2. CO2 (L3 – Apply): Develop basic AR overlays for civil structures using mobile AR platforms and BIM models.
3. CO3 (L3 – Apply): Create VR environments to simulate civil engineering scenarios like structural testing and site walkthroughs.
4. CO4 (L4 – Analyze): Evaluate AR/VR for on-site construction assistance, safety checks, and structural health monitoring through practical experiments.
5. CO5 (L3 – Apply): Integrate AR/VR outputs with civil engineering workflows for design review, collaboration, and reporting.

SET OF EXPERIMENTS (LI =28 hours)

1. Introduction to AR/VR interface: Setup Unity/Vuforia/ARCore, calibration, basic markers, overlay simple 2D/3D civil elements like beams on physical models.
2. AR on-site marking: Use AR glasses/app to project footing/column layout on floor slab model with dimensions.
3. VR walkthrough of building structure: Create immersive VR tour of a simple RCC framed building with navigation and annotations.
4. AR visualization of residential building: Overlay BIM plan, elevation, sections on printed/physical model using mobile AR app.
5. AR for infrastructure inspection: Overlay virtual crack detection, stress visualization on beam/column physical model.
6. VR simulation of road cross-section: Model rural/urban road with carriageway, drains, and footpaths; simulate construction sequence.

Suggested Learning Resources

Text books:

1. "Augmented Reality: Principles and Practice" by Dieter Schmalstieg & Tobias Hollerer – AR/VR fundamentals with Unity examples for engineering visualization.
2. "Virtual Reality & Augmented Reality: Myths and Realities" by Slater et al. – Applications in construction and civil infrastructure.

Reference Books:

1. **Jason Jerald**, *The VR Book: Human-Centered Design for Virtual Reality*.
2. **Jonathan Linowes**, *Augmented Reality with Unity AR Foundation.*

Web links and Video Lectures (e-Resources):

1. NPTEL "Augmented Reality and Virtual Reality" – Introductory lectures on AR/VR tools and applications.
2. Unity Learn: AR/VR for Civil Engineering Tutorials – Hands-on with Vuforia, Oculus for structural models.
3. YouTube: "AR in Construction" by Autodesk – BIM 360 AR demos for civil workflows.

NCrF – TW/SL Activities (2 hours) -Any one activity

- Watching and summarizing AR/VR tutorials on civil applications (e.g., HoloLens for site inspection).
- Self-paced practice: Additional AR overlays for bridges/utilities.
- Reflection note on AR/VR role in sustainable civil engineering and safety.
- Case study analysis of AR/VR application in a civil project or construction workflow.

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 marks for report and test shall be out of 50 marks.

Eligibility for SEE:

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

Rubrics for CIE- Continuous Assessment for practical courses

Performance Indicator	CO/PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
P1: Regularity & Participation	CO1/PO5 (Lab discipline)	Always punctual, fully engaged, leads peers.	Regular, actively participates.	Moderately regular, some participation.	Irregular, minimal effort.	Absent/frequent disruptions.
P2: Understanding Objectives & Setup	CO2/PO2 (Problem analysis)	Fully comprehends, independently sets up accurately.	Good grasp, sets up with minor help.	Partial understanding, basic setup.	Struggles with setup/aims.	No understanding, incorrect setup. scribd+1

P3: Execution & Results	CO3/PO4 (Investigation)	Flawless conduction, precise results with error analysis.	Correct execution, accurate results.	Partial success, some errors.	Major errors in procedure/results.	Fails to conduct properly.
P4: Record Writing	CO4/PO10 (Communication)	Neat, complete, analytical beyond requirements.	Complete, neat, includes calculations.	Basic record, some omissions.	Incomplete/untidy.	Not submitted/illegible
P5: Viva Voce & Presentation	CO5/PO12 (Lifelong learning)	Confident, deep insights, relates to applications.	Answers most questions correctly.	Basic responses, some hesitation.	Few correct answers.	Unable to respond.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	**Superior**	**Good**	**Fair**	**Needs Improvement**	**Unacceptable**
PI-1: Experimental Skill / Technique (CO-1 / PO-5)	Executes procedure flawlessly, handles equipment with confidence, completes work within time, and shows initiative in troubleshooting.	Performs procedure correctly; equipment handling is safe but with minor hesitation; completes most steps on time.	Follows procedure but with intermittent errors; needs frequent guidance; time management is poor.	Makes repeated procedural errors; unsafe handling; requires continuous supervision; incomplete work.	Fails to follow basic steps; unsafe practices; work not attempted or abandoned.
PI-2: Observation & Data Recording (CO-2 / PO-2)	Records all required observations systematically; data is accurate, well-labeled, and presented in prescribed format. scribd+1	Records most observations correctly; data is readable but with minor omissions or formatting issues.	Records incomplete or inconsistent data; units/labels missing; entries are disorganized.	Data recording is haphazard; major omissions; units/labels largely absent.	No meaningful data recorded; or copied/incorrect entries without any understanding.

PI-3: Computation / Analysis (CO-3 / PO-4)	Applies correct formulas, computes results accurately, interprets graphs/tables meaningfully, and identifies sources of error.	Computes results correctly with minor arithmetic errors; graph/plot is acceptable; interpretation on is partial.	Uses correct method but makes significant calculation errors; graph/plot is poorly drawn; interpretation is weak. i	Incorrect method or formula; computations are mostly wrong; no clear interpretation.	No attempt at computation/analysis; blank or nonsensical entries.
PI-4: Safety, Discipline & Professionalism (CO-4 / PO-12)	Maintains strict adherence to lab safety, SOPs, and instructions; respects peers and equipment; works independently.	Generally follows safety rules and instructions; acceptable conduct; needs minimal supervision.	Occasionally ignores minor safety precautions; requires reminders on discipline.	Repeated lapses in safety/behavior; disturbs others; needs constant monitoring.	Gross violation of safety norms; disruptive or negligent behavior; unsafe for self/others.
PI-5: Viva-Voce / Conceptual Understanding (CO-5 / PO-1)	Demonstrates deep understanding of concepts, objectives, and methodology; answers questions confidently and precisely. nsec+1	Shows clear understanding of key concepts; answers most questions satisfactorily.	Understands basics but struggles with detailed or application-based questions.	Limited understanding; answers are vague or incorrect on fundamental points.	Unable to answer basic questions; shows no understanding of the experiment.

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	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)

	design with proper reason (5)			
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. (7-8)	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)

Python Programming Lab for Civil Engineers			
Course Code	1BIF307C	Scheme	2025
Type of Course	Ability Enhancement Course (Laboratory)	Semester	III
Teaching Hours/Week (L :T : P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy CI(L :T):LI(P):SL:TW	30 (0:0:2:2)	SEE Marks	50
Credits	1	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:

1. **CO1 (L2 – Understand):** Explain basic Python syntax, data types, control structures and libraries relevant to numerical computations.
2. **CO2 (L3 – Apply):** Write simple Python scripts for solving fundamental civil engineering problems in areas such as solid mechanics, fluid mechanics and surveying.
3. **CO3 (L3 – Apply):** Use Python and spreadsheet integration for basic data handling, plotting and report generation.
4. **CO4 (L4 – Analyze):** Analyse numerical results, identify errors and improve scripts for robustness and clarity.

CO5 (L3 – Apply): Demonstrate digital skills aligned with Industry 5.0 by automating repetitive engineering calculations.

SET OF EXPERIMENTS (LI =28 hours)

1. Introduction to Python environment, variables, input–output, basic arithmetic and conditional statements.
2. Python basics for civil computations. Read two or more engineering values and compute arithmetic operations, unit conversion, and basic conditional checks.
3. Engineering formula evaluator. Write a program to compute a civil engineering formula such as stress, discharge, or density using functions.
4. Tabular civil data handling. Store civil data such as rainfall, load, density, or traffic counts using lists and tuples; perform insertion, deletion, and summary operations.
5. Dictionary-based data mapping. Use dictionaries to map material grades, soil classifications, or section properties and retrieve values by key.
6. Statistics for civil datasets. Read a list of values and compute mean, variance, standard deviation, minimum, maximum, and outlier checks.
7. Script for basic fluid mechanics calculations – Reynolds number, Bernoulli equation between two points, head loss using Darcy–Weisbach equation.
8. Program to read and process tabular data (CSV/spreadsheet) for plotting load–deflection, stress–strain or discharge–time graphs.
9. Use of functions and modules to organise repetitive calculations (e.g., design-style checks for sections).
10. Mini project. Develop a small Python tool for a civil engineering task such as mix proportion summary, rainfall analysis, load report, or survey data organizer.

Suggested Learning Resources

Text books:

1. Amir Hossein Roodpeyma et al., Introduction to Python for Civil Engineers: A Beginner's Guide.
2. H. P. Langtangen, Python for Science and Engineering (or similar engineering-oriented Python text).
3. Nayak & Gupta, Python for Engineers and Scientists: Concepts and Applications (for slightly advanced use with numerical methods)

Reference Books:

1. TU Delft – Python for Civil Engineers (freely available online course notes and examples).
2. Python for Structural Engineers (notes/book focusing on structural and civil examples).
3. GitHub repository Python for Civil Engineers – example scripts for structural, geotechnical and hydraulics problems

Web links and Video Lectures (e-Resources):

1. NPTEL: Programming, Data Structures and Algorithms using Python – core programming basics (variables, loops, functions, lists, files, OOP).
2. NPTEL: Python for Data Science – for handling tabular data (Excel/CSV from lab experiments, survey, traffic counts).
3. NPTEL: Scientific Computing using Python – numerical computing and plotting relevant to analysis/visualisation of civil data

NCrF – TW/SL Activities (2 hours) -Any one activity

- Completion of short online Python tutorials relevant to engineering applications.
- Preparation of a small digital portfolio of scripts with comments and sample outputs.

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 marks for report and test shall be out of 50 marks.

Eligibility for SEE:

- 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.**

Rrubrics for CIE- Continuous Assessment for practical courses

Component & CO-PO Mapping	Excellent (5)	Good (4)	Fair (3)	Marginal (2)	Unsatisfactory (1)
Problem understanding [CO1, CO2]	Clearly understands the civil problem and identifies the correct approach.	Understands the problem well with minor guidance.	Partial understanding; needs support.	Weak understanding of the objective.	Cannot identify the problem meaningfully.
Python logic and syntax [CO1, CO3]	Uses correct logic, syntax, and flow control accurately.	Mostly correct with minor errors.	Basic logic is present but inconsistent.	Frequent syntax/logic errors.	Unable to code the task.
Data structures and file handling [CO2, CO3]	Uses lists, dictionaries, files, and libraries effectively.	Uses them correctly with minor issues.	Limited but acceptable use.	Weak application of structures or file handling.	Misuses or avoids them.
OOP and modular design [CO4]	Clean modular structure with reusable classes/functions.	Mostly structured and reusable.	Basic modularity present.	Poor structure.	No modular design.
Result analysis and visualization	Produces correct outputs and interprets civil	Outputs are correct with some	Results are partially correct.	Weak interpretation.	No valid results.

[CO5]	relevance clearly.	interpretation.			
Documentation and professionalism [CO6]	Well-documented, neat, reproducible, and professionally presented.	Mostly complete and organized.	Adequate but incomplete in places.	Poorly organized.	Not submitted or unusable.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
PI-1: Python Coding Technique (CO1 / PO2)	Writes flawless Python code with correct syntax, logic, and civil data handling; debugs independently; completes within time.	Codes correctly with minor syntax issues; handles civil examples safely; finishes most tasks on time.	Follows basic Python structure but with errors; needs guidance on loops/functions; poor time management.	Repeated syntax/logic errors; unsafe file/data handling; requires constant help; incomplete code.	Fails basic Python steps; copies code without understanding; work abandoned.
PI-2: Data Handling & Output (CO2 / PO5)	Records all civil data (lists/dicts/files) systematically; outputs accurate, labeled, and formatted correctly.	Records most data correctly; outputs readable with minor omissions/formatting issues.	Incomplete/inconsistent data handling; missing labels/units; disorganized outputs.	Haphazard data recording; major omissions; no structure in lists/files.	No meaningful data handled; copied outputs without comprehension.

PI-3: Computation / Analysis (CO3 / PO3)	Applies correct Python libraries (NumPy etc.), computes accurately, interprets civil results (plots/tables), identifies code errors.	Computes correctly with minor bugs; plots acceptable; partial civil interpretation.	Uses right methods but significant errors; plots poorly drawn; weak analysis.	Wrong libraries/methods; computations invalid; no civil interpretation.	No computation/analysis; blank or nonsensical Python outputs.
PI-4: Safety, Discipline & Professionalism (CO6 / PO10)	Follows Python best practices, code ethics, lab SOPs strictly; respects peers/equipment; works independently.	Generally follows coding standards/SOPs; acceptable conduct; minimal supervision needed.	Occasionally ignores code hygiene/precautions; needs discipline reminders.	Repeated lapses in code safety/professionalism; disturbs lab; constant monitoring.	Gross violation of coding norms; disruptive/negligent; unsafe practices.
PI-5: Viva-Voce / Conceptual Understanding (CO5 / PO1)	Demonstrates deep Python-civil integration understanding; answers confidently on applications/visualization.	Shows clear grasp of Python-civil concepts; answers most questions well.	Understands basics but struggles with civil applications/data analysis questions.	Limited understanding; vague/incorrect on core Python-civil concepts.	Unable to answer basic Python or civil engineering questions.

Rubrics suggested for Practical continuous assessment

Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (PO1)	Student demonstrates deep knowledge of Python programming concepts and their civil engineering applications (loops, functions, data structures for civil data). (4-5)	Student has good knowledge of core Python topics and basic civil applications. (3)	Student can narrate Python answers but lacks depth in civil engineering context. (2)	Student has not understood Python concepts clearly or their civil relevance
Design of Experiment (PO2 & PO3)	Student discusses multiple Python solution designs for civil problems (e.g., data analysis, visualization) and	Student discusses few Python designs for civil problem but cannot select optimal one. (4)	Student explains single Python design approach with merits/demerits for civil task. (3)	Student can barely explain basic Python design for civil experiment. (1-2)

	proves best approach with civil examples. (5)			
Implementation (PO3 & PO8)	Student implements optimal Python solution with efficient algorithms for civil data processing/visualization; explains code thoroughly. (7-8)	Student implements good Python design with suitable algorithms; can explain civil implementation. (5-6)	Student implements basic Python design with proper explanation for civil task. (3-4)	Student implements minimal Python code without optimization or civil
Result & Analysis (PO4)	Student runs Python program across multiple civil datasets (rainfall, loads, surveys), compares results, and analyzes civil engineering implications. (5)	Student runs program successfully for all assigned civil test cases. (4)	Student runs code for few civil cases and provides basic output analysis. (3)	Student runs program but cannot analyze civil engineering outputs. (1-2)
Demonstration (PO9)	Lab record excellently organized with clear Python code sections, civil problem statements, results interpretation, and professional documentation. (7-8)	Lab record well-organized with Python code, civil examples, but some sections incomplete. (5-6)	Lab record has basic Python code organization but lacks clear civil structure. (3-4)	Lab record poorly organized with missing Python code sections or civil context. (1-2)

ENGINEERING GEOLOGY AND SOIL IDENTIFICATIONS LAB			
Course Code	1BIF307D	Scheme	2025
Type of Course	Ability Enhancement Course (Laboratory)	Semester	III
Teaching Hours/Week (L :T : P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy CI(L :T):LI(P):SL:TW	30 (0:0:2:2)	SEE Marks	50
Credits		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:

1. CO1 (L3 – Apply): Identify and classify common rock-forming minerals and rocks based on physical properties, textures, and structures relevant to civil engineering applications.
2. CO2 (L3 – Apply): Perform standard laboratory tests to determine physical and index properties of soils including moisture content, specific gravity, grain size distribution, and Atterberg limits.
3. CO3 (L4 – Analyze): Analyze soil classification using Unified Soil Classification System (USCS) and Indian Standard Classification (IS) based on laboratory test results and plasticity characteristics.
4. CO4 (L3 – Apply): Use geological instruments (clinometer compass, Brunton compass) to measure dip and strike of geological formations and interpret geological maps and cross- sections.
5. CO5 (L4 – Analyze): Evaluate engineering properties of rocks (specific gravity, porosity, water absorption) and assess their suitability for construction materials and infrastructure projects.
6. CO6 (L5 – Evaluate): Assess geological and geotechnical site conditions, relate laboratory findings to field observations, and recommend suitable foundation types and construction practices aligned with SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities).

