ADVANCED ENGINEERING MATHEMATICS AND DATA ANALYTICS			
Course Code	1MCV101	Scheme	2026
Type of Course	Professional Science Course (PSC)	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set):

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

1. CO1 L3 - Apply linear algebra and matrix methods to civil engineering problems like structural analysis.
2. CO2 L3 - Solve ODEs/PDEs for modeling vibrations, diffusion in infrastructure systems.
3. CO3 L4 -Analyze multivariate data using statistical methods and visualization for civil datasets.
4. CO4 L3 - Implement numerical methods and optimization for data analytics in engineering.
5. CO5 L4-Develop statistical models for regression, hypothesis testing in construction quality control.
6. CO6 L5 -Evaluate advanced transforms (Fourier, Laplace) and analytics tools for sustainable design predictions.

Module-1 Linear Algebra and Matrix Applications:

Vector s, Linear dependence and linear independence vectors , linear transformations, eigenvalues and eigenvectors for vibration analysis; Consistency of a system of equations, Systems of linear equations by Gauss elimination method.

Quadratic forms in structural optimization; Applications : truss analysis, finite element basics.

Linked COs: CO1 **Number of Hours =8 hrs**

Module-2 Solutions on Ordinary and Partial Differential Equations:

First-order ODEs (exact, integrating factors); Higher-order linear ODEs with constant coefficients; Power series/Frobenius methods;

PDEs: separation of variables method, Various possible solutions for wave and heat equations.

Linked COs: CO2 **Number of Hours = 9 hrs**

Module-3 Probability, Statistics & Data Visualization:

Probability distributions: Binomial, Poisson, normal distribution for success and failure rates.

Descriptive statistics, hypothesis testing; Data visualization (histograms, boxplots) with Python (Matplotlib, Seaborn)

Linked COs: CO3 **Number of Hours = 9 hrs**

Module-4 Numerical Methods & Optimization:

Root of transcendental equations : Regula false and Newton-Raphson methods. Lagrange Interpolation and splines Interpolation,

Optimization: unconstrained optimization and constrained optimization :Lagrange multipliers.

Linked COs: CO4 **Number of Hours = 8 hrs**

Module-5 Regression, Multivariate Analytics & Transforms:

Linear and multiple regressions model, problems relevant to civil engineering. PCA for dimensionality reduction; Laplace and Fourier transforms for signal processing in monitoring; Time-series basics (ARIMA for traffic).

Linked COs: CO5, CO6 **Number of Hours =8 hrs**

Suggested Learning Resources

Textbooks:

1. Kreyszig, E. (2011). Advanced Engineering Mathematics (10th ed.). Wiley.
2. Chapra, S. C. (2018). Applied Numerical Methods with MATLAB (4th ed.). McGraw-Hill.
3. Montgomery, D. C., et al. (2020). Introduction to Statistical Quality Control (8th ed.). Wiley.
4. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, latest edition.
5. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa, latest edition.

Reference Books

1. VanderPlas, J. (2016). Python Data Science Handbook. O'Reilly.
2. Haber, E. (2021). Data Analytics for Civil Engineers. ASCE Press (hypothetical).
3. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley, latest edition.
4. Peter V. O'Neil, Advanced Engineering Mathematics, Cengage, latest edition.

Web links and e-Resources:

1. NPTEL: Advanced Engineering Mathematics (IIT Madras)
2. Coursera: Mathematics for Machine Learning (Imperial College)
3. Kaggle: Civil engineering datasets (concrete, geotech)
4. MATLAB/Python tutorials on numerical methods
5. VTU e-learning: Data analytics modules
6. GitHub: Civil data analytics repos]

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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

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	Matrix eigenvalue assignments (5h); Numerical optimization (5h); Regression projects (5h); Data viz case studies (3h); Mini-project on civil stats (4h); Transform exercises (2h).	24
2	Solve matrix applications relevant to structural, thermal, fluid, or transport systems	24
3	Prepare a problem set on differential equations from core engineering applications.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	NPTEL modules on advanced engineering mathematics topics.	24
2	Problem-based learning on numerical methods for engineering modelling.	24

Sample Rubric for Matrix Applications:

Criteria	4 - Excellent	3 - Good	2 - Fair	1 - Needs Improvement
Problem formulation	Correctly identifies the engineering system, defines assumptions clearly, and formulates the matrix equations accurately.	Identifies the system and formulates the equations with minor omissions or small errors.	Formulation is partly correct but contains notable gaps in assumptions or equation setup.	Unable to identify the system correctly or formulate the matrix model.
Matrix construction	Constructs stiffness, conductance, incidence, or system matrices correctly and in proper order.	Constructs matrices mostly correctly with minor indexing or assembly errors.	Matrix structure is partially correct but has several technical mistakes.	Matrices are incorrect, incomplete, or missing.
Solution procedure	Applies the correct method systematically, such as elimination, inversion, decomposition, or numerical solving, with full accuracy.	Uses the correct method with minor computational errors.	Uses a partially correct method but makes multiple errors in steps.	Uses an incorrect or unclear method, or no valid solution procedure.
Engineering	Explains the meaning	Interpretation is	Interpretation is	No meaningful

Criteria	4 - Excellent	3 - Good	2 - Fair	1 - Needs Improvement
interpretation	of results in terms of structural response, temperature distribution, flow, or transport behaviour clearly and correctly.	mostly correct with limited depth.	weak, with partial understanding of results.	interpretation of results.
Verification and accuracy	Verifies the solution using checks, units, boundary conditions, or alternative computation.	Performs limited verification with minor omissions.	Verification is incomplete or poorly explained.	No verification or checking of results.
Presentation and documentation	Solution is neat, well-organized, properly labelled, and easy to follow.	Presentation is clear with minor formatting issues.	Presentation is readable but poorly organized in places.	Work is untidy, incomplete, or difficult to follow.

SUSTAINABLE AND CLIMATE RESILIENT PLANNING AND DESIGN			
Course Code	1MCV102	Scheme	2026
Type of Course	Professional Cor Course (PCC)	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T) :LI(P):SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

1. CO1: Explain the principles of sustainable planning, climate resilience, and the built environment.
2. CO2: Analyse climate risks, hazards, and vulnerabilities affecting settlements, infrastructure, and public spaces.
3. CO3: Apply planning and design strategies for resource-efficient, low-carbon, and resilient development.
4. CO4: Evaluate climate-responsive urban and building design measures for thermal comfort, water sensitivity, and disaster risk reduction.
5. CO5: Integrate policies, standards, nature-based solutions, and sustainability assessment tools in planning practice.
6. CO6: Incorporate digital tools, data-driven methods, and Industry 4.0/5.0 concepts for sustainable and climate resilient planning and design.

Module-1

Foundations of sustainable planning:

Concepts of sustainability, climate change, resilience, vulnerability, adaptation, mitigation, and decarbonisation. Principles of sustainable development, SDG linkage, life-cycle thinking, and circular economy in built environments. Introduction to climate-resilient planning for cities, campuses, and infrastructure systems.

Linked COs: CO1, CO6 **Number of Hours: 8**

Module-2

Climate risks and urban systems:

Climate hazards such as heat waves, intense rainfall, flooding, drought, storm surge, sea-level rise, and landslides. Exposure, sensitivity, and adaptive capacity in urban and rural settings. Risk mapping, vulnerability assessment, basic GIS-based planning concepts, and climate data interpretation for decision-making.

Linked COs: CO2, CO6 **Number of Hours: 8**

Module-3

Sustainable site and building strategies:

Orientation, passive design, daylighting, natural ventilation, shading, material efficiency, embodied carbon reduction, and water-sensitive design. Green infrastructure, permeable surfaces, rainwater harvesting, heat island mitigation, and demand reduction strategies for energy and water.

Linked COs: CO3, CO4, CO6 **Number of Hours:** 9

Module-4

Climate-resilient infrastructure and public realm:

Resilient road, drainage, utility, and open-space planning. Flood-resilient design, redundancy, modularity, emergency access, evacuation planning, and safe public spaces. Nature-based solutions, wetlands, urban forests, bioswales, and sponge-city concepts for resilience enhancement.

Linked COs: CO3, CO4, CO5 **Number of Hours: 9**

Module-5

Policy, assessment, and implementation:

Climate policy frameworks, green building rating systems, planning codes, disaster management provisions, and environmental clearance concepts. Sustainability assessment tools, carbon and water footprint basics, monitoring indicators, smart-city integration, digital twins, and data-based planning dashboards.

Linked COs: CO5, CO6 **Number of Hours: 8**

Suggested Learning Resources:

Textbooks:

1. Peter Newman and Isabella Jennings, *Cities as Sustainable Ecosystems: Principles and Practices*, Island Press, latest edition.
2. Peter P. Rogers, Kazi F. Jalal, and John A. Boyd, *An Introduction to Sustainable Development*, Earthscan / Routledge, latest edition.
3. E. A. Arceivala, *Wastewater Treatment for Pollution Control*, latest edition, where relevant to urban resilience.
4. R. K. Sapru, *Environment Planning and Management in India*, Ashish Publishing House, latest edition.
5. R. Subramanian, *Disaster Management*, Vikas Publishing House, latest edition.
6. R. Rajagopalan, *Environmental Studies, Biodiversity, Climate Change and Disaster Management*, OakBridge Publishing Pvt. Ltd., latest edition.

Reference Books:

1. IPCC Assessment Reports, relevant chapters.
2. NDMA guidelines on disaster risk reduction, latest edition.
3. MoHUA manuals on urban planning, climate resilience, and sustainable urban development, latest edition.
4. CPHEEO manuals on water supply, sewerage, stormwater drainage, and urban infrastructure, latest edition.
5. NBC provisions and relevant environmental standards, latest applicable editions.
6. Relevant BIS codes and state urban development guidelines, as applicable.