SET OF EXPERIMENTS (LI =28 hours)

1. Study of geological maps and symbols.
2. Identification of common rock-forming minerals by physical properties.
3. Identification and description of igneous rocks/sedimentary rocks/metamorphic rocks.
4. Study of structural features of rocks such as folds, faults, joints, and bedding planes.
5. Study of topographical maps and contour interpretation.
6. Interpretation of geological sections and rock strata.
7. Study of aerial photographs / stereoscopic photo interpretation.
8. Study of engineering geological conditions for site selection.
9. Visual manual identification and description of soil samples.

Suggested Learning Resources

Text books:

1. Parbin Singh. Engineering and General Geology. Katson Publishing House.
2. Venkat Reddy, D. Engineering Geology for Civil Engineers. Oxford & IBH Publishing.
3. Murthy, V. N. S. Soil Mechanics and Foundation Engineering (7th Edition). CBS Publishers.
4. Punmia, B. C., Jain, A. K., & Jain, A. K. Soil Mechanics and Foundations (17th Edition). Laxmi Publications.

Reference Books:

1. Krynine, D. P., & Judd, W. R. Principles of Engineering Geology and Geotechnics. McGraw-Hill.
2. 2.Goodman, R. E. Engineering Geology – Rock in Engineering Construction. Wiley.
3. 3.IS 2720 (Parts I to XXII) – Methods of Test for Soils – Indian Standard Code of Practice.
4. 4.Rahn, P. H. Engineering Geology: An Environmental Approach (2nd Edition). Prentice Hall.
5. Das, B. M. Principles of Geotechnical Engineering (9th Edition). Cengage Learning

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

NCrF – TW/SL Activities (2 hours) -Any one activity

1. Watching and summarizing selected video tutorials on geological field methods and advanced soil testing procedures. Self-paced practice: Identification of additional mineral and rock specimens; solving numerical problems on phase relationships and soil classification.
2. Preparation of digital portfolio: Compilation of all experiment results with photographs, calculations, and engineering interpretations.
3. Short reflection note on applications of engineering geology and soil testing in sustainable infrastructure development (SDG linkage).
4. Case study analysis: Review of a major landslide, dam failure, or foundation failure event caused by adverse geological/geotechnical conditions; lessons learned report.

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 marks for report and test shall be out of 50 marks.

Eligibility for SEE:

- 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.**

Rrubrics for CIE- Continuous Assessment for practical courses

Performance Indicator	CO/PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
P1: Regularity & Participation	CO1/PO5 (Lab discipline)	Always punctual, fully engaged, leads peers.	Regular, actively participates.	Moderately regular, some participation.	Irregular, minimal effort.	Absent/frequent disruptions.
P2: Understanding Objectives & Setup	CO2/PO2 (Problem analysis)	Fully comprehends, independently sets up accurately.	Good grasp, sets up with minor help.	Partial understanding, basic setup.	Struggles with setup/aims.	No understanding, incorrect setup. scribd+1

P3: Execution & Results	CO3/PO4 (Investigation)	Flawless conduction, precise results with error analysis.	Correct execution, accurate results.	Partial success, some errors.	Major errors in procedure /results.	Fails to conduct properly.
P4: Record Writing	CO4/PO10 (Communication)	Neat, complete, analytical beyond requirements.	Complete, neat, includes calculations.	Basic record, some omissions.	Incomplete/untidy.	Not submitted/illegible
P5: Viva Voce & Presentation	CO5/PO12 (Lifelong learning)	Confident, deep insights, relates to applications.	Answers most questions correctly.	Basic responses, some hesitation.	Few correct answers.	Unable to respond.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	**Superior**	**Good**	**Fair**	**Needs Improvement**	**Unacceptable**
PI-1: Experimental Skill / Technique (CO-x / PO-y)	Executes procedure flawlessly, handles equipment with confidence, completes work within time, and shows initiative in troubleshooting.	Performs procedure correctly; equipment handling is safe but with minor hesitation; completes most steps on time.	Follows procedure but with intermittent errors; needs frequent guidance; time management is poor.	Makes repeated procedural errors; unsafe handling; requires continuous supervision; incomplete work.	Fails to follow basic steps; unsafe practices; work not attempted or abandoned.
PI-2: Observation & Data Recording (CO-x / PO-y)	Records all required observations systematically; data is accurate, well-labeled, and presented in prescribed format. scribd+1	Records most observations correctly; data is readable but with minor omissions or formatting issues.	Records incomplete or inconsistent data; units/labels missing; entries are disorganized.	Data recording is haphazard; major omissions; units/labels largely absent.	No meaningful data recorded; or copied/incorrect entries without any understanding.

PI-3: Computation / Analysis (CO-x / PO-y)	Applies correct formulas, computes results accurately, interprets graphs/tables meaningfully, and identifies sources of error.	Computes results correctly with minor arithmetic errors; graph/plot is acceptable; interpretation is partial.	Uses correct method but makes significant calculation errors; graph/plot is poorly drawn; interpretation is weak. i	Incorrect method or formula; computations are mostly wrong; no clear interpretation.	No attempt at computation/analysis; blank or nonsensical entries.
PI-4: Safety, Discipline & Professionalism (CO-x / PO-y)	Maintains strict adherence to lab safety, SOPs, and instructions; respects peers and equipment; works independently.	Generally follows safety rules and instructions; acceptable conduct; needs minimal supervision.	Occasionally ignores minor safety precautions; requires reminders on discipline.	Repeated lapses in safety/behavior; disturbs others; needs constant monitoring.	Gross violation of safety norms; disruptive or negligent behavior; unsafe for self/others.
PI-5: Viva-Voce / Conceptual Understanding (CO-x / PO-y)	Demonstrates deep understanding of concepts, objectives, and methodology; answers questions confidently and precisely. nsec+1	Shows clear understanding of key concepts; answers most questions satisfactorily.	Understands basics but struggles with detailed or application-based questions.	Limited understanding; answers are vague or incorrect on fundamental points.	Unable to answer basic questions; shows no understanding of the experiment.

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	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)

	design with proper reason (5)			
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. (7-8)	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)

4th Semester Syllabus

Surveying and Geospatial Techniques for Infrastructure Projects			
Course Code	1BIF401	Scheme	2025
Type of Course	Profession Core Course (PCC)	Semester	IV
Teaching Hours/Week (L: T:P)	(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T): LI(P):SL&TW:	90 (CI-42 + TW/SL-48)	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. **CO1 (L2 –** Understand): Explain the fundamental principles of surveying, linear and angular measurements, and traditional surveying methods for civil infrastructure projects.
2. **CO2 (L3 – Apply):** Perform leveling operations, contouring, theodolite surveying, and tachometric measurements for establishing vertical and horizontal control in infrastructure planning.
3. **CO3 (L3 – Apply):** Operate modern surveying instruments including Total Station, Electronic Distance Measurement (EDM) devices, and GNSS/GPS receivers for precise positioning and data collection. Set curves for construction works and carry out estimation of areas and volumes
4. **CO4 (L4 – Analyze):** Apply Geographic Information Systems (GIS) and remote sensing techniques to analyze spatial data, create digital elevation models, and interpret geospatial information for infrastructure site analysis.
5. **CO5 (L4 – Analyze):** Integrate advanced geospatial technologies including LiDAR, UAV photogrammetry, and reality capture methods for infrastructure surveying, monitoring, and asset management.
6. **CO6 (L5 – Evaluate):** Evaluate geospatial data integration strategies for smart infrastructure development, sustainable planning, and resilient urban systems aligned with SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities).

Module-1

Fundamentals of Surveying and Linear Measurements

- Introduction to surveying – definition, objectives, principles (working from whole to part, location by measurements); classification of surveying (plane, geodetic; chain, compass, leveling, theodolite).
- Linear measurements – direct and indirect methods; instruments (chains, tapes, ranging rods, arrows, pegs); chain surveying principles and field procedures.
- Measurement of distances on level ground, sloping ground (slope and horizontal distance corrections); errors in chaining and their elimination.
- Ranging – direct ranging, indirect ranging; obstacles to ranging and chaining; methods of overcoming obstacles.
- Compass surveying – principles, magnetic meridian, true meridian; bearing systems (whole circle bearing, quadrantal bearing, reduced bearing), Plane Table Surveying.
- Prismatic compass – construction, temporary adjustments; measurement of bearings; local attraction and its detection and elimination.

Linked COs: CO1, partial CO2, CO6 **Number of Hours = 8 hours**

Module-2

- **Leveling, Contouring and Theodolite Surveying**
- Principles of leveling – definitions (level surface, horizontal plane, vertical line, datum, bench mark, reduced level); types of leveling (direct, indirect).
- Leveling instruments – dumpy level, tilting level, automatic level; components (telescope, bubble tube, leveling head, tripod, Leveling staff,); temporary adjustments.
- Differential leveling, fly leveling, profile leveling, cross-sectioning; errors in leveling and precautions; curvature and refraction corrections.
- Contouring – definition, characteristics and uses of contours; contour interval; methods of contouring (direct, indirect); interpolation of contours.
- Uses of contour maps – determination of indivisibility, gradient, catchment area, capacity of reservoir (qualitative); applications in highway and railway alignment.

- Theodolite – types (transit, non-transit); parts and functions; temporary adjustments (leveling, centering, elimination of parallax).

Linked COs: CO1, CO2, CO6 **Number of Hours = 9 hours**

Module-3

Total Station, EDM and Curves

- Electronic Distance Measurement (EDM) – principles of electromagnetic distance measurement; types (microwave, infrared, laser); accuracy and range.
- Total Station – components and features; integration of electronic theodolite and EDM; coordinate measurement system.
- Total Station operations – setup and orientation, measurement of coordinates, distance and angles; data recording and download; applications in infrastructure projects.
- Coordinate systems – local coordinates, grid coordinates; coordinate transformation; azimuth and bearing computations.
- Curves setting for infrastructure – horizontal curves (simple circular curves); elements of curves; setting curves by offsets, deflection angle method using Total Station.
- Vertical curves – types (crest, sag); elements; computation of elevations along vertical curves for highway and railway alignment.
- Areas and Volumes- Methods of determining areas by trapezoidal and Simpsons' rule. Measurement of volume by prismoidal and trapezoidal formula. Earthwork volume calculations from spot levels and from contour maps; Earthwork calculation in Embankments.

Linked COs: CO2, CO3, CO6. **Number of Hours = 8 hours.**

Module-4

GIS and Remote Sensing

- Introduction to Geographic Information Systems (GIS) – definition, components (hardware, software, data, people, procedures); spatial and attribute data.
- GIS data models – vector data (points, lines, polygons), raster data (grid cells, pixels); topology; data structures and formats (shape files, geo databases).
- Spatial data acquisition – primary sources (field surveys, GPS), secondary sources (maps, aerial photos, satellite imagery); digitization and geo referencing.
- GIS applications in civil infrastructure – site selection, route optimization for highways/pipelines, urban planning, utility mapping, disaster management.
- **Remote sensing fundamentals** – electromagnetic spectrum, passive and active remote sensing; platforms (satellite, airborne, UAV).
- Satellite remote sensing systems – optical sensors (Landsat, Sentinel, Cart sat), radar sensors (SAR); spatial, spectral, temporal, radiometric resolution.
- Image interpretation and analysis – visual interpretation elements (tone, texture, pattern, shape, size, association); digital image processing (enhancement, classification).
- Applications of remote sensing in civil engineering – land use/land cover mapping, terrain analysis, infrastructure monitoring, natural resource assessment.

Linked COs: CO2, CO5, CO6. **Number of Hours = 9 hours.**

Module-5

Advanced Geospatial Technologies for Infrastructure

- LiDAR (Light Detection and Ranging) technology – principles, components (laser scanner, GPS, IMU); airborne LiDAR, terrestrial LiDAR, mobile LiDAR.
- LiDAR data products – point clouds, intensity images, Digital Terrain Model (DTM), Digital Surface Model (DSM); classification of point clouds.
- Applications of LiDAR – corridor mapping for highways/railways, powerline surveys, flood modeling, volume computation, as-built documentation.
- Integration with Building Information Modeling (BIM) – scan-to-BIM workflows; clash detection between design and as-built; facility management applications.

- Geospatial data management – spatial databases, metadata standards, data sharing platforms; open-source GIS software (QGIS awareness).
- Smart infrastructure and IoT integration – sensor networks for infrastructure monitoring; real-time data visualization on GIS platforms; predictive analytics.
- Geospatial applications for sustainable development – smart cities, disaster risk reduction, climate resilience, infrastructure asset management.

Linked COs: CO4, CO5, CO6. **Number of Hours = 8 hours .**

Suggested Learning Resources

Textbooks:

1. Punima, B. C., Jain, A. K., & Jain, A. K. Surveying (Volumes I, II, and III) (17th Edition). Laxmi Publications.
2. Duggal, S. K. Surveying (Volumes I and II). Tata McGraw-Hill.
3. Kanetkar, T. P., & Kulkarni, S. V. Surveying and Levelling (Volumes I and II). Pune Vidyarthi Griha Prakashan.
4. Bhavikatti, S. S. Surveying and Levelling (Volumes I and II). I.K. International Publishing House.

Reference Books:

1. Schofield, W., & Breach, M. Engineering Surveying (6th Edition). CRC Press.
2. Ghilani, C. D., & Wolf, P. R. Elementary Surveying: An Introduction to Geomatics (15th Edition). Pearson.
3. Burrough, P. A., McDonnell, R., & Lloyd, C. D. Principles of Geographical Information Systems (3rd Edition). Oxford University Press.
4. Lillesand, T., Kiefer, R. W., & Chipman, J. Remote Sensing and Image Interpretation (7th Edition). Wiley.
5. Shan, J., & Toth, C. K. Topographic Laser Ranging and Scanning: Principles and Processing (2nd Edition). CRC Press.
6. IS Codes – IS 1024 (Chain Surveying), IS 1760 (Total Station), Survey of India publications.

Web links and e-Resources:

Web links and Video Lectures (e-Resources):

- NPTEL courses on Surveying (IIT Roorkee, IIT Kharagpur) – chain, compass, leveling, theodolite, total station.
- NPTEL courses on Geometrics Engineering and Remote Sensing and GIS (IIT Roorkee, IIT Bombay).
- NPTEL course on Principles and Applications of Building Information Models (BIM) – integration with geospatial data.
- Esri Training – Free GIS courses and tutorials: https://www.esri.com/training
- QGIS Tutorials and Tips: https://www.qgistutorials.com
- YouTube channels: The Engineering Surveyor, Surveying & Levelling (educational content on modern surveying).
- Survey of India – Maps, publications, and surveying standards: https://www.surveyofindia.gov.in
- NASA Earth Observing System – Satellite data and remote sensing resources: https://earthdata.nasa.gov/
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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
- Site Visit
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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.**

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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.	Surveying Fieldwork Mini-Project: Conduct field surveying for a selected infrastructure site (road corridor, campus, or land parcel) using leveling, traversing, and total station/GNSS. Prepare contour maps, profiles, and digital terrain models along with field notes and error analysis.	24
2.	Geospatial Case Study Portfolio: Analyze case studies of infrastructure projects (highways, railways, urban development) focusing on applications of GIS, remote sensing, and drone surveying. Evaluate data acquisition methods, accuracy, challenges, and decision-making outcomes; present findings through a seminar..	24
3.	Survey Data Processing and Mapping Workbook: Develop a computational workbook (Excel/GIS/CAD tools) for processing survey data, coordinate transformation, area and volume estimation, route alignment, and integration with GIS platforms for infrastructure planning.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	Study online modules on modern surveying techniques (Total Station, GNSS, remote sensing fundamentals) through platforms like NPTEL/Coursera.	24
2.	Explore geospatial standards, mapping techniques, and applications using GIS platforms through webinars and tutorials from organizations like ISRO and Open Geospatial Consortium...	24
3.	Complete self-paced tutorials on GIS and mapping software such as QGIS and ArcGIS, including spatial analysis, map creation, and infrastructure data visualization.	24

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

1. Field Surveying Project / GIS Analysis – Rubric

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Field data collection And procedure (CO1, CO2, CO3)	Systematic field observations with proper instrument setup and usage; Complete measurements recorded with stations, bearings, distances, and elevations; field book maintained professionally; safety protocols Followed.	Field work mostly systematic; minor Procedural gaps or incomplete recordings; Generally proper Instrument use.	Unsystematic field work; significant data gaps or errors in measurements; improper instrument handling	20%

Calculations And data processing (CO2, CO3, CO4)	All computations accurate (traverse closure, angular/linear disclosure, coordinates, reduced levels, GIS operations); proper formulas used; calculations clearly presented with units and significant figures.	Calculations mostly correct with minor arithmetic errors; formulas generally appropriate adequate presentation	Significant calculation errors; wrong formulas or methods; poor presentation or missing units	30%
Plotting And visualization (CO2, CO4)	Accurate plotting to scale; proper symbology and legends; neat, professional maps/drawings; contours/traverse correctly represented; GIS maps well-designed with appropriate layers and labeling	Generally accurate plots; minor scaling or symbology issues; acceptable map quality with some labeling gaps.	Significant plotting errors; poor scale selection; unprofessional appearance; inadequate legends or missing features.	20%
Technical interpretation and analysis (CO4, CO5, CO6)	Insightful engineering interpretation of results (alignment suitability, slope analysis, spatial relationships); error sources identified and discussed; practical applications to Infrastructure clearly articulated.	Basic interpretation provided; some discussion of results and applications; error analysis partially addressed.	Minimal or no interpretation; results presented without engineering context; no error discussion	20%
Report quality and documentation (CO6)	Comprehensive report with introduction, methodology, observations, calculations, results, maps, discussion, conclusions; professional formatting; explicit SDG 9/11 linkage for sustainable infrastructure.	Report generally complete; minor sections weak; acceptable formatting; brief SDG mention.	Incomplete report; missing key sections (methodology, results, conclusions); poor formatting; no SDG linkage.	10%

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:

i. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
ii. 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.
iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Water Supply and Sanitary Engineering			
Course Code	1BIF402	Scheme	2025
Type of 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 (42:0:28:64)	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:

1. **CO1 (L2 – Understand):** Explain water demand estimation, sources, quality parameters and basic planning considerations for water supply schemes in urban and rural contexts.
2. **CO2 (L3 – Apply):** Apply principles of water treatment unit operations (sedimentation, filtration, disinfection) and design simple treatment units for potable water production.
3. **CO3 (L4 – Analyze):** Analyse water distribution networks using pipe flow principles, Hardy–Cross method and software tools (EPANET), and evaluate pressure adequacy and losses.
4. **CO4 (L3 – Apply):** Apply sanitary engineering principles to design house drainage, sewerage systems and simple sewage pumping and conveyance facilities.
5. **CO5 (L4 – Analyze):** Analyse wastewater treatment processes (primary, secondary and tertiary) and their role in environmental protection and public health.
6. **CO6 (L5 – Evaluate):** Evaluate sustainability, resilience and climate adaptation aspects in water supply and sanitation systems with reference to SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities) and SDG 13 (Climate Action)

Module-1

Water Demand, Sources and Quality

Water Demand Estimation

- Population forecasting methods – arithmetic increase, geometric increase, incremental increase and logistic curve (simple numericals).
- Types of water demand – domestic, commercial, industrial, institutional, public uses and fire demand; factors affecting per capita demand.
- Design period, average daily demand, maximum daily demand and peak hourly demand; empirical formulae and typical values.

Sources of Water Supply

- Surface water sources – rivers, lakes, reservoirs; advantages, limitations and suitability.
- Groundwater sources – wells, tube wells, infiltration galleries; aquifer types, safe yield concept.
- Rainwater harvesting – methods, storage and integration into urban water supply (qualitative).

Water Quality and Standards

- Physical parameters – turbidity, colour, taste and odour; measurement and significance.
- Chemical parameters – pH, hardness, alkalinity, chlorides, fluorides, nitrates and dissolved oxygen; permissible limits as per BIS/WHO standards.
- Water quality for different uses – drinking, domestic, industrial and construction.

CO linkage: CO1, partial CO6 Number of Hours: 9 Hrs

Module-2

Water Treatment: Unit Operations and Processes

Introduction to Water Treatment

- Treatment philosophy – barriers to contamination, multi-barrier approach, fit-for-purpose water.
- Overview of treatment train – screening, aeration, sedimentation, coagulation/flocculation, filtration, disinfection.
- Unit operations vs unit processes.

Plain Sedimentation

- Principles of sedimentation – types of settling (discrete, flocculent, hindered, compression).
- Design of plain sedimentation tanks – detention period, overflow rate, inlet and outlet arrangements; simple numericals.

Coagulation and Flocculation

- Coagulants – alum, ferric chloride, polyelectrolytes; mechanism of coagulation.
- Jar test – determination of optimum coagulant dose.
- Flocculation – mixing, flocculator design concepts (qualitative).

Filtration

- Slow sand filters – construction, working, maintenance, advantages and limitations.
- Rapid gravity filters – media specifications, filter runs, backwashing, head loss considerations;
- Pressure filters and multi-media filters (overview).

Disinfection

- Methods of disinfection – chlorination, ozonation, UV irradiation (qualitative comparison).
- Chlorination – breakpoint chlorination, chlorine demand, residual chlorine; dosage calculations.
- Storage and handling of chlorine; safety considerations.

Linked COs: CO2, partial CO6 Number of Hours: 9 Hrs

Module-3

Water Distribution Systems and Network Analysis

Water Distribution System Layout

- Types of distribution systems – gravity, pumping and combined systems.
- Layout patterns – tree/branch, grid-iron, ring/loop and radial systems; comparative advantages.
- Service reservoirs – location, capacity determination (balancing and fire storage).

Pipe Materials and Appurtenances

- Pipe materials – CI, DI, HDPE, PVC, GI; selection criteria.
- Valves – gate, sluice, non-return, air and scour valves; hydrants and service connections.

Hydraulic Analysis of Distribution Networks

- Pipe flow fundamentals – Hazen-Williams and Darcy-Weisbach equations; head loss calculations.
- Pipes in series and parallel – equivalent pipe concept.
- Looped network analysis – Hardy-Cross method (iterative procedure for simple networks); nodal and loop formulation.

CO linkage: CO3, partial CO6 Number of Hours: 8 Hrs

Module-4

Sanitary Engineering: House Drainage and Sewerage

House Drainage and Plumbing

- Objectives and principles of house drainage; sanitary fixtures and traps – water seal, types of traps.
- Inspection chambers and septic tanks – construction, working and maintenance (qualitative).

Sewerage Systems

- Definitions – sewage, sullage, storm water; characteristics of sewage (physical, chemical and biological).
- Systems of sewerage – separate, combined and partially separate systems; suitability and comparison.
- Estimation of sewage flow – domestic, commercial, industrial and infiltration contributions; design flow calculations.

Sewer Design

- Hydraulic design of sewers – Manning's formula for gravity sewers; minimum and maximum velocities; self-cleansing velocity concept.
- Design procedure for sanitary sewers – discharge, diameter, slope and velocity determination; worked examples.
- Sewer appurtenances – manholes, drop manholes, inverted siphons, catch basins, flushing tanks

and grease traps (qualitative).

Sewage Pumping and Conveyance

- Necessity of pumping stations; types, layout and capacity estimation (awareness level).
- Force mains and rising mains – design considerations.

CO linkage: CO4, partial CO6 Number of Hours: 8 Hrs

Module-5

Wastewater Treatment and Sustainable Sanitation

Introduction to Wastewater Treatment

- Objectives of wastewater treatment; BOD, COD, suspended solids and nutrients – significance and permissible discharge limits.
- Treatment stages – preliminary, primary, secondary and tertiary.

Preliminary and Primary Treatment

- Screening – bar screens, comminutors, grit chambers (types and design considerations).
- Primary sedimentation tanks – design parameters, detention period, surface overflow rate; scum and sludge removal.

Secondary (Biological) Treatment

- Principles of biological treatment – aerobic and anaerobic processes.
- Activated sludge process (ASP) – process description, aeration tank, return sludge, excess sludge; BOD removal efficiency (qualitative).
- Trickling filters – construction, working, dosing and recirculation (overview).
- Oxidation ponds and waste stabilisation ponds (awareness level).

Tertiary Treatment and Disinfection

- Nutrient removal – nitrogen and phosphorus removal processes (qualitative).
- Disinfection of treated effluent – chlorination and UV methods.

Sludge Treatment and Disposal

- Sludge characteristics, thickening, digestion (aerobic and anaerobic), dewatering and drying.

Sustainable and Climate-Resilient Sanitation

- Decentralised wastewater treatment systems – community-scale and household treatment.
- Nature-based solutions – constructed wetlands, phytoremediation.
- Water reuse and resource recovery – nutrient recovery, biogas generation, circular economy principles.
- Climate adaptation in sanitation – flood-resilient systems, drought management, linkage to SDG 6, SDG 11 and SDG 13.

CO linkage: CO5, CO6 Number of Hours: 8 Hrs

PRACTICAL COMPONENTS OF IPCC

PART – A: FIXED SET OF EXPERIMENTS

1. Determination of pH Conductivity and Turbidity of water sample.
2. Determination of Acidity and Alkalinity.
3. Determination of hardness (Calcium, Magnesium and Total Hardness) of water sample by EDTA method.
4. Determination of chlorides, Available Chlorine and residual chlorine in water sample.
5. Jar test for determination of optimum coagulant dose for a given water sample.
6. Determination of Solids in Sewage: i) Total Solids, ii) Suspended Solids, iii) Dissolved Solids, iv)
7. Volatile Solids, Fixed Solids v) Settleable Solids.
8. Determination of DO and BOD and COD of a given wastewater sample.
9. Determination of COD of a given wastewater sample (demonstration).
10. Determination of Sulphates, Nitrates and Iron by spectrophotometer.

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. Concept 1: Mapping a small building/campus water distribution system, estimating head losses and commenting on pressure adequacy and possible energy savings (SDG 6, SDG 11).
2. Concept 2: Comparative analysis of water quality from different sources (groundwater, surface water, rainwater) and suggesting appropriate treatment train.
3. Concept 3: Design and testing of a small-scale slow sand filter or household filter model – performance evaluation and sustainability discussion.
4. Concept 4: Spreadsheet or EPANET-based design of a simple looped water distribution network

for a residential colony – optimisation for pressure and losses.

5. Concept 5: Case study on wastewater reuse potential – grey water recycling in buildings or treated wastewater for irrigation; environmental and health risk assessment (qualitative).
6. Concept 6: Small case study on climate-resilient water supply or sanitation – drought management strategies, flood-proofing of treatment plants, or decentralised systems (SDG 13).

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

Text books:

1. Birdie, G. S., Birdie, J. S. Water Supply and Sanitary Engineering. Dhanpat Rai Publishing.
2. Punmia, B. C., Jain, A. K., Jain, A. K. Water Supply Engineering. Laxmi Publications.
3. Garg, S. K. Water Supply Engineering. Khanna Publishers.
4. Metcalf & Eddy. Wastewater Engineering: Treatment and Resource Recovery. McGraw-Hill.

Reference books / Manuals:

1. Modi, P. N. Water Supply Engineering. Standard Book House.
2. Srinivasa Raghavan, Gupta, Environmental Engineering (Vol. I & II). PHI Learning.
3. BIS Standards – IS 10500 (Drinking Water), IS 456 (Water for Construction), CPHEEO Manual on Water Supply and Treatment.
4. WHO Guidelines for Drinking-water Quality.

Web links and Video Lectures (e-Resources):

1. NPTEL / SWAYAM courses on Water Supply Engineering, Environmental Engineering and Sanitary Engineering (IITs and NITs).
2. MOOCs on water and wastewater treatment (Coursera, edX).
3. EPANET software tutorials and user manual (EPA, USA).
4. CPHEEO (Central Public Health and Environmental Engineering Organisation) manuals and guidelines.
5. Manufacturer websites for pumps, filters, chlorinators and treatment equipment.

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.**

Students' activities for TW/SL under NCrF: Samples only: As per National credit farmwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/ Selfe learning (TW/Sl-50 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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.	Integrated Design Mini-Project: Design a small water supply scheme (source to distribution) or a sanitary system (house drainage to STP) covering demand estimation, treatment unit sizing, network/sewer layout and sustainability considerations.	25
2.	Programming & Tools Workbook: Build an Excel/MATLAB/Python/EPANET workbook for water and sanitation engineering problems – water demand forecasting, treatment unit design (sedimentation, filter), Hardy-Cross network analysis, sewer design and BOD removal calculations.	25

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	**MOOC +GATE/Open- Book Track.:** Complete selected FM MOOC modules and GATE-style tests, plus at least one integrated open-book exam on conceptual/design problems.	25
2.	**Case Study & Literature Portfolio**: Prepare 3–4 case briefs on real water supply/sanitation projects or failures (e.g., Chennai water crisis, Bengaluru STP performance, NRW reduction case studies)	25

Performance Indicator	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Problem understanding & SDG/NEP link (CO1, CO6)	Clear statement of system, objectives, constraints, and explicit linkage to SDGs and NEP values.	Mostly clear; SDG/NEP link mentioned but not deep.	Basic description; weak SDG/NEP connection.	Vague or incorrect description; no SDG/NEP link.
Use of fluid-mechanics concepts & calculations (CO2–CO4)	Correct methods; appropriate assumptions; consistent units and checks.	Minor errors; overall reasonable application.	Several errors; partial application of concepts.	Major conceptual errors; little use of theory.
Sustainability / resilience analysis (CO6)	Insightful discussion of options and their sustainability/resilience; clear recommendations.	Some discussion with reasonable recommendations.	Limited or generic sustainability remarks.	No meaningful sustainability analysis.