Web links and e-Resources:

1. NPTEL and SWAYAM courses on sustainable development, climate change, urban planning, disaster management, and GIS-based planning.
2. Open educational resources on green buildings, resilient infrastructure, and climate-sensitive urban design.
3. Government portals and e-learning modules on urban sustainability, resilience, and planning practice.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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

Suggested strategies:

- Use local climate data, flood maps, and heat maps for contextual learning.
- Compare conventional and climate-resilient planning solutions through case studies.
- Conduct campus or neighbourhood vulnerability assessments.
- Use drawings, models, GIS layers, and simple software tools to connect theory with practice.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

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 A – Climate vulnerability case study:** Students analyse a neighborhood, campus, or ward for heat stress, flooding, water scarcity, and propose resilient interventions. (CO1, CO2, CO5, CO6)	24
2	**Activity B – Sustainable design proposal:** Students prepare a concept-level sustainable and climate resilient design for a building/site/public space using passive design, water sensitivity, and nature-based solutions (CO3, CO4, CO5, CO6)	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	NPTEL / MOOC modules on climate change, sustainable planning, and resilient infrastructure.	24
2	Preparation of climate risk notes, design checklists, and a digital portfolio of resilient planning strategies.	24

Rubric for Students learning Activities-TW

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Problem understanding	Clearly defines climate issue with strong reasoning.	Mostly accurate with minor omissions.	Basic attempt with some gaps.	Concept not clearly defined.
Construction/design details	Accurate, neat, and professional design outputs.	Largely correct with minor errors.	Partially correct with technical mistakes.	Incorrect or missing diagrams/details.
Safety and sustainability	Insightful analysis of safety, resilience, and environmental impact.	Covers safety with limited sustainability comment.	Weak analysis with limited interpretation.	No meaningful interpretation.
Presentation and clarity	Well-organized, easy to follow, high-quality submission.	Generally clear with minor formatting issues.	Understandable but somewhat untidy.	Very unclear or incomplete submission.

AI, MACHINE LEARNING AND EMERGING DIGITAL TOOLS			
Course Code	1MCV103	Scheme	2026
Type of Course	Professional Cor Course (PCC)	Semester	I
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(42:0:0:50)	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

1. CO1: Explain and classify the fundamental concepts of Artificial Intelligence and Machine Learning, including their evolution, types, paradigms, and relevance to civil engineering applications.
2. CO2: Analyse intelligent systems and machine learning models, including supervised and unsupervised learning techniques, neural networks, and deep learning architectures, for solving engineering problems.
3. CO3: Apply appropriate AI and Machine Learning methods to diverse civil engineering domains such as structural analysis, geotechnical classification, transportation systems, water resource management, and sustainability assessment.
4. CO4: Evaluate AI-driven digital tools and techniques, including computer vision, geospatial AI, and data-driven decision systems, for infrastructure monitoring, analysis, and management.
5. CO5: Assess advanced AI applications, robotics, and ethical considerations, including governance frameworks and emerging trends, for responsible and effective deployment in civil engineering practice.

Module-1

Foundations of AI:

Introduction to Artificial Intelligence, definition, scope and evolution, types of AI, Weak AI including traditional AI, Explainable AI and Generative AI, Strong AI including Artificial General Intelligence, applications of different AI types in civil engineering, intelligent agents and Agentic AI, architecture of AI agents including perception, decision-making and action components, branches of AI including pattern recognition, speech recognition, Natural Language Processing, and AI in optimization including Swarm intelligence and Bio-inspired optimization and their applications in allied domains of civil engineering.

Linked COs: CO1 **Number of Hours: 8**

Module-2

Machine Learning – Supervised Learning Methods:

Introduction to Machine Learning with emphasis on supervised learning, types of supervised learning including regression, linear and polynomial regression for material behaviour analysis, advanced supervised learning paradigms including Transfer Learning and Federated Learning, introduction to Reinforcement Learning in civil engineering control contexts, ANN, Backpropagation, Deep Learning models, model evaluation metrics such as accuracy, precision, recall and F1-score, and diverse applications of supervised learning in allied fields of civil engineering

Linked COs: CO2, CO3 **Number of Hours: 09**

Module-3

ML – Unsupervised Learning and ANN Foundations:

Introduction to unsupervised learning, distinction from supervised learning, clustering techniques including K-means, K-medoids, hierarchical clustering and DBSCAN for spatial and geotechnical data analysis, dimensionality reduction techniques including Principal Component Analysis for data visualization and feature interpretation, introduction to artificial neural networks with focus on biological inspiration and computational models, representational power of a single perceptron, perceptron learning algorithm, limitations of single-layer networks, multilayer neural networks and hidden layers, supervised nature of ANN learning, introduction to deep learning architectures including CNN for image-based civil engineering applications and RNN/LSTM for time-series prediction, and applications in allied fields of civil engineering.

Linked COs: CO2, CO3 **Number of Hours: 09**

Module-4

Computer Vision and AI/ML Implementation Tools:
Introduction to AI-driven digital transformation in civil engineering, ML-based data modelling tools and libraries such as Google Colab, Kaggle, Prophet, statsmodels, SciPy, Matplotlib, and Visual R-Studio, overview of Computer Vision as a major branch of AI, steps of computer vision, CV tools such as OpenCV, Scikit-Image, BoofCV, SimpleCV, Kornia, TensorFlow, PyTorch and YOLO, and applications of computer vision in allied branches of civil engineering.

Linked COs: CO4 **Number of Hours: 8**

Module-5

Robotics, NLP and Ethical Aspects of AI:
Introduction to robotics as a branch of Artificial Intelligence, classification of robots including industrial, autonomous and collaborative robots, construction robotics including bricklaying robots, 3D printing robots, inspection and monitoring robots, and autonomous construction equipment, predictive maintenance and infrastructure asset management using machine learning, applications of Natural Language Processing in civil engineering, introduction to ethical AI practices, AI governance including frameworks by OECD and UNESCO, and Indian perspective on AI governance including initiatives by NITI Aayog.

Linked COs: CO5 **Number of Hours: 8**

Suggested Learning Resources

Textbooks:

1. Russell, S., & Norvig, P. (2021). Artificial Intelligence: A Modern Approach (4th ed.). Pearson. (Ideal for Module 1)
2. M.A.Jayaram, Artificial Intelligence and Applications in Core Engineering, PHI Learning , Delhi, 2026.
3. Christopher M. Bishop, Pattern Recognition and Machine Learning. Springer.
4. Springer,2006. (Strong theoretical foundation for supervised, unsupervised learning and probabilistic modelling: Modules 2 & 3).
5. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly, 3rd Edition, 2022. (Practical understanding of ML, ANN, deep learning and evaluation (Modules 2, 3, 4), for TW/SL).
6. Kundan Meshram, Machine Learning Applications in Civil Engineering, A volume in Woodhead Publishing Series in Civil and Structural Engineering. 2024. DOI:10.1016/C2022-0-01428-8
7. Vincent C. Müller (Ed.), Ethics of Artificial Intelligence and Robotics, Oxford / Stanford Encyclopedia

Reference Books:

1. Pan, Y., & Zhang, L. (2021). Roles of Artificial Intelligence in Construction Engineering and Management. ASCE.
2. Limao Zhang et al , Artificial Intelligence in Construction Engineering and Management, Springer, 2021.

Web links and e-Resources:

1. Web links and Video Lectures (e-Resources):
2. https://www.coursera.org/specializations/machine-learning-introduction?utm_source=chatgpt.com
3. https://colab.research.google.com/
4. https://www.kaggle.com/
5. https://www.tensorflow.org/
6. https://github.com/ipsumium/ML_civil_engineering

Teaching-Learning Process (Innovative Delivery Methods):
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- ICT-Enabled Teaching

- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

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

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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 A: Prepare and analyse an engineering dataset using spreadsheets or Python notebooks, and present findings with charts.	24
2	Activity B: Build a prompt-based AI workflow for drafting technical summaries, report outlines, or literature synthesis.	24
3	Activity C: Develop a simple predictive model for a civil engineering problem, such as demand estimation, condition prediction, or traffic trend analysis.	24
4	Activity D: Evaluate an emerging digital tool for accuracy, transparency, bias, and usefulness in engineering practice	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Prepare a short note on the evolution of AI, weak AI, strong AI, explainable AI, and generative AI, with one civil engineering example for each.	24
2	Practice a simple regression or classification task using Python, Google Colab, or a spreadsheet tool.	24
3	Review one computer vision application such as crack detection, object detection, or pavement distress analysis.	24
4	Prepare a case study on AI in structural health monitoring, traffic forecasting, water resource prediction, or sustainability analysis.	24

Rubric for Students learning Activities: TW/SL

A. Sample rubrics for Term Work

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Task completion	All required components completed accurately and fully.	Most components completed with minor gaps.	Basic components completed, but with noticeable gaps.	Incomplete or largely missing work.
Technical correctness	Concepts, methods, and results are correct and well justified.	Mostly correct, with minor conceptual or computational errors.	Partial correctness; several errors present.	Major errors or unclear understanding.
Application to civil engineering	Strong and relevant application to a civil engineering problem.	Relevant application, but limited depth.	Application is present but weakly connected.	No meaningful application.
Presentation and organization	Well-structured, neat, clear, and easy to follow.	Generally clear and organized.	Acceptable, but uneven or cluttered.	Poorly organized or difficult to read.
Analysis and interpretation	Insightful interpretation with valid conclusions.	Adequate interpretation with some reasoning.	Limited interpretation; conclusions are weak.	No analysis or incorrect conclusions.

B. Sample rubrics for Self-Learning

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Topic understanding	Demonstrates deep understanding of the chosen topic.	Shows good understanding with minor omissions.	Basic understanding only.	Understanding is poor or incorrect.
Independent learning effort	Strong evidence of self-study, reading, and exploration.	Adequate effort with some independent work.	Limited self-study evidence.	Very little independent effort.
Use of tools/resources	Effectively uses MOOCs, digital tools, datasets, or software.	Uses some tools/resources appropriately.	Uses few tools/resources with limited effectiveness.	Does not use relevant tools/resources.
Relevance and originality	Highly relevant and original approach or insight.	Relevant with some original elements.	Mostly generic with limited originality.	Irrelevant or copied content.
Reflection and communication	Clear reflection, strong explanation, and good communication.	Clear enough, with minor issues.	Understandable but weakly expressed.	Poor reflection or unclear communication.

1MCV104X:
Integrated Professional Core Course (IPCC)

BUILDING INFORMATION MODELING FOR STRUCTURAL SYSTEMS			
Course Code	**1MCV104A**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 Orientation:

The course is structured around the structural engineering information workflow: structural intent, model setup, member information, analytical readiness, coordination, quantities, documentation and handover.

The course is not a proprietary modelling-software course. Free, open-source and open-standard tools are used wherever possible. Assessment is based on structural information quality, model purpose, open exchange, validation and decision support. Structural safety design, code compliance and detailed finite-element modelling remain discipline subjects.

Course Flow and Integrated Workflow Logic:

The course follows a structured workflow aligned with real-world structural BIM practice, progressing through structural system framing, definition of information requirements, model setup, and structural object modelling, followed by an analytical-readiness review to ensure suitability for analysis. It then advances to coordination and issue resolution, quantity take-off and documentation, and concludes with open information delivery using interoperable formats such as IFC (Industry Foundation Classes). A small building or infrastructure-support structure is used as a continuous case study, with the same dataset developed across all stages from modelling to final portfolio delivery. Advanced topics such as automation, structural analysis integration, IDS (Information Delivery Specification)-based checking, and semantic or linked data are introduced selectively to support practical workflows in model validation, coordination, and decision-making.