Communication & teamwork (CO6)	Well-structured report/presentation; clear visuals; evidence of balanced participation.	Generally clear; some imbalance/minor issues.	Understandable but poorly structured or dominated by few.	Disorganized; weak teamwork evidence.

Rubric: Integrated Water Supply or Sanitation Design Mini-Project (Sample)

Criterion	**Exemplary (3)**	**Proficient (2)**	**Basic (1)**	**Weight**
Problem definition and scope	Clear objective, realistic water supply/sanitation system, complete data (population, demand, source/site) and assumptions documented; all five modules scoped.	Objective mostly clear; minor gaps in data or assumptions; most modules covered.	Vague problem; key data or assumptions missing or inconsistent; weak linkage across modules.	10%
Demand estimation / flow calculations (M1, M4)	Accurate population forecasting, per capita demand and design flows calculated with clear justification and correct use of formulae.	Generally, correct with minor calculation errors; method appropriate.	Frequent errors in demand estimation or flow calculations; method unclear or incorrect.	15%
Treatment design (M2, M5)	Correct sizing of treatment units (sedimentation tank, filter, etc.) or STP components; design parameters justified with standards; calculations clear and complete.	Mostly correct design with minor parameter gaps; some justification provided.	Incomplete or incorrect design; major parameter gaps; weak justification.	25%
Network/sewer design (M3, M4)	Accurate pipe sizing, head loss calculations, Hardy-Cross analysis or EPANET simulation for water network; or correct sewer design with Manning's formula; layout logical and well-documented.	Generally correct approach with minor errors in pipe sizing or head loss; layout acceptable.	Frequent errors in hydraulic calculations; layout unclear or illogical.	25%
Sustainability and SDG linkage (M1–M5, CO6)	Clear discussion of water conservation, energy efficiency, climate resilience, NRW reduction, wastewater reuse or nature-based solutions; explicit SDG 6, 11, 13 links.	Some discussion of sustainability or climate aspects; SDG links implied or brief.	Little or no discussion of sustainability beyond basic technical design.	15%
Use of tools and software	Appropriate selection and correct use of EPANET, Excel or other tools; results cross-checked with hand calculations; neat diagrams and plots.	Tools used with minor setup/interpretation issues; diagrams acceptable.	Minimal or incorrect use of tools; no meaningful comparison with hand calculations; poor or missing diagrams.	10%

Suggested rubrics 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. (7-8)	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)

Note: Can add Engineering & IT tool usage based on the nature of the course

Continuous Internal Evaluation (CIE)
(i)Theory component
The CIE marks of 25 shall be earmarked for two tests.
The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.
Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.
(ii) Laboratory component
Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.
The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

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

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).

Structural Analysis of R.C. Elements			
Course Code	1BIF403	Scheme	2025
Type of Course	Profession Core Course (PCC)	Semester	IV
Teaching Hours/Week (L:T:P)	56(3:1:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW:	120 (56:0:0:64)	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:

1. CO1 (L2 – Understand): Explain basic concepts of structural systems, loads, determinacy, stability and deformation.
2. CO2 (L3 – Apply): Analyse statically determinate beams, trusses and frames for support reactions, internal forces and influence lines.
3. CO3 (L3 – Apply): Determine slopes and deflections of determinate beams and frames using classical methods.
4. CO4 (L4 – Analyze): Evaluate indeterminacy and analyse simple indeterminate structures by force and displacement methods (introductory level).
5. CO5 (L3 – Apply): Apply energy principles and influence line concepts to obtain structural response under moving loads.

Module-1

Introduction and determinate beams

- Types of structures and loads; idealisation, load paths, internal forces.
- Static equilibrium; support conditions; shear force and bending moment diagrams for determinate beams and cantilevers.
- Concept of determinacy and stability, degree of freedom, static and kinematic indeterminacy (qualitative).

Linked COs: CO1, partial CO2, CO6. **Number of Hours Required (CI)**: **11 hours**

Module-2

Trusses and plane frames

- Analysis of determinate plane trusses: method of joints and method of sections; qualitative discussion of space trusses.
- Analysis of determinate plane frames (sway and non-sway) for member forces and reactions.
- Concept of internal and external redundancy in trusses and frames (awareness).

Linked COs: CO2, CO5. **Number of Hours Required (CI)**: **11 hours**

Module-3

Deflection of beams and frames

- Differential equation of elastic curve (concept only); relationship between load, shear, moment and slope/deflection.
- Double integration method, Macaulay's method for slopes and deflections of determinate beams.
- Moment–area theorems and conjugate beam method; simple applications to beams and single-bay frames.

Linked COs: CO3, CO4. **Number of Hours Required (CI)**: **11 hours**

Module-4

Introduction to indeterminate analysis

- Revision of static indeterminacy; classification of force and displacement methods.
- Force method (method of consistent deformations) for simple propped cantilevers, fixed beams and one-redundant trusses (numericals limited to 1–2 redundants).
- Displacement methods – slope–deflection and moment distribution concepts; analysis of single-bay, single-storey portal frames (no side sway or simple sway).

Linked COs: CO1, CO4, CO6. **Number of Hours Required (CI)**: **11 hours**

Module-5

Influence lines and moving loads, synthesis

- Influence line diagrams for reactions, shear and bending moment in determinate beams using direct and Muller–Breslau principle.
- Qualitative discussion of moving loads on simply supported beams; concept of maximum shear and moment envelopes; basic railway/highway bridge examples.
- Brief overview of arches and cables as funicular systems, with focus on structural behaviour and sustainable long-span infrastructure (qualitative).

Linked COs: CO2, CO5, CO6. **Number of Hours Required (CI)**: **11 hours**

Suggested learning resources

Text books

1. C.S. Reddy, Basic Structural Analysis, Tata McGraw Hill.
2. R.C. Hibbeler, Structural Analysis, Pearson.
3. Norris, Wilbur and Utku, Elementary Structural Analysis, McGraw Hill.
4. D.S. Prakash Rao, Structural Analysis: A Unified Approach, Universities Press.
5. A.P. Thandavamoorthy, Analysis of Structures, Oxford University Press.

Reference Books

1. S S Bhavikatti, structural analysis, vikas publishing house pvt.ltd., new Delhi
2. S Ramamrutham and R Narayanan, Theory of structures, Dhanpat Rai Publishing Company.
3. K.U. Muthu and H. Narendra, "Indeterminate Structural Analysis", IK International Publishing Pvt. Ltd.
4. Gupta S P, G S Pundit and R Gupta, "Theory of Structures", Vol II, Tata McGraw Hill Publications company Ltd.

e-Resources / Video lectures:

1. NPTEL: Structural Analysis I & II (IITs).
2. IIT Madras CE2020 Structural Analysis online resources.

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
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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.**

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity

Use of MOOCs and Online Platforms

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

As per National Credit Framework (NCrF), students must spend 120 hours of study for this 4 credit course, which includes Course Instructions (CI-52 hours) and Teamwork/Self Learning (TW/SL-52 hours). Hence, students must complete two activities as part of NCrF as part of CCA, which carries 25 marks. The evaluations of these activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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.	**Structural Behaviour Portfolio**-Document local structural elements like beams, trusses, frames and small bridges with photos, sketches of FBDs/SFDs/BMDs, and short notes on load paths, determinacy and observed deflections/cracking.	32
2.	**Small Bridge / Roof Truss Case Study** -Idealise a simple pedestrian bridge or roof truss from field photos/drawings; compute reactions, member forces, deflections under given loads; discuss critical sections and serviceability using classical methods.	32

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	**MOOC + GATE/Data- Driven Track**: Complete mapped NPTEL/MOOC modules, solve GATE-style and open-ended analysis problems involving probability and statistics in civil engineering, culminating in an integrated open-book test.	32
2.	Literature review on emerging tools; reflective learning journal	32

Rubric for Term-Work / Self-Learning (TW/SL)

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Conceptual understanding	Demonstrates clear, accurate grasp of structural-analysis concepts; correctly explains assumptions, sign conventions, and theory behind methods. [4][5]	Shows generally correct understanding; minor errors in assumptions or sign conventions.	Basic understanding shown but frequent conceptual errors or incomplete explanations.	Significant misconceptions; largely unable to relate theory to examples.
Problem-solving approach	Uses an efficient, logically structured method; chooses appropriate techniques (slope-deflection, moment-distribution, force method, etc.) and clearly states steps. [6][5]	Uses a sound method; minor gaps in logic or choice of technique.	Follows a method but with weak or inconsistent procedure; some correct steps.	Lacks a coherent approach; steps are arbitrary or skipped.
Mathematical accuracy & calculations	Computations are accurate; line-load, moment-area, equilibrium, and compatibility equations are correctly applied. [6][7]	Minor calculation errors; results are mostly correct.	Several calculation errors; results are partially correct.	Major calculation errors; final answers are largely incorrect.

Diagrams & sketches (FBD, BMD, SFD, etc.)	All diagrams are neat, properly scaled, labeled, and clearly depict free-body diagrams, deflected shapes, and internal-force diagrams. [6][7]	Diagrams are clear but may lack some labels or minor scaling issues.	Diagrams are present but untidy or poorly labeled.	Diagrams missing or grossly incorrect.
Documentation & reporting (TW/Portfolio)	Solutions are well-organized, with clear headings, labeled steps, and appropriate use of units and notation. [8][3]	Neatly presented; minor omissions in formatting.	Basic presentation; some parts are disorganized.	Poorly organized; difficult to follow.
Self-learning (SL) component	Independently explores additional resources, compares methods, and reflects on learning outcomes in a short note or log. [4][9]	Shows some independent exploration; brief reflection.	Minimal evidence of self-study; reports mainly classroom content.	Almost no self-learning activity evident.
Timeliness & completeness	All TW/SL assignments submitted on time; all required problems and tasks completed. [8][3]	Mostly on time; only minor tasks missing.	Frequently delayed; several tasks incomplete.	Repeatedly late or largely incomplete.

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:

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

ii. 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.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

Building Information Modelling (BIM) for Infrastructure			
Course Code	1BIF404	Scheme	2025
Type of Course	Professional Core Course (PCC)	Semester	IV
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. **CO1 (L2 – Understand):** Explain BIM fundamentals, lifecycle phases, standards (ISO 19650, LOD), data exchange (IFC) and role of BIM in infrastructure project delivery.
2. **CO2 (L3 – Apply):** Apply BIM workflows for 3D parametric modelling of basic infrastructure elements using Civil 3D/Revit – terrain, alignments, corridors, utilities.
3. **CO3 (L4 – Analyze):** Analyse BIM models for clash detection, quantity takeoff, 4D scheduling and basic 5D cost estimation in road, bridge and pipeline projects.
4. **CO4 (L3 – Apply):** Create and manage BIM documentation, sheets, schedules and federated models for interdisciplinary coordination (civil, structural, MEP).
5. **CO5 (L2 – Understand):** Describe BIM applications in infrastructure operations – asset management, GIS integration, digital twins and sustainability analysis.
6. **CO6 (L4 – Analyze/Evaluate):** Evaluate BIM implementation benefits, challenges, Level of Development (LOD), data security and alignment with Industry 5.0, SDG 9 and SDG 11.

Module-1

BIM Fundamentals and Infrastructure Context

Introduction to BIM

- Definition, evolution (from CAD to BIM), dimensions (3D, 4D, 5D, 6D, 7D, 8D); BIM vs traditional methods.
- BIM lifecycle – planning, design, construction, operations, decommissioning; roles (owner, designer, contractor, FM).
- Standards – ISO 19650 (information management), CIC BIM standards (India), LOD (Level of Development) 100–500; open standards (IFC, COBie).

BIM for Infrastructure

- Infrastructure BIM vs building BIM; challenges (linear assets, terrain, large scale); benefits – clash-free design, accurate quantities, constructability.
- Common software ecosystem – Autodesk Civil 3D (terrain, roads), Revit (structures/utilities), Navisworks (clash/4D), InfraWorks (conceptual), Dynamo (automation).
- Case studies – BIM in Indian infrastructure (Bharatmala, Smart Cities Mission, metro projects).

Linked COs: CO1, partial CO6 **Number of Hours (CI): 8 hrs.**

Module-2

BIM Modelling for Terrain, Roads and Utilities

Terrain Modelling

- Import survey data (points, contours); create digital terrain models (DTM) – TIN, grid surfaces.
- Surface analysis – volumes, cut/fill balance, slope analysis; labelling and styling.

Road Corridor Modelling (Civil 3D)

- Horizontal alignment – design criteria, curves, spirals; vertical profile, intersections.
- Corridor assembly – typical cross-sections (lanes, shoulders, kerbs, swales); subassemblies.
- Earthwork calculations, grading objects; superelevation and widening.

Utility Networks

- Gravity networks (sewers, stormwater) – pipes, structures, profiles, inverts.
- Pressure networks (water supply) – fittings, appurtenances, interference checks.
- Hands-on: Create simple road corridor with utilities from survey data.

Linked COs: CO2 **Number of Hours (CI): 8 hrs**

Module-3

BIM for Bridges, Structures and Clash Detection

Bridge Modelling

- Superstructure (girders, deck slabs); substructure (piers, abutments, foundations).
- Pre-stressed concrete girders, bearings, expansion joints; parametric families.
- Integration with road corridors – approach roads, ramps.

Structural and Site Elements

- Retaining walls, culverts, drainage structures; site furnishings (signage, railings).
- Reinforcement detailing in Revit/Civil 3D; analytical model generation.

Clash Detection and Model Review

- Navisworks workflow – model federation (NWC/NWD files), clash detective rulesets.
- Issue resolution – tolerance settings, prioritisation; 3D walkthroughs and sectioning.

Linked COs: CO3 **Number of Hours (CI): 8 hrs.**

Module-4

BIM Documentation, 4D/5D and Collaboration

BIM Documentation

- Views, sheets, annotations, title blocks, legends; construction drawings from model.
- Schedules – material takeoffs, BOQs, reinforcement summaries; dynamic updating.

4D (Time) and 5D (Cost)

- Construction sequencing – linking elements to schedule (Primavera/MS Project).
- 4D simulation, look-ahead planning; 5D quantity takeoff, cost estimation from model properties.

Collaboration and CDE

- Common Data Environment (CDE) – BIM 360/ACC; model sharing, version control.
- Interdisciplinary coordination – civil-structural-MEP clash resolution workflows.

Linked COs: CO4 **Number of Hours (CI): 8 hrs.**

Module-5

BIM in Operations, GIS Integration and Sustainability

BIM for Operations and Asset Management

- As-built models, handover (COBie); facility management – asset tagging, maintenance scheduling.
- Digital twins – IoT integration, predictive maintenance for infrastructure assets.

GIS and Geospatial Integration

- BIM-GIS interoperability (CityGML, IFC to GIS); urban planning, smart cities.
- Corridor studies, land use impact, flood/traffic analysis.

Sustainability and Advanced BIM

- 6D energy analysis, carbon footprint; material optimisation, lifecycle assessment.
- BIM challenges – data interoperability, training, legal issues; Industry 5.0 (AI/ML automation).
- Indian context – MoRTH BIM guidelines, RERA compliance, SDG 9/11 alignment.

Linked COs: CO5, CO6 **Number of Hours (CI): 10 hrs..**

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

Text books:

1. Eastman, C. et al. BIM Handbook: A Guide to Building Information Modeling. Wiley.
2. Succar, B. Building Information Modelling: Framework, Process and Roadmap. Routledge.

Reference Books:

1. Autodesk Official Guides – Civil 3D, Revit for Infrastructure, Navisworks.
2. CPWD BIM Manual, MoRTH Guidelines on BIM for Roads.
3. ISO 19650 series – BIM Information Management.

Web links and Video Lectures (e-Resources):

1. Autodesk University / LearnCivil3D tutorials; NPTEL BIM courses (IIT Madras).
2. YouTube: Civil 3D road corridor, Navisworks clash detection playlists.

3. Bhuvan (ISRO) and Autodesk InfraWorks demos for GIS-BIM.

Teaching-Learning Process (Innovative Delivery Methods):

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

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

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:

Students' Learning activities: These activities shall be:

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below.

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.	Integrated Infrastructure BIM Mini-Project: Create BIM model of a 1 km rural road stretch – import survey points, generate DTM, design alignment/corridor, add utilities, perform cut/fill, generate BOQ and sheets; clash check with sample bridge.	24
2.	BIM Case Study Portfolio: Analyse 3–4 Indian infrastructure projects using BIM (e.g., Chenab Bridge, Delhi Metro); document workflows, benefits, challenges; prepare presentation.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Self-learning modules on NPTEL/SWAYAM; completion of online certification courses.	24
2.	Literature review on emerging technologies; reflective learning journal.	24

Rubrics for Students learning activities -TW/SL - (Samples)

1. Integrated Design Mini-Project – Rubric

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Project scope & BIM execution planning (CO1, CO2)	Clearly defines infrastructure element (bridge, road, utility network); develops comprehensive BIM Execution Plan with LOD specifications, roles, and software workflow; timeline realistic.	Defines project scope; BIM plan covers main aspects (LOD, software) but lacks detail in roles or timeline.	Vague scope; minimal or generic BIM planning; workflow unclear or missing.	20%
3D modeling accuracy & information richness (CO3, CO4)	Model geometrically accurate with appropriate LOD (200–350); includes correct parametric families/assemblies; embedded properties (materials, specifications, IDs) complete and consistent.	Model mostly accurate; minor geometric errors; some properties incomplete or generic families used.	Significant geometric errors; poor LOD; minimal or missing embedded information.	25%
Data integration & interoperability (CO5)	Successfully integrates multidisciplinary data (structural, MEP, geospatial); demonstrates IFC/other format exchange; clash detection performed and documented with resolutions.	Integrates basic multidisciplinary elements; file exchange attempted with minor issues; clash detection done but resolution partial.	Limited integration; poor interoperability; no meaningful clash detection or data coordination.	20%
Engineering analysis & decision support (CO2, CO6)	Uses BIM for quantity take-off, 4D scheduling simulation, or cost estimation; outputs support design decisions with clear justification and visualization.	Performs basic analysis (quantities or simple scheduling); outputs provided but limited interpretation or decision linkage.	Minimal or incorrect analysis; outputs not used for decision-making; mostly descriptive model only.	20%
Portfolio organization & presentation	Well-structured report/portfolio with workflow diagrams, annotated model views (plans, sections, 3D renders), clash reports, and references; clear documentation of BIM process and deliverables.	Generally organized; some views/reports present but labeling or clarity issues; minor documentation gaps.	Disorganized; poorly labeled views; missing key reports or process documentation; hard to follow.	15%

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).

Surveying and Geospatial Engineering Laboratory		Scheme	2025
Course Code	**1BIFL405**	Semester	IV
Teaching Hours/Week (L:T:P)	28 (0:0:2)	CIE Marks	50
Total Hours of Pedagogy CI(L:T):LI(P):SLTW	30 (0:0:2:2)	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:

1. **CO1 (L3 – Apply):** Perform chain surveying, compass surveying, and traversing to measure distances, bearings, and plot survey plans for infrastructure projects.
2. **CO2 (L3 – Apply):** Conduct leveling operations including differential leveling, pro le leveling, and cross-sectioning to establish vertical control and prepare contour maps.
3. **CO3 (L3 – Apply):** Operate theodolite and tachometric instruments to measure horizontal and vertical angles, perform traversing, and conduct rapid surveys for infrastructure site assessment.
4. **CO4 (L4 – Analyze):** Utilize Total Station and GNSS/GPS receivers for precise coordinate measurements, control network establishment, and data processing for modern surveying applications.
5. **CO5 (L4 – Analyze):** Apply GIS software for spatial data entry, dereferencing, spatial analysis, and map preparation; interpret remote sensing imagery for infrastructure planning.
6. **CO6 (L5 – Evaluate**): Evaluate field survey data quality, error sources, and accuracy requirements; relate geospatial techniques to sustainable infrastructure development aligned with SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities).

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. 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.
4. 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.
5. For continuous internal evaluation, during the semester, classwork, the typical open-ended questions shall be from PART-B, and any other similar questions to enhance the skill of the students.

PART – A (LI =20 hours)
FIXED SET OF EXPERIMENTS

1. Use of Various types of tapes, Laser distance meter, Distance measuring wheel.
2. Differential levelling by Dumpy level by plane of collimation method
3. Measurement of horizontal and vertical angles by Theodolite. Method of repetition
4. Setting out simple curve using Rankine's method using Theodolite
5. Setting out central line of a small residential building.
6. Setting up of Total station. Features and components of Total station
7. Measurement of Distance, slope, vertical distance, horizontal and vertical angles using Total station
8. Coordinate measurement with Total station
9. Longitudinal sectioning and cross sectioning using Total station.
10. Contouring and plotting with Total station

PART – B (LI = 8 hours) 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. Comprehensive Topographic Survey of Campus/Site
2. Highway/Road Alignment Survey – Setting Out Curves
3. GIS-Based Infrastructure Mapping Project
4. Geospatial Data Integration for Smart Infrastructure.
5. UAV/Drone Photogrammetry for Site Documentation (Demonstration/Simulation)
6. Geospatial Data Integration for Smart Infrastructure.

Suggested Learning Resources:

Text books:

1. Punima, B. C., Jain, A. K., & Jain, A. K. Surveying (Volumes I, II, and III) (17th Edition). Laxmi Publications.
2. Duggal, S. K. Surveying (Volumes I and II). Tata McGraw-Hill.
3. Kanetkar, T. P., & Kulkarni, S. V. Surveying and Levelling (Volumes I and II). Pune Vidyarthi Griha Prakashan.
4. Basak, N. N. Surveying and Levelling (3rd Edition). Tata McGraw- Hill.

Reference books / Manuals:

1. Scho eld, W., & Breach, M. Engineering Surveying (6th Edition). CRC Press.
2. Ghilani, C. D., & Wolf, P. R. Elementary Surveying: An Introduction to Geometrics (15th Edition). Pearson.
3. Burrough, P. A., McDonnell, R., & Lloyd, C. D. Principles of Geographical Information Systems (3rd Edition). Oxford University Press.
4. Lille sand, T., Kiefer, R. W., & Chipman, J. Remote Sensing and Image Interpretation (7th Edition). Wiley.
5. IS Codes – IS 1024 (Chain Surveying), IS 1760 (Total Station), Survey of India publications and manuals.

Web links and Video Lectures (e-Resources):

1. Web links and Video Lectures (e-Resources):
2. NPTEL courses on Surveying (IIT Roorkee, IIT Kharagpur) – chain, compass, leveling, theodolite, total station experiments.
3. NPTEL courses on Geomatics Engineering and Remote Sensing and GIS (IIT Roorkee, IIT Bombay).
4. Virtual Labs – Surveying Virtual Lab (IIT Kharagpur): https://vlab.co.in
5. Esri Training – Free GIS courses and tutorials: https://www.esri.com/training
6. QGIS Tutorials and Tips: https://www.qgistutorials.com
7. YouTube channels: The Engineering Surveyor, Civil Engineering Essentials (surveying practical demonstrations).
8. Survey of India – Maps, publications, and surveying standards: https://www.surveyo ndia.gov.in

NCrF – TWSL Activities for Lab (2 hours) -Any one Activity

- Watching and summarizing selected video tutorials on surveying eld procedures, Total Station operations, and GIS/remote sensing software.
- Self-paced practice: Solving numerical problems on traverse computation, leveling calculations, tachometric formulas, coordinate transformations.
- Preparation of digital portfolio: Compilation of all experiment results with eld sheets, calculations, plots, maps, and engineering interpretations.
- Short reflection note on applications of modern geospatial technologies in sustainable infrastructure development (SDG linkage).
- Case study analysis: Review of major infrastructure project (highway, metro, dam, smart city) utilizing advanced surveying and geospatial techniques; lessons learned report..

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.

Eligibility for SEE:

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.

A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**

Rubrics for CIE- Continuous Assessment for practical courses

Performance Indicator	CO/PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
P1: Regularity & Participation	CO1 / PO5 (Lab discipline & teamwork)	Always punctual, highly disciplined, actively participates and leads team during field/lab work	Regular and participates actively in field/lab activities.	Moderately regular, limited participation in tasks.	Irregular attendance, minimal involvement in activities.	Frequently absent or disruptive in field/lab sessions.
P2: Understanding Objectives & Setup	CO2 / PO2 (Problem analysis & instrument handling)	Demonstrates complete understanding of surveying/geospatial concepts; independently sets up instruments (e.g., total station, GPS) accurately.	Good understanding; sets up instruments with minor guidance.	Partial understanding; able to perform basic setup with support.	Limited understanding; struggles with instrument setup and objectives.	No understanding of objectives; incorrect or unsafe instrument handling.
P3: Execution & Results	CO3 / PO4 (Investigation & data accuracy)	Executes surveys flawlessly; collects precise data, performs accurate calculations, includes error analysis and interpretation	Executes procedures correctly; obtains mostly accurate results.	Partial execution; some errors in observation or calculations.	Major procedural errors; unreliable data/results.	Unable to perform survey or generate meaningful results.

P4: Record Writing & Data Presentation	CO4 / PO10 (Communication & documentation)	Field book and reports are neat, complete, well-structured with maps/plots, calculations, and insightful analysis beyond requirements.	Complete and neat records with required calculations and sketches/maps.	Basic record with some missing details or clarity issues.	Incomplete, poorly organized, or untidy records.	Not submitted, illegible, or lacks essential content.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
T1: Conceptual Understanding *(CO1 / PO1 – Engineering Knowledge)*	Demonstrates thorough understanding of surveying and geospatial concepts; answers all questions accurately with clarity.	Shows good understanding; answers most questions correctly.	Basic understanding; able to answer some questions.	Limited understanding; answers are mostly incomplete or incorrect.	No understanding of fundamental concepts.
T2: Problem Solving & Calculations *(CO2 / PO2 – Problem Analysis)*	Accurately solves all numerical problems (e.g., leveling, traversing, coordinate computation) with correct procedures and results.	Solves most problems correctly with minor errors.	Partial solutions; noticeable calculation/procedural errors.	Attempts problems but with major mistakes.	Unable to solve problems or no meaningful attempt.
T3: Application of Techniques & Tools *(CO3 / PO5 – Modern Tool Usage)*	Effectively applies surveying methods and tools (e.g., total station, GPS, GIS concepts) in problem-solving.	Applies methods correctly with minor gaps.	Basic application; lacks depth in tool usage.	Struggles to apply appropriate methods/tools.	No application of techniques or tools.
T4: Data Interpretation & Analysis *(CO4 / PO4 – Investigation)*	Accurately interprets survey data, performs error analysis, and provides logical conclusions.	Good interpretation with minor gaps in analysis.	Basic interpretation; limited analytical depth.	Poor interpretation; incorrect conclusions.	No meaningful interpretation of data.

T5: Presentation & Clarity of Answers *(CO5 / PO10 – Communication)*	Answers are well-organized, clear, neat with proper diagrams, units, and steps.	Mostly clear and organized; minor issues in presentation.	Adequate presentation; lacks clarity in some parts.	Poorly organized, difficult to follow.	Illegible, disorganized, or not attempted.

Rubrics suggested for Practical continuous assessment

Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Regularity & Participation	Always punctual; highly active in field and lab work; shows leadership in team activities.	Regular and actively participates in most activities.	Occasionally irregular; participates when prompted.	Frequently irregular; minimal participation.
Understanding of Experiment / Survey Objective	Clearly understands objectives and procedures; independently plans and executes tasks.	Good understanding; requires minimal guidance.	Basic understanding; needs frequent support.	Limited understanding; unable to proceed without continuous help.
Instrument Handling & Setup	Accurately handles and sets up instruments (e.g., level, theodolite, total station, GPS) independently.	Handles instruments well with minor guidance.	Basic handling; errors in setup.	Improper handling; unable to set up correctly.
Execution & Data Collection	Conducts survey systematically; collects precise and reliable data.	Performs procedures correctly; data mostly accurate.	Partial execution; some errors in observations.	Poor execution; unreliable or insufficient data.
Calculations & Results	All calculations are correct; results are precise with proper units and checks.	Minor calculation errors; results mostly correct.	Some correct steps; noticeable errors in results.	Incorrect or incomplete calculations.
Record Writing / Field Book	Neat, complete, well-organized with sketches, tables, and analysis.	Complete with minor omissions; reasonably neat.	Basic record; lacks clarity or details.	Incomplete, untidy, or not submitted.

Bioremediation and Environmental Sustainability in Civil and Infrastructure Engineering			
Course Code:	1BIF407	Scheme	2025
Type of Course	Basic Science Course (BSC)	Semester	IV
Teaching Hours/Week (L:T:P)	28(2:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI(L/T): LI (P): SL&TW:	60(28:0:0:32)	SEE Marks	50
Credits	03	Total Marks	100
Examination type (SEE)	**Theory**	Exam Hours	03

Course outcome (Course Skill Set)

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

1. **CO1 (L2 – Understand):** Explain principles of bioremediation, microbial mechanisms and their applications in treating civil engineering contaminants (wastewater, soil, construction waste).
2. **CO2 (L3 – Apply):** Apply bioremediation techniques (in-situ, ex-situ, bioaugmentation) to design sustainable remediation strategies for contaminated sites and wastewater from infrastructure projects.
3. **CO3 (L4 – Analyze):** Analyse environmental impacts of infrastructure projects and evaluate sustainable mitigation measures integrating bioremediation and green infrastructure.
4. **CO4 (L2 – Understand):** Describe key sustainability concepts, LCA, circular economy and their integration into civil engineering design and construction.
5. **CO5 (L3 – Apply):** Apply SDG mapping to infrastructure projects, identifying alignments with SDG 6, 9, 11, 13 and proposing bioremediation-based solutions.
6. **CO6 (L5 – Evaluate):** Evaluate role of bioremediation and sustainability practices in resilient infrastructure, Industry 5.0 and long-term environmental stewardship

Module-1

Fundamentals of Bioremediation

Principles and Microbial Mechanisms

- Definition, types (natural attenuation, biostimulation, bioaugmentation); aerobic vs anaerobic processes.
- Microorganisms involved – bacteria (Pseudomonas, Bacillus), fungi, algae, consortia; enzymes and metabolic pathways.
- Contaminants treated – hydrocarbons, heavy metals (Cr, Pb, Cd), pesticides, PAHs, VOCs from construction/demolition waste.