Course outcome (Course Skill Set):

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

1. CO1 (L2 - Understand): Explain structural BIM as an information-management workflow supporting structural design, coordination, quantity, construction and handover decisions.
2. CO2 (L3 - Apply): Set up structural model information using grids, levels, coordinates, spatial structure, element identity, classification, LOD/LOI/LOIN and openBIM exchange requirements.
3. CO3 (L3 - Apply): Develop and inspect structural BIM elements such as foundations, columns, beams, slabs, walls, bracing, stairs and steel/concrete members with appropriate metadata and quantity-readiness.
4. CO4 (L4 - Analyze): Analyze structural BIM models for analytical-readiness, coordination, constructability, openings, load-path assumptions, information gaps, clashes and revision issues.
5. CO5 (L4 - Analyze): Prepare structural schedules, quantity outputs, IFC/BCF-style review reports, issue logs, drawing/documentation packages and handover-ready information.
6. CO6 (L5 - Evaluate): Evaluate a complete structural BIM portfolio using open exchange, model validation, coordination evidence, quantity reliability and workflow reflection.

Module-1

Structural Engineering Context and BIM Foundations:

- Role of BIM in structural systems: design intent, coordination, construction support, quantities, revision control and handover.
- Difference between drawing, 3D geometry, information model, analytical model, fabrication/detailing model and asset record.
- Structural systems and model uses: foundations, columns, beams, slabs, walls, bracing, stairs, trusses, frames and secondary structural members.

- Model purpose and Level of Information Need: avoid unnecessary over-modelling; model only what supports a decision, check, quantity or deliverable.
- OpenBIM foundations: IFC classes for structural elements, property sets, quantity sets, BCF-style issue communication and IDS-style information requirements.
- Free/open tool orientation: Bonsai/BlenderBIM, FreeCAD BIM, IfcOpenShell, xBIM/IFC viewers, LibreOffice and open coordination records.

Linked COs: CO1, CO2 **Number of Hours: 10**

Module-2

Structural Model Setup and Information Requirements:

- Project setup: coordinates, grids, levels, storeys/zones, shared origin, naming conventions, file status, revision logic and CDE-style folder structure.
- Structural information requirements: element ID, type, material, grade, section size, load-bearing status, fire/corrosion notes where relevant, phase, location and quantity fields.
- Classification and object identity: element types, system grouping, foundation zones, work packages, story/level association and asset/record IDs.
- IFC inspection: project/site/building/storey hierarchy, IfcColumn, IfcBeam, IfcSlab, IfcFooting, IfcWall, IfcMember and related property/quantity sets.
- Quality checks: duplicates, misalignment, wrong levels, missing IDs, missing material/grade, incomplete properties, model origin issues and inconsistent quantities.
- Simple information matrices: LOD/LOI/LOIN table, structural model use matrix and exchange-purpose checklist.

Linked COs: CO2, CO3 **Number of Hours: 8**

Module-3

Structural Modelling and Analytical-Readiness:

- Model structural elements with fit-for-purpose detail: foundations, columns, beams, slabs, walls, stairs/bracing and steel/concrete member systems.
- Analytical-readiness concepts: member axis, connectivity, supports, boundary assumptions, material/section properties, levels, load path and transfer limitations.
- Information transfer awareness: what can and cannot be reliably transferred from BIM models to structural analysis/checking workflows.
- Prepared simple checks using spreadsheets/OpenSees-style examples or instructor-provided outputs; assessment focuses on interpreting model data and assumptions, not software command mastery.
- Reinforcement/detailing awareness: represent only the level needed for quantities, coordination or construction communication unless a dedicated detailing workflow is required.
- Model limitations and responsibility: distinguish engineering judgement from model geometry.

Linked COs: CO2, CO3, CO4 **Number of Hours: 8**

Module-4

Coordination, Quantities and Issue Management:

- Model federation using open files or sample models: structural with architectural, MEP/service, site and infrastructure context.
- Coordination checks: openings, shafts, service penetrations, headroom, clearances, support conflicts, foundations/utilities, constructability and temporary works awareness.
- Quantity extraction: concrete, steel, formwork zones, member counts, material take-off and reliability checks against model purpose and classification.
- Issue management: BCF-style issue log, screenshots, responsible party, severity/risk, decision required, status, due date and closure evidence.
- Revision response: update model information, re-export, recheck, record decisions and maintain traceable status.
- 4D/5D awareness: link model elements to work packages, schedule IDs and quantity/cost records through tables, not mandatory proprietary 4D software.

Linked COs: CO4, CO5, CO6 **Number of Hours: 08**

Module-5	
Documentation, Handover and Portfolio Delivery: • Structural documentation outputs: plans, sections, schedules, member lists, quantity tables, coordination reports and revision notes. • Open information delivery: IFC export/check, property/quantity review, BCF issue register, model validation note and deliverable index. • Handover and asset-readiness: maintainable structural asset fields where relevant, as-built updates, inspection/maintenance references and record model limitations. • Portfolio compilation: model files, open exchange files, information matrix, issue log, QTO report, validation evidence, drawings/screenshots and decision memo. • Professional review: evaluate whether the model is useful, trustworthy, coordinated and fit for the stated structural BIM use.	
Linked COs: CO5, CO6	**Number of Hours:08**

PRACTICAL COMPONENTS OF IPCC (LI-28 Hrs)

LIST OF EXPERIMENTS

Students shall perform practical exercises related to:

1. Define the structural BIM project brief for a small building or infrastructure-support structure, including roles, model uses, exchange purposes, and the LOD/LOI/LOIN matrix.
2. Set up the free/open tool workspace with units, coordinates, levels, grids, zones, naming, status, and a CDE-style folder structure.
3. Inspect a sample IFC structural model to study its hierarchy, classes, property sets, quantity sets, relationships, and missing information.
4. Model the core structural elements using a Bonsai/FreeCAD/open IFC workflow, including foundations, columns, beams, slabs, walls or bracing, and stairs where required.
5. Prepare a structural information register with element IDs, material or grade, section data, level or location, classification, phase, and quantity fields.
6. Prepare an analytical-readiness review table covering connectivity, member axis, support assumptions, properties, load-path notes, and model limitations.
7. Extract and verify quantities for concrete, steel, formwork, and member counts using IFC properties, schedules, or spreadsheet-based quantity checks.
8. Federate or compare the structural model with architectural, service, and site context using open files, and prepare a BCF-style coordination issue log.
9. Update the model and register based on the issues, recheck the outputs, and prepare a revision or decision record.
10. Compile the final structural BIM portfolio, including the model or open file, IFC inspection report, issue log, quantity report, documentation sheets or screenshots, and handover note.

Suggested Learning Resources

Text Books

1. Eastman, C., Teicholz, P., Sacks, R., and Liston, K., *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers*, John Wiley & Sons.
2. Nawari, O. Nawari and Kuenstle, M., *Building Information Modeling: Framework for Structural Design*, Routledge.
3. Hardin, B. and McCool, D., *BIM and Construction Management: Proven Tools, Methods, and Workflows*, John Wiley & Sons.
4. Borrmann, A., König, M., Koch, C., and Beetz, J., *Building Information Modeling: Technology Foundations and Industry Practice*, Springer.
5. Kumar, B., *A Practical Guide to Adopting BIM in Construction Projects*, Whittles Publishing
6. Mark Baldwin, The BIM Manager: A Practical Guide for BIM Project Management - for openBIM, project information and coordination context.

Reference Books / Manuals

1. BuildingSMART documentation on openBIM, IFC, and interoperability. Publisher / Source: buildingSMART International
2. BS 1192 collaborative production guidance / BIM information management guidance. Publisher / Source: British Standards and related BIM guidance resources
3. ISO 19650 introductory resources. Publisher / Source: ISO BIM information management standards and guides
4. CPWD: Introducing BIM in CPWD. Publisher: Central Public Works Department, Government of India
5. Institutional BIM guidelines, execution planning documents, and project scheduling manuals. Source: Department-prescribed manuals and guidelines.

Web links and video lectures:

1. NPTEL / SWAYAM modules related to BIM, structural modeling, and digital construction.
2. BuildingSMART resources on open BIM and IFC.
3. Official software learning portals and tutorials for structural BIM tools.
4. Public BIM case studies from India and abroad for structural coordination and documentation.

Software Tools:

The course shall be delivered using free, open-source, open-standard or freely accessible educational tools wherever possible. No proprietary software ecosystem shall be treated as mandatory or preferred. Assessment shall be based on workflow understanding, information quality, open exchange, validation, coordination response and decision support, not on proprietary software command mastery.

Workflow Need	Recommended Free / Open / Freely Accessible Tools
BIM/IFC authoring and inspection	Bonsai (formerly BlenderBIM), FreeCAD BIM, IfcOpenShell, xBIM, IFC.js/web-ifc, BIMVision/Open IFC Viewer
Coordination and issues	BCF tools, IFC viewers, spreadsheet issue logs, Speckle Community/free use where available
Quantities and documentation	Bonsai schedules, IfcOpenShell quantity/property extraction, LibreOffice Calc, open templates
Structural analysis awareness	OpenSees, CalculiX/Code_Aster awareness, spreadsheet checks, instructor-prepared outputs
Project planning and delivery	ProjectLibre, OpenProject, structured CDE-style folders, LibreOffice registers

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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

Suggested Strategies:

- Use problem-based labs built around one connected project dataset rather than disconnected software exercises.
- Start each topic with the real project decision, then define the information needed, the model/data workflow, the exchange/checking method and the output evidence.
- Use demonstrations, guided practice, openBIM/GIS inspection, peer review, issue-response cycles, role-play and portfolio submissions.
- Industry guest lectures may be used to discuss workflow, information requirements and decision-making, not brand-specific command training.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(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 of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

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 the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	**Description**	**Marks**
Allotment of marks for regular classwork		
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**

Term work and Self Learning:
Students' activities for TW/SL under NCrF: As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Structural BIM modeling mini-project: grids, levels, foundations, and framing system.	25
2	Structural quantity and schedule portfolio: concrete, reinforcement, and formwork mapping.	25
3	Open-book team challenge on structural coordination and review comments.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	MOOCs / online certification on BIM and structural modeling.	25
2	Tool and software exploration using approved BIM / structural design tools.	25
3	Competitive aptitude and concept practice in structural analysis, detailing, and BIM workflows.	25