Factors Affecting Bioremediation

- Environmental parameters – pH, temperature, moisture, nutrients (C:N:P ratio), oxygen availability.
- Site characteristics – soil type (clay vs sand permeability), groundwater flow, bioavailability of pollutants.

Linked COs: CO1 **Number of Hours (CI):6 hours**

Module-2

Bioremediation Techniques and Applications

In-Situ Techniques

- Bioventing, biosparging, permeable reactive barriers (PRB); phytoremediation (hyperaccumulators like Vetiver, Sunflower).
- Applications in civil engineering – contaminated sites from fuel spills at construction camps, leachate treatment.

Ex-Situ Techniques

- Biopiles, windrows, landfarming, slurry phase reactors; constructed wetlands for wastewater.
- Wastewater applications – constructed wetlands, biofilters for construction site runoff, sewage from labour camps.

Case Studies

- Bioremediation of oil-contaminated sites (Bhopal gas tragedy legacy), heavy metal remediation in industrial effluents, constructed wetlands in Indian Smart Cities.

Linked COs: CO2 **Number of Hours (CI):6 hours**

Module-3

Environmental Impact Assessment and Mitigation

EIA in Infrastructure Projects

- EIA process (screening, scoping, prediction, mitigation); infrastructure impacts – air, water, soil, noise, biodiversity.
- Construction phase impacts – dust, erosion, sedimentation; operational phase – emissions, wastewater.

Bioremediation-Based Mitigation

- Soil stabilisation using microbial induced calcite precipitation (MICP); biofilters for air pollution control.
- Green infrastructure – permeable pavements with bio-layers, vegetated swales, rain gardens for stormwater management.

Linked COs: CO3 **Number of Hours (CI):5 hours**

Module-4

Sustainability Principles in Civil Engineering

Sustainable Infrastructure Concepts

- Triple bottom line (people, planet, profit); lifecycle assessment (LCA) – cradle-to-grave analysis.
- Circular economy – reduce, reuse, recycle construction waste; low-carbon materials (fly ash concrete, geopolymers).

Green Building and Infrastructure

- GRIHA/IGBC ratings for infrastructure; LEED for roads/bridges; low-impact development (LID).
- Energy-efficient design – passive cooling, solar integration; water conservation in construction.

Linked COs: CO4 **Number of Hours (CI):6 hours**

Module-5

SDG Integration and Resilient Infrastructure

SDG Mapping to Civil Engineering

- SDG 6 (Clean Water) – bioremediation wetlands; SDG 9 (Industry/Innovation) – sustainable materials; SDG 11 (Cities) – green infrastructure; SDG 13 (Climate) – resilient design.

Bioremediation for Resilience

- Climate-resilient remediation – drought/flood tolerant microbial systems; post-disaster site recovery.
- Industry 5.0 integration – AI/ML for bioremediation monitoring, digital twins for sustainability tracking.

Future Directions

- Policy framework – India's National Bioremediation Programme, NEP 2020 green skills; challenges and opportunities.

Linked COs: CO5, CO6 **Number of Hours (CI):5 hours**

Suggested Learning Resources

Text books:

1. Vidali, M. Bioremediation: An Overview. Pure & Applied Chemistry.
2. Crawford, R. Sustainable Construction. Butterworth-Heinemann.

Reference Books / Manuals

1. Atlas, R. M. Bioremediation: Applied Microbial Solutions. ASM Press.
2. CPHEEO Manual on Water & Wastewater Treatment; MoEFCC EIA Notification.

UN SDG Guidelines for Infrastructure

Web links and Video Lectures (e-Resources):

1. 1. NPTEL courses on Environmental Biotechnology, Sustainable Engineering.
2. SWAYAM – Bioremediation & Waste Management.
3. TERI, CSE India reports on green infrastructure.

Teaching-Learning Process (Innovative Delivery Methods):

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

- **Flipped Classroom** – Pre-class videos/notes; in-class problem solving.
- **PBL** – Group work on real project scenarios using equipment planning.
- **Case-Based Teaching** – Analyze Indian and global project case studies.
- **Simulation / Virtual Labs** – Simple tools for equipment cycles and scheduling.
- **Industry Expert / Visits** – Expert talks and site/yard/plant visits or virtual tours.
- **ICT-Enabled Teaching** – LMS, NPTEL videos, spreadsheets, online quizzes.
- **Role Play** – Simulated contractor–client–supplier negotiation on equipment and costs.

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.**

Students' Learning activities: These activities shall be:

Course Project – Mini smart-city intervention plan for a selected area (problem, data, smart solution, basic feasibility).

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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

As per National credit farmwork (NCrF) students must spend 60 hours of study for 2 credit courses, which incl

Course instructions (CI- 28 hour) and Teamwork/ Selfe learning (TW/Sl-32 hours). Hence, students must comp

minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed fo

each activity. The following sample activities are listed below.

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 activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Integrated Bioremediation Site-Assessment Mini-Project: Design a bioremediation system for a contaminated site (e.g., fuel-spill campsite, C&D-waste leachate, or industrial effluent). Tasks include: conceptual site model (CSM), contaminant profile, soil-type and groundwater-flow analysis, selection of techniques (natural attenuation, biostimulation, bioaugmentation, in-situ/ex-situ methods), EIA-based mitigation measures, and SDG-linkage (SDG 6, 9, 11, 13).	16
2	SDG-Integrated Infrastructure Case-Study Portfolio: Select 3–4 Indian infrastructure projects (e.g., smart-city constructed-wetland, MICP-based foundation stabilisation, low-impact road project, or bioremediation-linked housing scheme). Document contamination/background, bioremediation/EIA measures, sustainability practices, and SDG-mapping; prepare a structured presentation or report.	16
3	Bioremediation / EIA Workbook: Digital workbook with exercises on contaminant identification (hydrocarbons, metals, PAHs, VOCs), microbial roles (bacteria, fungi, consortia), C:N:P ratio calculations, EIA-step checklists, and simple bioremediation-rate or mass-balance problems; includes mini-case lets on construction-camp, demolition-waste, and industrial-site scenarios.	16

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Self-learning modules on NPTEL/SWAYAM; completion of online certification courses.	16
2	Literature review on emerging technologies; reflective learning journal.	16

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

Integrated Design Mini-Project

1. Sample Rubrics -Integrated Design Mini-Project

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Site understanding & CSM (CO1)	Robust CSM with clear contaminant sources, pathways, receptors, and hydrogeology; soil type, permeability, and groundwater flow well-described.	CSM present but with minor gaps in hydrogeology or receptor identification; some uncertainty in pathways.	Very weak or generic CSM; key elements (receptors, flow, bioavailability) missing.	20%
Bioremediation strategy &	Appropriately selects and justifies in-situ/ex-situ	Techniques chosen with partial	Methods chosen mainly by rote; poor	25%

technique selection (CO1,CO2)	techniques (bioventing, landfarming, PRB, phytoremediation, MICP) with rationale for each; considers aerobic vs anaerobic, nutrients, and timescales.	justification; some mismatch between site conditions and selected method.	or illogical fit to site conditions; limited justification.	
Environmental & engineering analysis (CO2,CO3)	Performs simple mass-balance or rate-based calculations; links EIA impacts (air, water, soil, noise) to proposed mitigation; evaluates effectiveness and limitations of bioremediation.	Carries out basic calculations and identifies EIA impacts but with limited depth in evaluation or trade-off analysis.	Superficial analysis; mainly descriptive; no clear evaluation of technical or environmental trade-offs.	25%
SDG / sustainability linkage (CO4,CO5,CO6)	Explicitly maps design to SDG 6, 9, 11, 13; explains how bioremediation enhances resilience, circular-economy, and low-impact development; includes policy/implementation challenges.	Mentions selected SDGs and links to project, but connections are somewhat general or weakly argued.	Minimal or very superficial SDG/sustainability references; no clear policy or resilience angle.	15%
Portfolio organisation & presentation (CO6)	Well-structured report or digital portfolio with clear sections, labelled diagrams (site map, CSM, flowchart of bioremediation steps, EIA-mitigation hierarchy), and references; language clear and professional.	Generally organised; some figures missing labels or showing minor inconsistencies; minor issues with clarity.	Disorganised; photos/figures poorly labelled or missing; hard to follow logic or sequence.	15%

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:

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

ii. 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.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Highway and Traffic Engineering			
Course Code:	1BIF409	Scheme	2025
Type of Course	SDC	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	03	Total Marks	100
Examination type (SEE)	**Theory**	Exam Hours	03

Course outcome (Course Skill Set)

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

1. **CO1 (L2 -- Understand):** Explain highway planning, alignment principles, geometric design elements and cross-sectional features.
2. **CO2 (L3 – Apply):** Analyze highway geometric elements like sight distances, curves, gradients and evaluate their safety implications.
3. **CO3 (L4 – Analyze):** Design flexible and rigid pavements, highway drainage systems and select appropriate materials for highway.
4. **CO4 (L4 – Analyze):** Conduct and analyze traffic engineering studies including volume, speed, delay, parking and signal design.
5. **CO5 (L4 – Analyze):** Apply traffic safety measures, intersection design principles and road sign/marking standards.

Module-1

Highway Development & Alignment

- Scope and importance of highway engineering in transportation infrastructure.
- Jayakar Committee recommendations, road classification, road patterns.
- Factors affecting highway alignment, engineering surveys (conventional & modern methods).
- Highway cross-section elements: right of way, carriageway, shoulders, medians, kerbs.

Linked COs: CO1, partial CO5, CO6 **Number of Hours (CI):8 hours**

Module-2

Geometric Design Elements

- Factors affecting road geometrics, design speed, traffic, topography.
- Sight distances: stopping, overtaking (problems), intermediate.
- Horizontal alignment: extra widening, transition curves, super elevation (problems, no derivations).
- Vertical alignment: gradients, summit & valley curves (problems).

Linked COs: CO1, CO5, CO6 **Number of Hours (CI):8 hours**

Module-3

Highway Materials & Pavements

- Highway materials: aggregates (properties, tests), bitumen (properties, tests), soil subgrade.
- Pavement types: flexible vs rigid, components, functions, joints in rigid pavements.
- Stresses in pavements, design factors (IRC methods awareness).
- Highway drainage: surface & subsurface systems, cross-drainage structures (problems on longitudinal drains).

Linked COs: CO2, partial CO6 **Number of Hours (CI):8 hours**

Module-4

Traffic Studies & Safety

- Traffic engineering scope, road user & vehicle characteristics, PIEV theory.
- Traffic studies: volume, spot speed, speed-delay, O-D, parking, accidents (methods, analysis, problems).
- PCU concepts, factors, applications at different facilities.
- Road safety: accidents causes, prevention measures.

Linked COs: CO3, CO4 **Number of Hours (CI):9 hours**

Module-5

Traffic Control & Signals

- Traffic signs, markings, islands, channelization.
- Intersections: types, design principles.
- Signals: Webster method, IRC method (problems), cycle time, green time optimization.
- Traffic management: parking regulation, one-way streets, bus lanes.

Linked COs: CO3, CO4, CO6 **Number of Hours (CI):9 hours**

Suggested Learning Resources

Textbooks:

1. S.K. Khanna & C.E.G. Justo, "Highway Engineering", Nem Chand Bros.
2. L.R. Kadyali, "Traffic Engineering & Transport Planning", Khanna Publishers.
3. R. Srinivasan, "Highway Engineering", Charotar Publishing.

Reference Books:

1. IS code extracts on subsurface exploration and site investigation – awareness. Relevant IRC codes: IRC:37 (flexible pavement), IRC:58 (rigid), IRC:86 (geometric design).
2. S.K. Khanna, "Highway Engineering Lab Manual".

Web links and Video Lectures (e-Resources):

1. NPTEL: Highway Engineering, Traffic Engineering.
2. IRC website (irc.nic.in) for latest codes.

Teaching-Learning Process (Innovative Delivery Methods):

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

- **Flipped Classroom** – Pre-class videos/notes; in-class problem solving.
- **PBL** – Group work on real project scenarios using equipment planning.
- **Case-Based Teaching** – Analyze Indian and global project case studies.
- **Simulation / Virtual Labs** – Simple tools for equipment cycles and scheduling.
- **Industry Expert / Visits** – Expert talks and site/yard/plant visits or virtual tours.
- **ICT-Enabled Teaching** – LMS, NPTEL videos, spreadsheets, online quizzes.
- **Role Play** – Simulated contractor–client–supplier negotiation on equipment and costs.

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.**

Students' Learning activities: These activities shall be:

Course Project – Mini smart-city intervention plan for a selected area (problem, data, smart solution, basic feasibility).

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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

As per National credit farmwork (NCrF) students must spend 90 hours of study for 3 credit courses, which incl

Course instructions (CI- 42 hour) and Teamwork/ Selfe learning (TW/Sl-48 hours). Hence, students must comp

minimum of two actives as part of NCrF. The evaluation activities will be done using set of rubrics developed fo

each activity. The following sample activities are listed below.

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 activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Traffic Volume Survey: Groups conduct 2-hour manual/automatic traffic count at urban intersection; classify vehicles; record peak hour data	24
2	Highway Geometric Design: Design horizontal/vertical alignment for 5km highway section using IRC:73; prepare cross-section drawings	24
3	Pavement Failure Analysis: Visit nearby road; document distress types (cracking, rutting); suggest maintenance strategy.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Self-learning modules on NPTEL/SWAYAM; completion of online certification courses.	24
2	Literature review on emerging technologies; reflective learning journal.	24

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

Integrated Design Mini-Project

1. Sample Rubrics -Integrated Design Mini-Project

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Data Collection & Methodology	Comprehensive data using proper techniques; systematic sampling; full documentation	Adequate data; mostly systematic; minor gaps	Limited/incomplete data; disorganized	20%
Technical Analysis & Calculations	Accurate calculations; correct IRC application; proper design aids	Mostly accurate; minor errors; generally correct standards	Several errors; incomplete standards application	25%
Engineering Interpretation & Solutions	Clear theory linkage; realistic recommendations; multi-factor justification	Reasonable interpretations; partial justification	Mostly descriptive; weak justification	25%
Sustainability & SDG Linkage	Explicit SDG connections (9,11,13); environmental/social/economic aspects	General sustainability mentions	Minimal/no sustainability	15%
Presentation & Documentation	Well-organized report; labeled figures/tables; professional; proper references	Generally organized; minor clarity issues	Disorganized; incomplete documentation	15%

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:

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

ii. 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.

iii. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

Ability Enhancement Course (Laboratory) Syllabus

AI AND DATA-DRIVEN CIVIL AND INFRASTRUCTURE ENGINEERING LABORATORY			
Course Code	**1BIFL406A**	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 CI(L :T):LI(P):SL:TW	30 (0:0:2:2)	SEE Marks	50
Credits	1	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:

1. CO1 (L2 – Understand): CO1 (L2 – Understand): Describe fundamentals of data collection, preprocessing, and exploratory data analysis techniques for civil engineering datasets including sensor data, structural monitoring, and infrastructure assets.
2. CO2 (L3 – Apply): Apply Python-based libraries to process and analyze civil engineering data for predictive modeling and optimization.
3. CO3 (L3 – Apply): Develop machine learning models (regression, classification, clustering) for civil engineering applications.
4. CO4 (L4 – Analyze): Evaluate and compare different AI/ML algorithms using appropriate metrics and validation techniques for infrastructure datasets.
5. CO5 (L5 – Evaluate): Create data-driven solutions to real-world civil engineering problems.

SET OF EXPERIMENTS (LI =28 hours)

1. Data Exploration and Visualization for Building Performance: Understand data collection techniques and visualization methods for civil engineering datasets.
2. Data Preprocessing and Feature Engineering for Infrastructure Datasets: Preprocess real-world noisy civil engineering data and create engineered features.
3. Regression Analysis for Structural Property Prediction: Develop and evaluate regression models for predicting civil engineering parameters
4. Classification for Infrastructure Risk Assessment Apply classification algorithms for civil engineering decision-making tasks.
5. Clustering and Anomaly Detection for Monitoring Data: Identify patterns and anomalies in infrastructure monitoring datasets.
6. Time-Series Forecasting for Infrastructure Predictions: Develop models for predicting future infrastructure behavior.

Suggested Learning Resources

Text books:

1. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron – Practical ML fundamentals with Python; excellent for civil engineering applications and model implementation.
2. "Introduction to Statistical Learning" by James, Witten, Hastie, Tibshirani – Foundational ML theory with R and Python examples; covers regression, classification, and model selection relevant to civil engineering.
3. "Data Science for Civil Engineers" by David E. Newcombe – Specifically tailored to civil engineering applications of data science and machine learning.

Reference Books:

1. "Python for Data Analysis" by Wes McKinney – Essential guide to Pandas and data manipulation; critical for preprocessing civil engineering datasets.
2. "Machine Learning in Civil Engineering: A Review" (Journal Articles) – Recent reviews on AI/ML applications in structural health monitoring, traffic management, and sustainable construction.
3. "Feature Engineering for Machine Learning" by Alice Zheng and Amanda Casari – Practical guide to creating effective features from civil engineering data.
4. "Applied Machine Learning in Python for Engineers" by Nishanth Koganti – Engineering-focused ML applications with practical Python implementations

Web links and Video Lectures (e-Resources):

1. Coursera: "Machine Learning" by Andrew Ng – Comprehensive foundational course on ML algorithms.
2. Kaggle Learn: Free ML courses and datasets; excellent for practicing with real engineering datasets.
3. YouTube NPTEL: "Soft Computing and Machine Learning" and "Data Mining" – Lectures applicable to civil engineering contexts.
4. Microsoft Learn: ML fundamentals with Python and Scikit-learn modules.

NCrF – TW/SL Activities (2 hours) -Any one activity

- Watching and analyzing video case studies of AI/ML applications in smart cities, structural health monitoring, and sustainable infrastructure.
- Self-paced practice: Implement additional ML experiments using datasets from your own research or open repositories.
- Reflection notes: Document lessons learned, challenges encountered during model building, and how different algorithms performed differently on the same dataset.
- Peer review sessions: Present your mini-projects in class and provide constructive feedback on methodology and results.
- Journal article review: Read recent papers on AI in civil engineering (from Structural Health Monitoring, Automation in Construction, Engineering Structures) and summarize key findings.

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 marks for report and test shall be out of 50 marks.

Eligibility for SEE:

- 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.**

Rrubrics for CIE- Continuous Assessment for practical courses

Performance Indicator	CO/PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
P1: Regularity & Participation	CO1/PO5 (Lab discipline)	Always punctual, fully engaged, leads peers.	Regular, actively participates.	Moderately regular, some participation.	Irregular, minimal effort.	Absent/frequent disruptions.
P2: Understanding Objectives & Setup	CO2/PO2 (Problem analysis)	Fully comprehends, independently sets up accurately.	Good grasp, sets up with minor help.	Partial understanding, basic setup.	Struggles with setup/aims.	No understanding, incorrect setup. scribd+1

P3: Execution & Results	CO3/PO4 (Investigation)	Flawless conduction, precise results with error analysis.	Correct execution, accurate results.	Partial success, some errors.	Major errors in procedure /results.	Fails to conduct properly.
P4: Record Writing	CO4/PO10 (Communication)	Neat, complete, analytical beyond requirements.	Complete, neat, includes calculations.	Basic record, some omissions.	Incomplete/untidy.	Not submitted/illegible
P5: Viva Voce & Presentation	CO5/PO12 (Lifelong learning)	Confident, deep insights, relates to applications.	Answers most questions correctly.	Basic responses, some hesitation.	Few correct answers.	Unable to respond.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	**Superior**	**Good**	**Fair**	**Needs Improvement**	**Unacceptable**
PI-1: Experimental Skill / Technique (CO-1 / PO-5)	Executes procedure flawlessly, handles equipment with confidence, completes work within time, and shows initiative in troubleshooting.	Performs procedure correctly; equipment handling is safe but with minor hesitation; completes most steps on time.	Follows procedure but with intermittent errors; needs frequent guidance; time management is poor.	Makes repeated procedural errors; unsafe handling; requires continuous supervision; incomplete work.	Fails to follow basic steps; unsafe practices; work not attempted or abandoned.
PI-2: Observation & Data Recording (CO-2 / PO-2)	Records all required observations systematically; data is accurate, well-labeled, and presented in prescribed format.	Records most observations correctly; data is readable but with minor omissions or formatting issues.	Records incomplete or inconsistent data; units/labels missing; entries are disorganized.	Data recording is haphazard; major omissions; units/labels largely absent.	No meaningful data recorded; or copied/incorrect entries without any understanding.

PI-3: Computation / Analysis (CO-3 / PO-4)	Applies correct formulas, computes results accurately, interprets graphs/tables meaningfully, and identifies sources of error.	Computes results correctly with minor arithmetic errors; graph/plot is acceptable; interpretation on is partial.	Uses correct method but makes significant calculation errors; graph/plot is poorly drawn; interpretation is weak. i	Incorrect method or formula; computations are mostly wrong; no clear interpretation.	No attempt at computation/analysis; blank or nonsensical entries.
PI-4: Safety, Discipline & Professionalism (CO-4 / PO-12)	Maintains strict adherence to lab safety, SOPs, and instructions; respects peers and equipment; works independently.	Generally follows safety rules and instructions; acceptable conduct; needs minimal supervision.	Occasionally ignores minor safety precautions; requires reminders on discipline.	Repeated lapses in safety/behavior; disturbs others; needs constant monitoring.	Gross violation of safety norms; disruptive or negligent behavior; unsafe for self/others.
PI-5: Viva-Voce / Conceptual Understanding (CO-5 / PO-1)	Demonstrates deep understanding of concepts, objectives, and methodology; answers questions confidently and precisely. nsec+1	Shows clear understanding of key concepts; answers most questions satisfactorily.	Understands basics but struggles with detailed or application-based questions.	Limited understanding; answers are vague or incorrect on fundamental points.	Unable to answer basic questions; shows no understanding of the experiment.

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	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)

	design with proper reason (5)			
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. (7-8)	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)

Water Distribution Network Modelling with Water GEMS Lab			
Course Code	1BIFL406B	Scheme	2025
Type of Course	Ability Enhancement Course (Laboratory)	Semester	IV
Teaching Hours/Week (L: T: P)	28(0:2:2)	CIE Marks	50
Total Hours of Pedagogy L: T:P:SL:TW	30(0:0:2:2)	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:

1. **CO1 (L2 – Understand):** Explain the components and function of a water distribution network and the Water GEMS interface.
2. **CO2 (L3 – Apply):** Create a simple water distribution model using Water GEMS with nodes, pipes, tanks, reservoirs, pumps and valves.
3. **CO3 (L3 – Apply):** Enter data, assign demands and run steady-state hydraulic analysis for a small network
4. **CO4 (L4 – Analyze):** Interpret pressure, flow, velocity and head loss results and identify critical network locations.
5. **CO5 (L4 – Analyze):** Evaluate alternative pipe sizes, pump settings and operational scenarios for economical and reliable performance.

SET OF EXPERIMENTS

1. Introduction to Water GEMS Interface: Water distribution networks overview, workspace setup, project creation, units (SI), templates, basic hydraulic principles, CAD/GIS import.
2. Simple Pressure Network Analysis: Assign elevation, Pipe Diameter, assign Pump, design the model and check for head loss, velocity and pressure. Assign demand for node considering different demand pattern
3. Create demand pattern running an Extended Period Simulation (EPS) and assign demand pattern for nodes, Add elevated tank and pump; create 24-hour demand pattern (peak factor 1.5x); run 24-hour EPS; analyze tank levels and pump operation.
4. Head loss Analysis & Critical Nodes: Run steady-state analysis; compute Darcy-Weisbach/Hazen-Williams losses; identify low-pressure nodes (<20m); generate contour maps and profile plots.
5. Pipe Sizing & Pump Optimization: Use Scenario Manager; test pipe upgrades (200→250mm); select pump curve; compare scenarios for uniform pressure (25-50m) and energy cost.
6. Fire Flow & Leakage Analysis: Simulate fire hydrant demand (50 L/s); model 20% leakage at nodes; analyze pressure drops; propose valve isolation and pump adjustments.

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

Text books:

1. Larry W. Mays - Water Distribution System Handbook
2. Bentley Systems - Water GEMS User Guide V8i CONNECT Edition.

Reference books / Manuals:

1. EPA EPANET 2.2 User's Manual (importable to Water GEMS)
2. IS 1172:1993 - Code of Practice for Water Supply
3. CPHEEO Manual - Water Supply and Treatment

Web links and Video Lectures (e-Resources):

- Bentley Water GEMS CONNECT Edition Tutorials (bentley.com)

- NPTEL: Water & Wastewater Engineering (IIT Kharagpur)
- YouTube: "Water GEMS Tutorial Series" by Civil Engineering Academy
- Bentley Learning Server: Water Distribution Modeling

NCrF – TW/SL Activities (2 hours) - Any one activity

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. Video Tutorial Summary: Watch Bentley Water GEMS Quick Start tutorials; prepare summary notes on interface navigation, model setup, and result interpretation.
2. Digital Portfolio: Compile 3 Water GEMS models (gravity network, EPS, optimization) with screenshots, contour maps, and brief analysis reports.
3. Reflection Note: Write on role of hydraulic modelling in sustainable water supply (NRW reduction, energy optimization, SDG 6) using course models.
4. Case Study Analysis: Review real water supply failure (e.g., low pressure zones in Indian cities) and propose Water GEMS-based solutions.

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.

Eligibility for SEE:

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

Rubrics for CIE – Continuous assessment:

Criteria	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
Problem Understanding (PO1)	Clearly interprets given network requirements	Minor clarification needed	Basic understanding	Misinterpretation	No understanding
Model Development (PO3)	Complete accurate model within time	Minor errors	Partially complete	Major errors	Incomplete
Tool Efficiency (PO5)	Efficient WaterGEMS usage	Minor delays	Moderate efficiency	Slow execution	Unable to proceed
Output Quality (PO2)	Professional contoured maps/reports	Minor issues	Acceptable output	Poor quality	Incorrect output

Rubrics for SEE / CIE Test:

Criteria	Superior (6)	Good (5)	Fair (4)	Needs Improvement (2-3)	Unacceptable (1)
Problem Interpretation (PO1)	Fully understands network scenario	Minor clarification needed	Basic understanding	Misinterpretation	No clarity
Network Design Accuracy (PO2,PO3)	Fully accurate model with standards	Minor errors	Acceptable design	Major issues	Incorrect
Tool Application (PO5)	Advanced WaterGEMS usage	Minor inefficiencies	Basic usage	Limited usage	Unable to use
Scenario Analysis (PO4)	Excellent scenario comparison	Minor issues	Some analysis	Poor analysis	No analysis
Report Quality (PO9)	Professional output with annotations	Minor issues	Average	Poor	Incomplete

Rubrics suggested for Practical continuous assessment				
Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	Deep knowledge of hydraulic modelling concepts (4)	Good knowledge of core topics (3)	Basic understanding (2)	Concepts unclear (1)
Design Of Experiment (5) (PO2 & PO3)	Multiple design alternatives evaluated (5)	Few designs compared (4)	Single design justified (3)	Basic design explained (1-2)
Implementation (8) (PO3 & PO8)	Optimal model with best algorithms (7-8)	Good implementation explained (5-6)	Basic implementation (3-4)	Minimal implementation (1-2)
Result & Analysis (5) (PO4)	Multi-scenario analysis with comparisons (5)	All cases analyzed (4)	Few cases analyzed (3)	Results without analysis (1-2)
Demonstration (8) (PO9)	Well-organized lab record (7-8)	Organized with minor issues (5-6)	Poor organization (3-4)	Disorganized record (1-2)

Note: Engineering & IT tool usage (WaterGEMS V8i/CONNECT) emphasized throughout the course.

Intelligent Drone Surveying and Mapping Laboratory for Infrastructure			
Course Code	**1BIFL406C**	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 CI (L: T):LI(P):SL:TW	30 (0:0:2:2)	SEE Marks	50
Credits	1	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:

1. **CO1 (L3 – Apply):** Operate unmanned aerial vehicles (UAVs/drones) with appropriate flight planning, pre- flight checks, manual and autonomous flight modes, and adherence to safety protocols and regulations for infrastructure surveying applications.
2. **CO2 (L4 – Analyze):** Plan and execute drone-based aerial photogrammetry missions including light parameter optimization, ground control point establishment, image. acquisition strategies, and quality assessment for mapping and modeling applications.
3. **CO3 (L4 – Analyze):** Process aerial imagery using photogrammetric software (Pix4D, Agi soft Meta shape, DJI Terra) to generate Ortho mosaics, digital elevation models (DEMs), digital surface models (DSMs), and textured 3D models for infrastructure documentation.
4. **CO4 (L5 – Evaluate):** Apply LiDAR-equipped drones for point cloud data acquisition; process and analyze point cloud data for terrain modeling, vegetation analysis, volume computation, and as-built infrastructure documentation.
5. **CO5 (L5 – Evaluate):** Implement AI and machine learning techniques for automated analysis of drone imagery including defect detection, crack identification, corrosion mapping, and infrastructure condition assessment to support predictive maintenance.
6. **CO6 (L6 – Create):** Design and execute comprehensive autonomous drone inspection work ows for infrastructure assets (bridges, highways, buildings, pipelines, power lines) with integration of multi-sensor data, automated analysis, and digital twin platforms aligned with SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities).