Sample rubrics for Structural BIM Mini-Project rubric:

Criterion	Exemplary (3)	Proficient (2)	Basic (1)
Problem definition and scope	Clear objective, appropriate project scope, complete assumptions and structural breakdown.	Objective mostly clear with minor gaps.	Scope vague; assumptions incomplete or inconsistent.
Modeling quality	Accurate element placement, correct geometry, and logical structural organization.	Mostly correct with minor errors.	Frequent modeling errors or incomplete workflow.
Coordination and constructability	Meaningful identification of interface issues and practical structural insight.	Basic issue identification and limited interpretation.	Minimal or unclear coordination review.
Documentation	Well-structured model set,	Organized but some	Poorly organized or

Criterion	Exemplary (3)	Proficient (2)	Basic (1)
and presentation	schedules, quantities, and reflection.	sections are weak.	incomplete portfolio.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)	Student has good knowledge of some topics related to construction planning and BIM workflows. (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 planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output. (3)	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio 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)

BIM FOR CONSTRUCTION SEQUENCING AND RESOURCE MODELING			
Course Code	**1MCV104B**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 – Understand): Explain traditional construction planning and compare it with BIM-based 4D/5D workflows.
2. CO2 (L3 – Apply): Develop WBS, activity list, dependencies, milestones, calendars, and baseline schedule.
3. CO3 (L3 – Apply): Prepare BIM-ready model data for sequencing and resource planning.
4. CO4 (L4 – Analyze): Create and analyze 4D construction sequences to identify project issues.
5. CO5 (L4 – Analyze): Prepare resource-linked and progress-linked project control outputs.
6. CO6 (L5 – Evaluate): Evaluate a complete BIM-enabled construction planning workflow through a portfolio project.

Module-1

Fundamentals of Construction Planning and BIM

- Construction project lifecycle and contractor-side planning responsibilities.
- Difference between planning, scheduling, sequencing, monitoring, and control.
- Traditional planning tools: WBS, activity definition, dependencies, milestones, calendars, bar charts, CPM basics, baselines, look-ahead planning, and progress reporting.
- Limitations of 2D drawings and bar charts in communicating sequence, workspace, logistics, safety, constructability, and progress.
- Introduction to BIM: definition, scope, benefits, history, and evolution.
- BIM as a process and information-management method: object-based models, information-rich elements, 3D/4D/5D concepts, CDE basics, interoperability, and openBIM awareness.
- Project delivery outputs: model-readiness review, WBS, baseline schedule, model breakdown, 4D sequence, quantity/resource sheet, issue log, site logistics plan, progress report, and final portfolio.

Course Outcomes mapped: CO1, CO2 **Number of Hours: 10**

Module-2

BIM Software Overview and Model Readiness:

- BIM software ecosystem: authoring, coordination, scheduling, quantity extraction, and collaboration tools.
- BIM-ready planning environments: levels, grids, zones, locations, packages, systems, trades, and construction stages.
- Model quality for 4D/5D: correct categories, object naming, classification, properties, quantities, duplicates, modelling omissions, and planning usability.
- Information management basics: revision, status, approval, shared/published information, responsibility matrix, CDE logic, and information updates.
- OpenBIM awareness: IFC exchange, BCF-style issue communication, model viewing/checking, and basic information validation.
- Model breakdown structure and schedule-model mapping rules for construction sequencing, resource planning, and progress updates.

Course Outcomes mapped: CO2, CO3, partial CO6 **Number of Hours: 08**

Module-3	
4D BIM and Schedule-Model Integration: • Construction sequence logic for excavation, foundations, substructure, superstructure, enclosure, MEP rough-in, finishes, testing, commissioning, and handover. • Linking building components to activities, work packages, phases, locations, and timelines for 4D simulation. • Task dependencies, construction calendars, baselines, milestones, planned stages, and sequence alternatives within BIM-supported workflows. • 4D BIM as a review and communication method for construction methodology, trade interfaces, access, temporary works, workspace conflicts, logistics, and safety review. • Limitations of 4D: model quality dependence, incorrect schedule logic, excessive detail, false precision, and animation without construction reasoning.	
Course Outcomes mapped: CO2, CO4, partial CO6	**Number of Hours: 08**
Module-4	
5D BIM, Resource Modelling and Project Control: • Traditional resource planning: labour, materials, equipment, crews, productivity, temporary works, workspace, and procurement/package logic. • Quantity take-off and model-assisted quantity review: activity-wise material requirements, cost heads, package-level quantities, and limits of model-based quantities. • Resource-loaded schedules: productivity assumptions, crew/equipment allocation, histograms, smoothing/levelling awareness, and resource constraints. • 5D awareness: linking quantities and cost heads to activities for procurement planning, cash-flow support, and package monitoring. • Project controls: planned vs actual progress, status updates, site evidence, delay/variance explanation, corrective action, and dashboard/report preparation.	
COs mapped: CO3, CO5, partial CO6	**Number of Hours: 08**
Module-5	
Site Logistics, Coordination, and Delivery Portfolio: • Site logistics modelling: access routes, storage areas, crane/equipment locations, temporary facilities, safety barricades, movement paths, and constrained-site planning. • Coordination using linked architectural, structural, and MEP models for execution-stage review and trade interface management. • Issue tracking: issue type, location, severity, responsible party, due date, status, action taken, and closure evidence. • Safety and method planning: hazards, access control, temporary works, sequence-dependent risks, and method-statement support. • Final information delivery: portfolio compilation, CDE folder structure, model/schedule/report deliverables, handover awareness, ethics, data governance, and future directions.	
Course Outcomes mapped: CO4, CO5, CO6	**Number of Hours: 08**
PRACTICAL COMPONENTS OF IPCC	
LIST OF EXPERIMENTS	**LI: 28 hrs**
1. Map a BIM-enabled planning workflow and compare it with traditional bar-chart/CPM practice. 2. Inspect a sample building model and prepare a **model readiness checklist** (levels, grids, zones, categories, naming, properties, quantities, IFC readiness).	

3. Develop WBS, activities, dependencies, milestones, calendars and a baseline schedule using a planning tool (spreadsheet, MS Project, Primavera, ProjectLibre or similar).
4. Prepare a model breakdown structure (by level, zone, trade, package, stage) and define mapping rules for schedule-model linking.
5. Link schedule activities to model elements and generate a 4D sequence (excavation to handover).
6. Extract/map quantities and prepare activity-wise resource requirements (materials, labour, equipment, workspace, basic cost heads).
7. Create a site logistics plan (access, storage, temporary facilities, cranes/equipment, safety and movement paths).
8. Review sequencing conflicts and logistics constraints using the model and document them in an **issue log**.
9. Prepare a planned vs actual progress update with model/status snapshots, site photos/evidence, variance explanations and corrective actions.
10. Compile a final **BIM construction planning portfolio** (WBS, schedule, model QA, 4D, resource sheet, logistics plan, progress report, issue log, reflection).

Suggested Learning Resources

Text Books

1. **Sacks, R., Eastman, C., Lee, G., Teicholz, P.** *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers*, 3rd Ed., Wiley, 2018.
2. **Hardin, B., McCool, D.** *BIM and Construction Management: Proven Tools, Methods, and Workflows*, 2nd Ed., Wiley, 2015.
3. **Baldwin, A., Bordoli, D.** *A Handbook for Construction Planning and Scheduling*, Wiley-Blackwell, 2014.
4. **Kymmell, W.** *Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations*, McGraw-Hill, 2008.
5. **Kumar, B.** *A Practical Guide to Adopting BIM in Construction Projects*, Whittles Publishing, 2015.

Reference Books / Manuals

1. buildingSMART International resources on openBIM, IFC, BCF, IDS, and bSDD.
2. BSI resources on ISO 19650 and BIM information management.
3. CPWD, Introducing BIM in CPWD, Government of India, 2024.
4. GSA BIM Guide Series and National 3D-4D-BIM Program documents.
5. EFCA, BIM and ISO 19650 from a Project Management Perspective.

Web links and Video Lectures (e-Resources) & Software tools:

1. NPTEL/SWAYAM modules on construction planning, project management, BIM and digital construction.
2. buildingSMART openBIM learning resources and certification outcomes.
3. Selected software vendor learning portals (only for demonstrations, not as the main academic content).
4. Public BIM case studies (Norway, Singapore, Europe, USA, India) for comparing regulatory submissions, project controls and information management maturity.
5. Institutional datasets: sample models, drawing sets, schedule templates, resource templates, issue logs, progress report templates and portfolio templates.

Web links and Video Lectures (e-Resources) & Software tools

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9. Public BIM case studies (Norway, Singapore, Europe, USA, India) for comparing regulatory submissions, project controls and information management maturity.
10. Institutional datasets: sample models, drawing sets, schedule templates, resource templates, issue logs, progress report templates and portfolio templates.

Indicative Software / Web Resources for 4D and 5D BIM Workflows:
Software tools listed below are indicative references only. No single vendor software stack is mandatory. The laboratory may use any proprietary, open-source, academic, or institutionally available tools that support the required workflow outputs: model viewing or authoring, schedule preparation, schedule-model linking, 4D sequence review, quantity/resource/cost tabulation, progress tracking, issue coordination, reporting, and openBIM exchange where applicable.

Sl.No	Work flow	Recommended Software Tools
1	Scheduling / Planning	Oracle Primavera P6; Oracle Primavera Cloud; Microsoft Project; ProjectLibre; GanttProject
2	4D BIM / Construction Sequencing	Bentley SYNCHRO; Fuzor; Fuzor Construction Sequencing; ACCA usBIM.gantt; BEXEL Manager
3	5D BIM (Quantity, Cost & Resources)	ACCA PriMus-IFC; RIB CostX; BEXEL Manager; Microsoft Excel; Microsoft Power BI; LibreOffice Calc
4	Model Review, Coordination & Issue Management	Solibri; BIMcollab; Revizto; BIM Track; BIMvision; Sortdesk IFC Viewer
5	OpenBIM / Interoperability & Model Data	IfcOpenShell; Bonsai (BlenderBIM); buildingSMART IFC; buildingSMART BCF; buildingSMART IDS
6	Model Source / CDE & Collaboration	Autodesk Revit; Autodesk Navisworks; Autodesk
7	Construction Cloud;	Trimble Connect; Dalux; Tekla Structures; Archicad

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

Suggested Strategies:

1. Flipped classroom segments for core concepts like WBS, CPM and 4D linking.
2. Problem based learning using one live or hypothetical building project throughout the semester.
3. Simulation and portfolio labs for 4D, resource planning, logistics and progress reporting.
4. Case based teaching and guest lectures by planning engineers, BIM/VDC coordinators or project

control engineers.

5. ICT enabled teaching and role play for coordination meetings and issue tracking exercises.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(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 of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

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 the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
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**

Term work and Self Learning:

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

below. The course coordinator can also design learning activities based on course outcomes. The learning activities of TW/SL shall be considered as CCA component of CIE.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	Prepare a BIM-enabled construction planning workflow and compare it with traditional planning methods.	25
2	Prepare a model readiness checklist covering levels, grids, zones, categories, naming, and properties.	25
3	Create a model breakdown structure for 4D sequencing and resource planning.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Explore open-source BIM tools and their application in model viewing and IFC workflows.	25
2.	Prepare a short note on BIM-based progress monitoring and project control.	25

Rubrics for -BIM Mini-Project

Criterion	**Exemplary 3**	**Proficient 2**	**Basic 1**
Problem definition and scope	Clear objective, appropriate project scope, complete assumptions and geotechnical breakdown.	Objective mostly clear with minor gaps.	Scope vague, assumptions incomplete or inconsistent.
Modeling quality	Accurate element placement, correct geometry, and logical subsurface organization.	Mostly correct with minor errors.	Frequent modeling errors or incomplete workflow.
Coordination and constructability	Meaningful identification of interface issues and practical geotechnical insight.	Basic issue identification and limited interpretation.	Minimal or unclear coordination review.
Documentation and presentation	Well-structured model set, schedules, quantities, and reflection.	Organized but some sections are weak.	Poorly organized or incomplete portfolio.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)	Student has good knowledge of some topics related to construction planning and BIM workflows. (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 planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output. (3)	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio 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)

REMOTE SENSING AND GIS FOR TRANSPORT MODELING			
Course Code	**1MCV104C**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 - Understand the concepts of remote sensing, GIS, and transport modeling workflows.
2. CO2 L3 - Apply geospatial data, transport data, and field observations for transport system analysis.
3. CO3 L3 - Apply GIS tools for mapping, preprocessing, network preparation, and spatial analysis of transport variables.
4. CO4 L4 - Analyze travel patterns, accessibility, congestion, and transport service characteristics using geospatial methods.
5. CO5 L4 - Analyze transport modeling outputs to support planning, traffic management, and infrastructure decisions.
6. CO6 L5 - Evaluate a remote sensing and GIS based transport modeling workflow through a portfolio-based project.

Module-1

Foundations of remote sensing and GIS for transport systems:

- Concepts of transport planning, traffic analysis, and transport modeling.
- Role of geospatial technologies in transport studies, mobility planning, and infrastructure assessment.
- Overview of remote sensing, GIS, GNSS, mobile mapping, and in-situ traffic sensing.
- Transport-relevant geospatial data sources: satellite imagery, aerial photographs, road centerline data, GPS traces, POI datasets, census data, traffic counts, and network data.
- Transport case examples: urban road network expansion, congestion hotspots, transit accessibility, accident-prone locations.

Linked COs: CO1, CO2 **Number of Hours: 8**

Module-2

Remote sensing for transport data and change detection:

- Fundamentals of remote sensing: electromagnetic spectrum, spectral signatures of built-up areas, roads, parking surfaces, open spaces, and land use around corridors.
- Sensors and platforms for transport applications: multispectral, high-resolution optical, thermal, and SAR imagery.
- Image preprocessing: radiometric and geometric correction, atmospheric correction, mosaicking, image registration for corridor analysis.
- Image classification and extraction of transport features: road, built-up, land-use/land-cover classification, impervious surface mapping.
- Change detection for transport studies: urban expansion, road corridor growth, encroachment, and land conversion affecting transport demand.

Linked COs: CO1, CO2 **Number of Hours: 10**

Module-3

GIS and spatial analysis for transport modeling:

- GIS concepts and data models: raster and vector data, topology, attribute tables, geodatabase design for transport datasets.
- Spatial data acquisition and management: digitization, georeferencing, projections, metadata, and quality control.
- Road network analysis: connectivity, shortest path, service areas, origin-destination concepts, route choice, and accessibility mapping.
- Spatial analysis tools: buffering, overlay, proximity, network analysis, and suitability analysis for transport corridors, terminals, and service areas.
- Terrain and corridor analysis: slope, elevation, curvature, visibility, and constraint mapping for route planning and infrastructure alignment.

Linked COs: CO2, CO3 **Number of Hours: 8**

Module-4

Transport modeling with geospatial inputs:

- Role of models in transport engineering: trip generation, trip distribution, mode choice, assignment, and simulation.
- Travel demand inputs from GIS: land use, population, employment, activity centers, and network characteristics.
- Congestion and accessibility modeling: travel time surfaces, impedance, service coverage, and equity indicators.
- Public transport and paratransit modeling: stop spacing, catchment analysis, feeder service planning, and accessibility to transit.
- Uncertainty in transport geospatial models: data gaps, scale effects, temporal variation, model assumptions, and reliability communication.

Linked COs: CO3, CO4 **Number of Hours: 8**

Module-5

Advanced tools, cloud platforms, and transport case studies:

- Open-source and commercial platforms for transport GIS: QGIS, GRASS, ArcGIS Pro, ArcGIS Network Analyst, and transport extensions.
- GPS and GNSS-based mobility data: floating car data, mobile mapping, trajectory analysis, and traffic monitoring.
- Cloud-based geospatial workflows for large-area transport analysis and time-series mobility studies.
- Basic machine learning for transport prediction: traffic volume estimation, congestion classification, accident hotspot prediction, and accessibility modeling.
- Case studies in transport modeling: urban road network planning, transit accessibility, freight movement, corridor development, and smart mobility.
- Ethics, governance, and sustainability: privacy in mobility data, open transport data, and responsible use of geospatial information.

Linked COs: CO4, CO5 **Number of Hours: 8**

PRACTICAL COMPONENTS OF IPCC (LI-28 Hrs)

LIST OF EXPERIMENTS

Students shall perform practical exercises related to:

1. Prepare georeferenced base maps of a transport study area using GIS software.
2. Import and preprocess satellite or UAV-derived transport and land-use data.

3. Generate road network and land-use maps from sample imagery.
4. Perform buffer and overlay analysis for transport corridors and service zones.
5. Create terrain-derived layers such as slope, aspect, and elevation zones for route planning.
6. Carry out accessibility or proximity analysis for transport facilities.
7. Prepare a congestion hotspot or accident hotspot map.
8. Develop a simple transport suitability or corridor analysis map.
9. Integrate field survey or GPS observations with GIS layers.
10. Compile a transport GIS portfolio.

Suggested Learning Resources

Text Books

1. Basudeb Bhatta — *Remote Sensing and GIS* — Oxford University Press
2. M. Anji Reddy — *Textbook of Remote Sensing and Geographical Information Systems* — B. S. Publications
3. Kang-Tsung Chang — *Introduction to Geographic Information Systems* — Tata McGraw-Hill Education Private Limited
4. Lillesand, Kiefer and Chipman — *Remote Sensing and Image Interpretation* — Wiley
5. Remote Sensing and GIS — OUP India, 3rd edition.

Reference Books / Manuals

1. Chor Pang Lo and Albert K. W. Yeung, Concepts & Techniques of GIS, Prentice Hall of India, 2006.
2. John R. Jensen, Remote Sensing of the Environment: An Earth Resource Perspective, Pearson Education, 2007.
3. Peter A. Burrough, Rachael A. McDonnell, and Christopher D. Lloyd, Principles of Geographical Information Systems, Oxford University Press, 2004.
4. M. Demers, Fundamentals of Geographic Information Systems, John Wiley & Sons, 2008.
5. L. R. A. Narayana, Basics of Remote Sensing and Its Applications, Universities Press, 2001.

Web links and Video Lectures (e-Resources) & Software tools:

1. NPTEL/SWAYAM preview: Remote Sensing and GIS.
2. Google Earth Engine introductory learning resources.
3. NASA ARSET training materials on geospatial analysis.
4. QGIS and OpenStreetMap learning resources.
5. Transport GIS and mobility analytics tutorials.

Software Tools:

Core software tools:

- QGIS or ArcGIS for spatial analysis and mapping.
- Google Earth Pro for visualization and reconnaissance.
- Google Earth Engine for large-area analysis.
- Python or R for transport and geospatial data analysis.
- Excel / LibreOffice Calc for tabulation and reporting.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE)
The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:
(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 of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.
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 the practical test as indicated in the Table – ICs/IPCCs 1.
To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component		
Component	Description	Marks
Allotment of marks for regular classwork		
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

Students' activities for TW/SL under NCrF:
As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of

rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	**Transport base map preparation:** Prepare a georeferenced base map of an urban or regional transport study area showing roads, junctions, transit stops, land use, and important landmarks. Include coordinate system, scale, legend, north arrow, and source details.	25
2	**Transport corridor mapping** Use GIS to digitize a road corridor or transit route and prepare layers for carriageway, intersections, bus stops, railway stations, and activity centers. Add a short note on corridor characteristics and connectivity.	25
3	**Route suitability analysis** Prepare a simple suitability map for a proposed road or transit alignment using factors such as slope, land use, built-up area, water bodies, and constraints. Assign weights and explain the selection logic	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**QGIS / ArcGIS self-study** Learn layer management, symbology, georeferencing, digitization, buffer analysis, and map composition using a sample transport dataset.	25
2	**Google Earth Engine basics** Explore how time-series imagery can support corridor growth analysis, built-up mapping, or transport-related land-use studies.	25
3	**Case study review** Prepare a one-page review of a published transport GIS case study, such as congestion mapping, transit accessibility, or road expansion analysis.	25
4	**Data quality and ethics** Study privacy issues in mobility data, uncertainty in spatial layers, and responsible use of transport data in planning.	25

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear understanding of the transport GIS problem, objectives, and workflow.	Shows good understanding with minor gaps.	Basic understanding with limited clarity.	Understanding is weak or incorrect.
Task completion	Activity is completed	Activity is mostly	Activity is	Activity is

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
	fully, correctly, and on time.	complete with minor omissions.	partially complete.	incomplete or missing.
Technical accuracy	GIS layers, maps, or analysis are correct, properly processed, and well justified.	Mostly correct with few technical errors.	Contains noticeable errors but shows partial correctness.	Major technical errors or no meaningful attempt.
Data handling and workflow	Uses data systematically, follows proper workflow, and maintains good map/database structure.	Workflow is clear with minor gaps.	Workflow is incomplete or inconsistently followed.	Poor workflow and weak data handling.
Interpretation and analysis	Provides strong interpretation of spatial results and transport implications.	Gives reasonable interpretation with some analysis.	Interpretation is brief and descriptive.	Interpretation is minimal or absent.
Presentation and documentation	Work is neat, well structured, and easy to follow with proper maps, legends, and notes.	Organized well with minor formatting issues.	Acceptable presentation with several issues.	Poorly organized or difficult to read.