SET OF EXPERIMENTS (LI =28 hours)

1. Drone System Components, Pre-Flight Inspection, and Safety Protocols
2. Manual Flight Training and Flight Modes
3. Ground Control Point (GCP) Survey and Deployment
4. Aerial Photogrammetry Mission for Ortho mosaic Generation
5. Comprehensive Infrastructure Site Mapping – Topographic Survey with Drone Photogrammetry and LiDAR Integration
6. Bridge Inspection Using Autonomous Drone Flight and Image Analysis
7. Construction Progress Monitoring Using Multi- Temporal Drone Surveys and 4D BIM Integration
8. Smart Infrastructure Asset Management – Digital Twin Development Using Multi-Sensor Drone Data and IoT Integration.

Suggested Learning Resources

Text books:

1. Colo mina, I., & Molina, P. Unmanned Aerial Systems for Photogrammetry and Remote Sensing: A Review. ISPRS Journal of Photogrammetry and Remote Sensing.
2. Eisenbeiss, H. UAV Photogrammetry. ETH Zurich Dissertation.
3. Shan, J., & Toth, C. K. Topographic Laser Ranging and Scanning: Principles and Processing (2nd Edition). CRC Press.
4. Linder, W. Digital Photogrammetry: A Practical Course (4th Edition). Springer

Reference Books:

1. Pix4D Knowledge Base and User Manuals – Pix4Dmapper, Pix4Dcapture documentation.
2. Agi soft Meta shape User Manual – Photogrammetric processing work flows.
3. DJI Enterprise Documentation – DJI Terra, DJI Pilot, drone platform specifications.
4. ASPRS Positional Accuracy Standards for Digital Geospatial Data (2015).
5. DGCA (India) – Civil Aviation Requirements (CAR) for Remotely Piloted Aircraft Systems (RPAS).
6. IS Codes and ICAO Standards for UAV operations (awareness).

Web links and Video Lectures (e-Resources):

1. Pix4D Learning Resources: https://www.pix4d.com/learn – Free courses on photogrammetry, mission planning, data processing.
2. Agi soft Tutorials: https://agisoft.freshdesk.com/support/solutions – Meta shape processing tutorials and webinars.
3. DJI Enterprise YouTube Channel – Tutorials on DJI drones, DJI Terra, inspection work flows.
4. .NPTEL Course: Remote Sensing and GIS (IIT Roorkee, IIT Bombay) – Relevant modules on photogrammetry and image processing.
5. Coursera/Udemy Courses: Drone Mapping and photogrammetry, AI for Infrastructure Inspection.
6. Cloud Compare Official Documentation: https://www.cloudcompare.org/doc – Point cloud processing tutorials.
7. Digital Sky Platform (India): https://digitalsky.dgca.gov.in – Drone registration and flight permissions
8. YouTube Channels: Drone Deploy, Propeller Aero, Fly Guys – Professional drone surveying and mapping work flows.

NCrF – TW/SL Activities (2 hours) -Any one activity

1. Watching and summarizing video tutorials on drone flight operations, photogrammetric processing work flows, LiDAR data analysis, and AI-powered inspection techniques.
2. Self-paced practice: Solving numerical problems on photogrammetric calculations (GSD, overlap, flight parameters), point cloud volume computations, accuracy assessment (RMSE calculations).
3. Software exploration: Self-learning of Pix4D trial version, Agi soft Meta shape trial, Cloud Compare (open-source), QGIS with point cloud plugins.
4. Preparation of digital portfolio: Compilation of all experiment results including flight plans, Ortho mosaics, DEMs, 3D models, point clouds, defect detection reports, technical documentation.
5. Case study analysis: Review of major infrastructure projects utilizing drone surveying (smart city development, large-scale highway/railway projects, bridge inspection programs, BIM- integrated construction monitoring); lessons learned and best practices report.
6. Research literature review: Study of recent research papers on AI/ML for infrastructure defect detection, autonomous drone navigation, digital twin applications in civil engineering; summary presentation.

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 marks for report and test shall be out of 50 marks.

Eligibility for SEE:

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

Rubrics for CIE- Continuous Assessment for practical courses

Performance Indicator	CO/PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
CO1, PO1, PO2	Understanding of Concepts (Drone, Sensors, GIS, Mapping)	Demonstrates thorough understanding of drone systems, sensors, and mapping principles; explains concepts clearly with real-world linkage	Good understanding with minor gaps	Basic understanding; lacks depth	Limited understanding; several misconceptions	No understanding demonstrated
CO2, PO3, PO5	Flight Planning & Mission Design	Optimal mission planning with correct parameters (altitude, overlap, path); uses software effectively	Minor errors in planning	Basic planning with noticeable inefficiencies	Poor planning; incorrect parameters	No proper planning
CO3, PO4, PO5	Data Acquisition (Drone Operation)	Executes flight safely and efficiently; high-quality data captured	Minor operational errors; data mostly usable	Adequate execution; data quality average	Frequent errors; poor-quality data	Unable to acquire usable data
CO4, PO4, PO5	Data Processing & Mapping (Ortho mosaic, DEM, GIS Analysis)	Accurate processing; high-quality outputs (Ortho mosaic, DEM); correct tools used	Minor processing errors	Basic output generated with some inaccuracies	Poor processing; significant errors	No meaningful output generated
CO5, PO9, PO10	Analysis & Interpretation	Insightful analysis; correct interpretation for infrastructure applications	Good interpretation with minor gaps	Basic analysis; limited insights	Weak interpretation	No analysis

CO6, PO10	Report Quality & Documentation	Well-structured report; clear visuals, maps, and explanations	Good structure; minor formatting issues	Average clarity; missing some elements	Poorly organized report	Incomplete or no report

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
CO1, PO1, PO2 Conceptual Understanding (Drone, GIS, Mapping)	Demonstrates comprehensive and accurate understanding; confidently answers all questions	Good understanding with minor errors	Basic understanding; some gaps	Limited understanding; frequent errors	No understanding demonstrated
CO2, PO3, PO5 Mission Planning & Setup	Designs optimal mission with correct parameters (altitude, overlap, GCPs, flight path)	Minor errors in setup	Basic setup; lacks optimization	Incorrect parameters; inefficient planning	Unable to plan mission
CO3, PO4, PO5 Drone Operation & Data Acquisition	Executes flight safely, precisely; collects high-quality data	Minor operational issues; data mostly usable	Adequate execution; average data quality	Poor handling; incomplete/low-quality data	Unsafe or failed operation
CO5, PO4, PO10 Analysis & Interpretation	Provides clear, insightful analysis for infrastructure applications	Good interpretation with small gaps	Basic interpretation	Weak/incorrect conclusions	No analysis provided
CO6, PO10 Result Presentation / Viva	Clear, structured explanation with technical depth	Good explanation; minor clarity issues	Average communication	Poor explanation	Unable to explain results
CO7, PO8, PO12 Safety, Ethics & Compliance	Strict adherence to drone regulations and safety norms	Minor lapses	Basic compliance	Frequent violations	Unsafe/irresponsible behavior

Rubrics suggested for Practical continuous assessment

Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Conceptual Understanding (CO1, PO1, PO2)	Demonstrates complete and in-depth understanding of drone systems, GIS, and mapping concepts	Strong understanding with minor gaps	Basic understanding; limited depth	Minimal understanding; major gaps
Mission Planning (CO2, PO3, PO5)	Designs efficient and optimized flight plans with correct parameters	Minor errors in planning; mostly effective	Basic planning; lacks optimization	Poor or incomplete planning
Drone Operation & Data Acquisition (CO3, PO4, PO5)	Executes flights safely and precisely; collects high-quality data	Minor operational issues; data usable	Adequate execution; average data quality	Poor handling; incomplete/low-quality data
Data Processing & Mapping (CO4, PO4, PO5)	Generates accurate orthomosaic/DEM using proper workflow	Minor processing errors	Basic outputs with some inaccuracies	Significant errors; poor outputs
Analysis & Interpretation (CO5, PO4, PO10)	Provides clear and insightful analysis for infrastructure applications	Good interpretation with small gaps	Basic analysis; limited insights	Weak or incorrect interpretation
Report Writing & Documentation (CO6, PO10)	Well-structured report with clear maps, visuals, and technical explanation	Good report; minor formatting issues	Average report; missing some elements	Poorly organized or incomplete report
Safety & Professional Practice (CO7, PO8, PO12)	Strict adherence to safety norms and drone regulations	Minor lapses in safety	Basic compliance	Frequent safety violations

BASIC CONSTRUCTION MATERIALS TESTING LABORATORY			
Course Code	**1BIFL406D**	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 CI (L: T):LI(P):SL:TW	30 (0:0:2:2)	SEE Marks	50
Credits	1	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:

1. CO1 (L2-Understand): Fundamentals of construction materials properties, testing standards, and their role in civil engineering relevance. SDG9.
2. CO2 (L3-Apply): Apply standard testing procedures like consistency, specific gravity, and sieve analysis on cement/aggregates per IS codes. SDG9, SDG11.
3. CO3 (L4-Analyze): Analyze mechanical properties (compressive strength, impact/crushing value) and feasibility using lab data and BIS assessment methods. SDG11.
4. CO4 (L3-Apply): Conduct specialized tests (setting time, slump, brick absorption) and evaluate material performance for construction applications. SDG9.
5. CO5 (L5-Evaluate): Evaluate sustainable material options (e.g., recycled aggregates, admixtures) integrating quality control and environmental factors. SDG9, SDG11.
6. CO6 (L4-Analyze): Assess advanced NDT and hardness tests on metals for quality assurance in infrastructure. SDG12.

SET OF EXPERIMENTS (LI =28 hours)

1. Tests on Bricks, Tiles, Cement Concrete blocks (Weight & Dimensionality, Water Absorption, Strength).
2. Tests on Fine aggregates - Sieve Analysis, Moisture content, Specific gravity, Bulk density, Bulking and Silt Content.
3. Tests on Coarse aggregates - Sieve Analysis, Water absorption, Moisture content, specific gravity and Bulk density.
4. Compression test on mild steel, cast iron and wood.
5. Tension test on mild steel and HYSD bars.
6. Torsion test on mild steel circular sections.
7. Bending Test on Wood Under two-point loading.
8. Shear Test on Mild steel - single and double shear.
9. Impact test on Mild Steel (Charpy & Izod).
10. Hardness tests on ferrous and non-ferrous metals - Brinell's, Rockwell and Vicker's.
11. Demonstration of Strain gauges and Strain indicators.

Suggested Learning Resources

Text books:

1. M.L. Gambhir, Concrete Manual (Dhanpat Rai) – Aggregates/concrete tests.
2. S.S. Bhavikatti, Building Materials Lab Manual.
3. Bansal R.K., Basic Civil Engineering & Mechanics (Laxmi Pub.).

Reference Books:

1. Neville, Properties of Concrete.
2. BIS Codes: IS 4031, 2386, 516, 3495, 1608.
3. Punmia, Soil Mechanics (for aggregates).

Web links and Video Lectures (e-Resources):

1. NPTEL: Building Materials Testing (IIT Kharagpur).
2. VTU e-Learning: SOM & BMT videos.
3. vlab.co.in: Virtual material tests.

NCrF – TW/SL Activities (2 hours) -Any one activity

1. Watching and summarizing selected video tutorials on construction material testing methods and advanced laboratory procedures. Self-paced practice: Identification of different building materials and conducting numerical problems related to mix design, aggregate properties, and strength calculations.
2. Preparation of digital portfolio: Compilation of all experiment results with photographs, observations, calculations, graphs, and engineering interpretations related to material testing.
3. Short reflection note on applications of building material testing in sustainable construction and infrastructure development (SDG linkage).
4. Case study analysis: Review of a major structural failure, concrete failure, bridge collapse, or material-related construction defect caused by poor quality materials/testing; preparation of lessons learned report.

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 marks for report and test shall be out of 50 marks.

Eligibility for SEE:

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

Rubrics for CIE- Continuous Assessment for practical courses

Performance Indicator	CO/PO Mapping	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
P1: Regularity & Participation	CO1/PO5 (Lab discipline)	Always punctual, fully engaged, leads peers.	Regular, actively participates.	Moderately regular, some participation.	Irregular, minimal effort.	Absent/frequent disruptions.
P2: Understanding Objectives & Setup	CO2/PO2 (Problem analysis)	Fully comprehends, independently sets up accurately.	Good grasp, sets up with minor help.	Partial understanding, basic setup.	Struggles with setup/aims.	No understanding, incorrect setup.
P3: Execution & Results	CO3/PO4 (Investigation)	Flawless conduction, precise results with error analysis.	Correct execution, accurate results.	Partial success, some errors.	Major errors in procedure/results.	Fails to conduct properly.

P4: Record Writing	CO4/PO10 (Communication)	Neat, complete, analytical beyond requirements.	Complete, neat, includes calculations.	Basic record, some omissions.	Incomplete/ untidy.	Not submitted/illegible.
P5: Viva Voce & Presentation	CO5/PO12 (Lifelong learning)	Confident, deep insights, relates to applications.	Answers most questions correctly.	Basic responses, some hesitation.	Few correct answers.	Unable to respond.

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior	Good	Fair	Needs Improvement	Unacceptable
PI-1: Experimental Skill / Technique (CO-x / PO-y)	Executes procedure flawlessly, handles equipment confidently, completes work within time, and shows initiative in troubleshooting.	Performs procedure correctly; equipment handling is safe with minor hesitation; completes most steps on time.	Follows procedure but with intermittent errors; needs frequent guidance; time management is poor.	Makes repeated procedural errors; unsafe handling; requires continuous supervision; incomplete work.	Fails to follow basic steps; unsafe practices; work not attempted or abandoned.
PI-2: Observation & Data Recording (CO-x / PO-y)	Records all required observations systematically; data is accurate, well-labeled, and presented in prescribed format.	Records most observations correctly; data is readable but with minor omissions or formatting issues.	Records incomplete or inconsistent data; units/labels missing; entries are disorganized.	Data recording is haphazard; major omissions; units/labels largely absent.	No meaningful data recorded; or copied/incorrect entries without understanding.
PI-3: Computation / Analysis (CO-x / PO-y)	Applies correct formulas, computes results accurately, interprets graphs/tables meaningfully, and identifies sources of error.	Computes results correctly with minor arithmetic errors; graph/plot is acceptable; interpretation is partial.	Uses correct method but makes significant calculation errors; graph/plot is poorly drawn; interpretation is weak.	Incorrect method or formula; computations are mostly wrong; no clear interpretation.	No attempt at computation/analysis; blank or nonsensical entries.
PI-4: Safety, Discipline & Professionalism (CO-x / PO-y)	Maintains strict adherence to lab safety, SOPs, and instructions; respects peers and equipment; works independently.	Generally follows safety rules and instructions; acceptable conduct; needs minimal supervision.	Occasionally ignores minor safety precautions; requires reminders on discipline.	Repeated lapses in safety/behavior; disturbs others; needs constant monitoring.	Gross violation of safety norms; disruptive or negligent behavior; unsafe for self/others.

PI-5: Viva-Voce / Conceptual Understanding (CO-x / PO-y)	Demonstrates deep understanding of concepts, objectives, and methodology; answers questions confidently and precisely.	Shows clear understanding of key concepts; answers most questions satisfactorily.	Understands basics but struggles with detailed or application-based questions.	Limited understanding; answers are vague or incorrect on fundamental points.	Unable to answer basic questions; shows no understanding of the experiment.

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 (Introduction, Method, Results, Conclusion). Transitions between sections are smooth (7-8).	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).