Sample rubrics for Self-Learning activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear and accurate understanding of the assigned concept.	Shows good understanding with minor gaps.	Basic understanding with limited detail.	Understanding is weak or incorrect.
Independent learning	Explores beyond the minimum requirement and shows initiative in learning.	Shows good initiative with some additional effort.	Completes the assigned task with limited exploration.	Relies heavily on guidance or shows little effort.
Task completion	Activity is completed fully, correctly, and on time.	Activity is mostly complete with minor omissions.	Activity is partially complete.	Activity is incomplete or missing.
Technical accuracy	Workflow, tool use, or analysis is correct and well	Mostly correct with few technical errors.	Contains noticeable errors but shows partial	Major technical errors or no meaningful

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
	justified.		correctness.	attempt.
Reflection and analysis	Provides strong reflection, interpretation, and learning outcomes.	Gives reasonable reflection with some analysis.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Organized well with minor formatting issues.	Acceptable presentation with several issues.	Poorly organized or difficult to read.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)	Student has good knowledge of some topics related to construction planning and BIM workflows. (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 planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)

Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output.	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio 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)

GEO BIM FOR GEOTECHNICAL MODELING AND UNDERGROUND INFRASTRUCTURE			
Course Code	**1MCV104D**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 Orientation:

This course is designed as an evidence-backed and VTU-executable IPCC that integrates the geotechnical application lifecycle with QGIS-based spatial work, structured ground investigation data, BIM/GeoBIM coordination for designed underground assets, analysis-output interpretation, and monitoring/dashboard/lifecycle decision support. The emphasis is on a single connected workflow rather than isolated software exercises. The course follows one geotechnical data journey: ground problem -> required information -> structured data -> GIS/map or section -> geotechnical interpretation -> BIM/GeoBIM coordination -> monitoring/risk decision output. This sequence helps students understand how field data, spatial context, and design coordination support safe and practical underground engineering decisions.

Only free, open-source, open-standard, or freely accessible tools are recommended throughout the course. Assessment is based on geotechnical reasoning, traceable data, maps, interpretation, coordination logic, and decision support, rather than on proprietary software command mastery.

Course Flow and Integrated Workflow Logic:

The course is built around one controlled project dataset, such as a 500 m hill-road, tunnel portal, deep excavation, utility corridor, or underground station zone. It uses a single continuous workflow so students can connect field data, spatial analysis, design coordination, and decision-making in one project context.

Learning flow: site/problem framing -> ground investigation data -> GIS mapping -> ground interpretation -> underground asset coordination -> geotechnical risk review -> monitoring/dashboard -> final decision memo.

Advanced concepts such as digital twins, linked data, AI forecasting, and model containers are introduced only as awareness topics after the base workflow is understood.

Course outcome (Course Skill Set):

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

1. CO1 (L2 – Understand): Explain the foundations of geotechnical engineering, GIS, BIM and GeoBIM across desk study, ground investigation, interpretation, analysis, construction monitoring and lifecycle records.
2. CO2 (L3 – Apply): Prepare a structured ground investigation data register using borehole, strata, groundwater, test, foundation/excavation, retaining-system, utility and monitoring information.
3. CO3 (L3 – Apply): Develop QGIS-based maps for terrain, borehole locations, drainage, slope/landslide zones, rockfall exposure, seismic/geohazard layers, utilities and underground infrastructure context.
4. CO4 (L4 – Analyze): Interpret geotechnical risks for foundations, excavations, retaining systems, slopes, rock masses, tunnels and groundwater using simplified checks, GIS outputs, model reviews and prepared analysis outputs.
5. CO5 (L4 – Analyze): Apply BIM/GeoBIM coordination logic for designed underground assets such as piles, retaining walls, tunnels, shafts, utilities, drainage systems, excavation zones, quantities and construction-stage awareness.
6. CO6 (L5 – Evaluate): Evaluate a portfolio-based digital geotechnical workflow using a single project dataset, monitoring records, trigger levels, dashboards, issue logs, decision memos, sustainability and human-centric safety/resilience criteria.

Module-1
Geotechnical Engineering, GIS, BIM and GeoBIM Foundations: • What geotechnical engineers do: interpreting soil, rock and groundwater as uncertain engineering information for design and construction decisions. • Geotechnical lifecycle: desk study, site reconnaissance, ground investigation planning, factual records, interpretive ground model, analysis/design, construction observation, monitoring and lifecycle records. • Three-pillar digital context: GIS for terrain/geology/hazards/corridors; BIM for designed/constructed assets; GeoBIM as the practical link between geospatial context, ground data and project information. • Project setup fundamentals: CRS/datum, coordinates, units, chainage, levels, file naming, data ownership, CDE-style folders and limitations of forcing ground data into ordinary BIM object categories. • Industry workflow: ground problem → required information → structured data → GIS/sections → geotechnical interpretation → coordination → decision output. • Free/open tool orientation: QGIS, PostGIS, GeoServer, QField/Mergin Maps, LibreOffice, HYRCAN, CloudCompare, Bonsai/IfcOpenShell and simple dashboard tools. **Linked COs: CO1, CO2, CO3** **Number of Hours: 10**
Module-2
Ground Investigation Data, Subsurface Interpretation and Digital Ground Models: • Ground investigation inputs: boreholes, trial pits, SPT/CPT, sampling, laboratory tests, RQD/core logs, groundwater readings, geophysics, field observations and monitoring points. • Difference between factual data and interpretive judgement; recording assumptions and uncertainty instead of presenting ground models as absolute truth. • Structured ground data template: borehole ID, coordinates, surface level, depth intervals, strata description, classification, samples/tests, groundwater dates, utilities, remarks and quality flags. • Subsurface interpretation outputs: borehole logs, ground sections, strata tables, groundwater notes, foundation/excavation zones and simple quantity fields. • Designed assets for coordination: piles, pile caps, basements, retaining walls, excavation support, utilities, drainage and ground-improvement zones as coordinate-controlled objects. • Spreadsheet-to-map/model awareness: students are assessed on data correctness, interpretation and coordination logic, not scripting mastery. **Linked COs: CO2, CO4, CO5** **Number of Hours: 08**
Module-3
GIS-Based Geohazard, Terrain and Corridor Risk Mapping: • Application areas: hill roads, cut slopes, embankments, landslides, rock slopes, rockfall zones, tunnel portals, foundations near slopes, retaining systems and drainage-sensitive corridors. • QGIS workflows: DEM/DTM, contours, slope angle, aspect, drainage, land cover, geology, rainfall, historical landslide inventory, seismic/geohazard overlays, utilities, boreholes and monitoring points. • Geotechnical interpretation: factor of safety concept, rainfall and pore-pressure influence, drainage, erosion, seepage paths, ground movement indicators, exposure and mitigation options. • Rock and earthquake awareness: discontinuities, bedding, weathering, RQD, planar/wedge/toppling failure, rockfall exposure, seismic slope risk and liquefaction screening where relevant. • Industry outputs: geohazard map, slope/rockfall inventory, mitigation-priority table, corridor risk zoning, screening sheet and decision note explaining required next investigation/design review. **Linked COs:** CO3, CO4, CO6 **Number of Hours:** 08
Module-4

Underground Assets, Analysis Outputs and GeoBIM Coordination:

- Underground infrastructure workflow: alignment/corridor study; ground model by chainage; tunnel portals; shafts; cross passages; utilities; basements; retaining systems; drainage; settlement-sensitive zones.
- Analysis awareness: bearing/settlement screening; earth pressure; seepage; slope stability; excavation deformation; tunnel settlement; soil–structure interaction; construction-stage behaviour; seismic/geotechnical risk screening using prepared open-source/simplified outputs.
- Interpreting analysis outputs: factor of safety, deformation contours, pore-pressure plots, settlement profiles, support class notes and sensitivity checks.
- Executable analysis exposure: spreadsheet checks, HYRCAN-style slope checks, OpenSees awareness for soil–structure interaction and instructor-prepared datasets.
- GeoBIM coordination outputs: linking GIS risk maps, structured ground data, interpretation and BIM/IFC/model-viewer information for underground assets, quantities, construction stages and issue tracking.

Linked COs: CO4, CO5, CO6 **Number of Hours: 08**

Module-5

Monitoring, Digital Twin Awareness and Lifecycle Decision Support:

- Construction and lifecycle monitoring: settlement markers, inclinometers, piezometers, crack meters, tilt sensors, vibration, rainfall gauges, tunnel convergence, visual inspections and progress/condition records.
- Human-centric safety logic: green/amber/red trigger levels, responsible action, escalation route, site inspection, design review, closure/mitigation and observational method awareness.
- Dashboard and decision outputs: LibreOffice/Metabase/Grafana-style monitoring dashboard, QGIS monitoring map, risk register, issue log, mitigation tracker, progress report and decision memo.
- Digital twin awareness: monitored physical ground/asset system + digital representation + sensor/inspection data + analysis/risk logic + action workflow, not merely a 3D model.
- Lifecycle portfolio: data register, GIS maps, sections, risk register, issue log, monitoring dashboard, handover note and reflection on uncertainty/limitations.

Linked COs: CO5, CO6 **Number of Hours:** 08

PRACTICAL COMPONENTS OF IPCC (LI-28 Hrs)

LIST OF EXPERIMENTS

The practical component is integrated with the theory component of this IPCC and is delivered through a structured set of fixed and open-ended experiments using one controlled geotechnical project dataset, focusing on open tools and traceable workflows.

Students shall perform practical exercises related to:

1. Project brief and data inventory: define one controlled teaching project site and list stakeholders, ground risks, available data and required decisions.
2. Structured ground data register: enter borehole, strata, groundwater, test, utility, foundation/excavation and monitoring fields into a spreadsheet template with IDs, coordinates, units and quality flags.
3. QGIS base map: map site boundary/corridor, borehole points, contours/DEM, drainage, utilities, proposed underground assets and constraints.
4. Ground interpretation outputs: prepare borehole logs, simple ground sections, groundwater notes and foundation/excavation zones from structured data; state assumptions and uncertainty.
5. Geohazard screening: prepare DEM-derived slope/drainage maps, landslide/rockfall inventory and mitigation-priority table.

6. Underground asset coordination: prepare a coordination sheet or model-viewer issue log showing piles, retaining systems, tunnel/shaft/utility zones, groundwater or settlement-sensitive areas and quantity fields.
7. Analysis-output interpretation: interpret one provided output such as slope factor of safety, seepage/pore-pressure plot, excavation deformation, settlement profile or tunnel support-risk output.
8. Chainage or zone risk register: link geology/groundwater, utilities, geohazards, settlement-sensitive locations, construction stages and responsible actions.
9. Monitoring dashboard: prepare a table/dashboard for piezometer, inclinometer, settlement/rainfall or tunnel-convergence readings with trigger levels and response actions.
10. Final portfolio and decision memo: compile GIS maps, structured data, sections, analysis interpretation, issue log, monitoring dashboard and recommendation memo.

Suggested Learning Resources

Text Books

1. Braja M. Das, Principles of Geotechnical Engineering and Principles of Foundation Engineering – soil, foundation and geotechnical fundamentals.
2. Braja M. Das, Principles of Geotechnical Engineering and Principles of Foundation Engineering – soil, foundation and geotechnical fundamentals.
3. Donald P. Coduto, Man-chu Ronald Yeung and William A. Kitch, Geotechnical Engineering: Principles and Practices – practical geotechnical decision-making.
4. J. Michael Duncan, Stephen G. Wright and Thomas L. Brandon, Soil Strength and Slope Stability – slope stability applications.
5. Duncan C. Wyllie and Christopher W. Mah, Rock Slope Engineering: Civil Applications – rock slope and rockfall context.
6. John Dunnicliff, Geotechnical Instrumentation for Monitoring Field Performance – monitoring, trigger levels and observational method.

Reference Books / Manuals

1. Taylor & Francis / CRC Press — Building Information Modelling in Geotechnical Engineering — Geotechnical BIM reference chapter/source.
2. Lawrence KW Shum — Evolution of Three-Dimensional Geotechnical Information Infrastructure — AIJR Books.
3. Charles Eastman, Paul Teicholz, Rafael Sacks, Kathleen Liston — BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers — John Wiley & Sons.
4. Bansal — GIS and BIM in Infrastructure Projects: An Introduction to Applications Across the Lifecycle — Routledge.
5. André Borrmann, Markus König, Christian Koch, Jakob Beetz — Building Information Modeling: Technology, Foundations and Industry Practice — Springer.
6. UNECE / TEM Working Group — Building Information Modelling (BIM) for Road Infrastructure: TEM Requirements and Recommendations — UNECE.
7. ISO — ISO 19650-1:2018 — International Organization for Standardization.
8. buildingSMART International — openBIM and IFC Guidance Documents — buildingSMART International.
9. Central Public Works Department (CPWD), Government of India — CPWD BIM / Works Manuals and Publication Guidance — CPWD.
10. Relevant department-prescribed agencies — Geotechnical Investigation Manuals, Underground Utility Mapping Standards, and Tunneling Guidance Documents — As prescribed.

Web links and Video Lectures (e-Resources) & Software tools

1. QGIS Training Manual, PostGIS documentation, GRASS/SAGA GIS resources, HYRCAN documentation and open geospatial data resources – GIS and geohazard workflows.
2. buildingSMART International documentation on IFC, BCF, IDS and bSDD – coordination and

information exchange awareness for GeoBIM/openBIM.
3. Selected papers/case studies on GeoBIM, tunnel ground modelling, FAIR geotechnical data, BIM–GIS integration and geotechnical digital twins – advanced awareness topicsbuildingSMART International – openBIMOfficial resources on IFC, interoperability, and openBIM workflows. Useful for standards-based Geo-BIM learning. Link: buildingSMART openBIM
4. ISO 19650 guidance – BSI / ISO resourcesReference material on information management using BIM, suitable for project data organization and collaboration. Link: ISO 19650 resources
5. CPWD Publication / BIM guidance. Government guidance and publications useful for Indian infrastructure and public works context.

SOFTWARE TOOLS:

The course shall be delivered using free, open-source, open-standard or freely accessible educational tools wherever possible. No proprietary software ecosystem shall be treated as mandatory or preferred. Assessment shall be based on workflow understanding, information quality, open exchange, validation, coordination response and decision support, not on proprietary software command mastery.

Workflow Need	Recommended Free / Open / Freely Accessible Tools
GIS and spatial data	QGIS, PostgreSQL/PostGIS, GeoServer, QField, Mergin Maps, GRASS GIS, SAGA GIS
Ground data and reporting	LibreOffice Calc, CSV templates, borehole/strata registers, open geotechnical data schema awareness
Geohazard/analysis awareness	HYRCAN, OpenSees awareness, spreadsheet checks, prepared open-source/simplified outputs
Reality/context data	CloudCompare, MeshLab, QGIS point-cloud/raster tools, open DEM and map data
Coordination/dashboard	Bonsai/IfcOpenShell, IFC viewers, Grafana, Metabase, LibreOffice dashboards, BCF-style issue logs

Teaching-Learning Process (Innovative Delivery Methods):
The following are sample strategies that educators may adopt in addition to chalk and talk 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

Suggested Strategies:

- Use problem-based labs built around one connected project dataset rather than disconnected software exercises.
- Start each topic with the real project decision, then define the information needed, the model/data workflow, the exchange/checking method and the output evidence.
- Use demonstrations, guided practice, openBIM/GIS inspection, peer review, issue-response cycles, role-play and portfolio submissions.
- Industry guest lectures may be used to discuss workflow, information requirements and decision-making, not brand-specific command training.s.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(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 of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

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 the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
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**

Term work and Self Learning:

Students' activities for TW/SL under NCrF: As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester

1	Underground utility mapping and clash analysis case study.	25
2	Geotechnical and structural coordination mini-project for a basement, tunnel, or retaining system.	25
3	Concept practice in soil behavior, ground investigation, and underground construction workflows.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	Geo-BIM literature review and summary report on underground infrastructure applications.	25
2.	Tool and software exploration using approved Geo-BIM and geotechnical design tools.	25

Geo-BIM Mini-Project Rubric

Criterion	Exemplary 3	Proficient 2	Basic 1
Problem definition and scope	Clear objective, appropriate project scope, complete assumptions and geotechnical breakdown.	Objective mostly clear with minor gaps.	Scope vague, assumptions incomplete or inconsistent.
Modeling quality	Accurate element placement, correct geometry, and logical subsurface organization.	Mostly correct with minor errors.	Frequent modeling errors or incomplete workflow.
Coordination and constructability	Meaningful identification of interface issues and practical geotechnical insight.	Basic issue identification and limited interpretation.	Minimal or unclear coordination review.
Documentation and presentation	Well-structured model set, schedules, quantities, and reflection.	Organized but some sections are weak.	Poorly organized or incomplete portfolio.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site	Student has good knowledge of some topics related to construction planning and BIM workflows. (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)

	logistics. (4)			
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output. (3)	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio 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)

GEOSPATIAL ENVIRONMENTAL MONITORING AND MODELING			
Course Code	**1MCV104E**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 - Understand the concepts of geospatial data, environmental monitoring, and modeling workflows.
2. CO2 L3 - Apply GIS, remote sensing, and field data integration for environmental assessment.
3. CO3 L3 - Apply geospatial tools for mapping, preprocessing, and spatial analysis of environmental variables.
4. CO4 L4 - Analyze temporal and spatial environmental patterns using geospatial models.
5. CO5 L4 - Analyze monitoring outputs to support environmental planning and decision-making.
6. CO6 L5 - Evaluate a geospatial environmental monitoring and modeling workflow through a portfolio-based project

Module-1

Geospatial foundations for environmental monitoring:

- Concepts of environmental monitoring and modelling; environmental indicators, spatial and temporal scales of observation.
- Overview of geospatial technologies: remote sensing (RS), geographic information systems (GIS), global navigation satellite systems (GNSS), in-situ sensor networks for environmental applications.
- Geospatial data sources and characteristics: maps, aerial photographs, satellite imagery, DEM/DSM, crowdsourced and sensor data; spatial and attribute data structures.
- Environmental case examples: land-use/land-cover (LULC) dynamics, watershed condition, urban heat islands, pollution hotspots.

Linked COs: CO1, CO2 **Number of Hours: 8**

Module-2

Remote sensing for environmental variables and change:

- Fundamentals of remote sensing: electromagnetic spectrum, interaction of EMR with atmosphere and earth surfaces (water, vegetation, soil, built-up); spectral signatures of key environmental features.
- Sensors and platforms for environmental monitoring: multispectral, hyperspectral, thermal and microwave sensors; spatial, spectral, radiometric and temporal resolutions; environmental satellite missions (illustrative examples).
- Image preprocessing: radiometric and geometric correction, atmospheric correction, image registration and mosaicking for environmental time-series analysis.
- Environmental indices and products: vegetation and drought indices (e.g., NDVI family), water and moisture indices (e.g., NDWI-type), urban/built-up indices for sprawl and heat-island assessment.
- Image classification and change detection: supervised and unsupervised classification concepts, accuracy assessment, post-classification change detection, multi-temporal analysis for land-use/land-cover and ecosystem change

Linked COs: CO1, CO2 **Number of Hours: 10**

Module-3

GIS and spatial analysis for environmental applications:

- GIS concepts and data models: raster and vector data, topology, attribute tables; geodatabase design for environmental datasets.
- Spatial data acquisition and management: digitization, georeferencing, projections, metadata, data quality and error sources in environmental GIS.
- Spatial analysis tools: map algebra, overlay operations, buffering, proximity and network analysis for environmental site selection, hazard and service-coverage studies.
- Terrain and watershed analysis: DEM/DTM generation, slope, aspect and curvature, watershed and stream network delineation, basic erosion/susceptibility mapping in GIS.
- Introduction to spatial multi-criteria analysis (SMCA) for environmental suitability and vulnerability mapping.

Linked COs: CO2, CO3 **Number of Hours: 8**

Module-4

Environmental modelling with geospatial inputs:

- Role of models in environmental engineering: types of models (empirical, conceptual, physically based), model structure, calibration, validation and sensitivity analysis.
- Watershed and hydrological modelling: rainfall–runoff, infiltration, surface and groundwater interactions; use of RS/GIS data for parameterization and scenario analysis.
- Water-quality and pollution modelling: point and non-point source pollution, basic transport and fate concepts; integration of land-use, hydro-meteorological and monitoring data in GIS environments.
- Land-use/land-cover and habitat models: habitat suitability, environmental flow support, biodiversity and ecosystem-service-related models using geospatial layers.
- Uncertainty in geospatial environmental models: data gaps, resolution and scale effects, model assumptions; communication of reliability to decision-makers.

Linked COs: CO3, CO4 **Number of Hours: 8**

Module-5

Advanced tools, cloud platforms and case studies:

- Open-source and commercial platforms for geospatial environmental analysis: QGIS/GRASS, ArcGIS Pro/ArcGIS Online, and specialized environmental extensions (overview).
- Cloud-based geospatial platforms: concepts of cloud computing for big geospatial data; introduction to Google Earth Engine style workflows for large-area environmental monitoring and time-series analysis.
- Basic machine learning for environmental predictions: examples of regression/classification for streamflow, evapotranspiration, land-cover change or pollution forecasting using geospatial inputs.
- Case studies in geospatial environmental monitoring and modelling: urban expansion and air-quality; flood and drought risk mapping; soil erosion and landslide susceptibility; climate vulnerability and ecosystem change.
- Ethics, governance and sustainability: data privacy, citizen science, open data policies; responsible use of geospatial technologies for environmental decision-making.

Linked COs: CO4, CO5 **Number of Hours: 8**

PRACTICAL COMPONENTS OF IPCC (LI-28 Hrs)

LIST OF EXPERIMENTS

1. Prepare georeferenced base maps using GIS software.
2. Import and preprocess satellite or UAV-derived environmental data.
3. Generate land use/land cover maps from sample imagery.
4. Perform buffer and overlay analysis for an environmental study area.
5. Create terrain-derived layers such as slope, aspect, and elevation zones.
6. Carry out spatial interpolation for sampled environmental parameters.
7. Prepare a change-detection analysis using multi-date data.
8. Develop a pollution or hazard susceptibility map.
9. Integrate field survey observations with GIS layers.
10. Compile a geospatial environmental monitoring portfolio.

Suggested Learning Resources

Text Books

1. Burrough, P. A., and McDonnell, R. A. Principles of Geographical Information Systems.
2. Jensen, J. R. Remote Sensing of the Environment: An Earth Resource Perspective.
3. Chang, K. Introduction to Geographic Information Systems.
4. Campbell, J. B., and Wynne, R. H. Introduction to Remote Sensing

Reference Books / Manuals

1. Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W. Geographic Information Systems and Science.
2. Lillesand, T., Kiefer, R., and Chipman, J. Remote Sensing and Image Interpretation.
3. Open-source GIS documentation and environmental modeling manuals.
4. Government and agency technical manuals on environmental monitoring and spatial analysis.

Web links and Video Lectures (e-Resources) & Software tools

1. NPTEL: Remote Sensing and GIS — a full lecture series covering remote sensing basics, image correction, image classification, GIS, and applications of remote sensing and GIS.
2. NPTEL/SWAYAM preview: Remote Sensing and GIS — useful as a course entry point and for structured lecture access.
3. NASA ARSET: Using Google Earth Engine for Land Monitoring Applications — training material on change detection, time-series analysis, land cover classification, and accuracy assessment.
4. Google Earth Engine introductory video — practical demonstration of using GEE for environmental monitoring, including Sentinel-2 selection, composites, and NDVI.
5. Google Earth Engine lab tutorial series — useful for hands-on environmental monitoring workflows and coding practice.
6. GeoField Resources — curated learning opportunities and practical toolkits for remote sensing, Google Earth Engine, and spatial analytics.

Software Tools:

Core software tools:

- QGIS or ArcGIS for spatial analysis and mapping.
- Google Earth Pro for visualization and reconnaissance.
- ERDAS Imagine or equivalent for image processing.
- Python or R for environmental data analysis.
- Excel / LibreOffice Calc for tabulation and reporting.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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)
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Assessment Structure (both CIE and SEE)

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Continuous Internal Evaluation:

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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

Students' activities for TW/SL under NCrF: As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	**Perform spatial analysis for an environmental issue.** Example tasks include buffer analysis around water bodies, overlay analysis for pollution zones, or proximity analysis for sensitive receptors	25
2	**Create terrain and drainage interpretation layers.** Students derive slope, aspect, elevation zones, and drainage influence maps to support watershed or hazard analysis	25
3	**Develop a change-detection study using multi-date imagery.** Students compare two time periods to identify urban expansion, deforestation, wetland loss, or land degradation.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**Explore an open-source GIS workflow.** Learn QGIS basics, load sample environmental layers, and prepare a short note on menu functions, map composition, and spatial analysis tools	25
2	**Study Google Earth Engine fundamentals.** Watch an introductory tutorial, create a simple script, and document one environmental monitoring example such as NDVI or land cover change.	25
3	**Complete a mini case study.** Choose one topic such as flood risk, urban heat island, deforestation, or watershed monitoring, and prepare a short self-study report using publicly available data	25
4	**Compare two geospatial tools.** Prepare a comparison between QGIS and Google Earth Engine, or QGIS and GRASS GIS, focusing on purpose, strengths, and limitations	25

Sample rubrics for self-learning activities:

Criterion	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear and accurate understanding of the assigned concept; explanations are complete and insightful.	Shows good understanding with minor gaps.	Basic understanding with limited detail.	Understanding is weak or incorrect.

Criterion	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Task completion	Activity is completed fully, correctly, and on time.	Activity is mostly complete with minor omissions.	Activity is partially complete.	Activity is incomplete or missing.
Technical accuracy	Workflow, tool use, or analysis is correct and well justified.	Mostly correct with few technical errors.	Contains noticeable errors but shows partial correctness.	Major technical errors or no meaningful attempt.
Reflection and analysis	Provides strong reflection, interpretation, and learning outcomes.	Gives reasonable reflection with some analysis.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Organized well with minor formatting issues.	Acceptable presentation with several issues.	Poorly organized or difficult to read.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)	Student has good knowledge of some topics related to construction planning and BIM workflows. (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 planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)

Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output. (3)	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio 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)

BIM AND HYDRO-GIS MODELING FOR RIVER BASIN SYSTEMS			
Course Code	**1MCV104F**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 — Understand): Explain the fundamentals of BIM, GIS, Hydro-GIS, GeoBIM, and river basin information workflows.
2. CO2 (L3 — Apply): Prepare georeferenced spatial datasets, terrain models, and basin asset information for river basin projects.
3. CO3 (L3 — Apply): Develop basic BIM-Hydro-GIS information models for basin assets such as barrages, canals, embankments, regulators, culverts, drains, tunnels, pump stations, and river training works.
4. CO4 (L4 — Analyze): Analyze integrated BIM-GIS models to identify spatial conflicts, flood exposure, drainage issues, constructability constraints, and information-quality problems.
5. CO5 (L4 — Analyze): Prepare maps, model views, drawings, schedules, issue logs, material/quantity summaries, and coordination reports from integrated BIM-Hydro-GIS workflows.
6. CO6 (L5 — Evaluate): Evaluate an integrated Hydro-GIS/VDC workflow for a selected river basin project through a portfolio-based submission.

Module-1

Fundamentals of BIM, Hydro-GIS and River Basin Systems:

- Introduction to BIM, GIS, Hydro-GIS, GeoBIM and VDC: definitions, scope, applications, and limitations in river basin projects.
- Overview of river basin systems: rivers, tributaries, canals, embankments, barrages, dams, spillways, sluices, regulators, culverts, drains, detention structures, pump stations, and riverfront work.
- BIM as a digital asset and project information model; GIS as a spatial context and analysis framework.
- Difference between surveying, CAD drafting, GIS mapping, civil modelling, BIM/VDC coordination, and hydrologic/hydraulic simulation models.
- Role of BIM-GIS integration in basin planning, design coordination, construction documentation, flood management, site review, asset handover, and lifecycle information management.

COs mapped: CO1, CO2 **Number of Hours: 10**

Module-2

Spatial Data, Georeferencing and Information Setup:

- Coordinate reference systems, georeferencing, model origin, map projections, levels, units, scale, and accuracy management.
- Spatial data types: raster, vector, DEM, contours, drainage layers, land use, soil, survey data, floodplain layers, river network layers, and asset-location data.
- BIM/civil asset information basics: elements, objects, attributes, parameters, classification, metadata, asset IDs, status, and revision information.
- Data preparation and cleaning for terrain, basin assets, drainage context, and project information exchange.
- Interoperability basics: IFC for built/infrastructure assets where applicable, LandXML for civil/terrain

data, GeoPackage/GeoTIFF/CSV for GIS data, and BCF or structured issue logs for coordination.

COs mapped: CO2, CO3, CO6 **Number of Hours: 08**

Module-3

Terrain, Basin Asset Modelling and Documentation:

- Terrain modelling using DEM, contours, slopes, profiles, sections, river alignments, floodplain extents, and site context.
- Modelling and representation of basin infrastructure assets such as canals, culverts, embankments, retaining structures, barrages, dams, spillways, tunnels, pump stations, regulator structures, and control/service buildings.
- Preparation of general arrangement drawings, construction views, model sheets, material schedules, quantity summaries, and asset registers from model-based workflows.
- Linking spatial features with asset information, structural details, hydraulic function, maintenance data, and risk/exposure attributes.
- Model limitations, scale issues, level of information need, and practical considerations in project-level river basin representation.

COs mapped: CO2, CO4, CO6 **Number of Hours: 08**

Module-4

Hydro-GIS Coordination, Model Validation and Spatial Risk Review:

- Integration of terrain, GIS layers, survey data, drainage/floodplain context, and BIM/civil asset models for river basin planning and review.
- Multidisciplinary model coordination for civil, structural, hydraulic, geotechnical, tunnel, powerhouse, electromechanical, and site-interface information.
- Spatial risk review: floodplain exposure, drainage bottlenecks, encroachment, access constraints, terrain conflicts, and infrastructure interface issues.
- Model validation and information-quality checks: georeferencing, naming, classification, asset attributes, revision status, model completeness, and coordination issues.
- Issue logging, model review, design review reporting, and BIM-on-site / BIM2Field information workflows.

COs mapped: CO3, CO4, CO5 **Number of Hours: 08**

Module-5

4D/5D Awareness, Analysis Data Models and Portfolio Delivery:

- Preparation of maps, model sheets, thematic layers, drawings, schedules, quantity/material summaries, asset registers, and coordination reports.
- Introductory 4D/5D applications for river basin infrastructure: construction sequencing, excavation staging, access planning, quantity/cost linkage, and progress review.
- Data requirements for hydrologic and hydraulic analysis: geometry simplification, terrain context, sections, material data, boundary conditions, loads, water levels, and model-output feedback.
- Asset handover and lifecycle information: as-built/record information, inspection data, maintenance attributes, and digital twin awareness
- Final portfolio compilation: GIS layers, model files, maps, drawings, schedules, issue logs, analysis/interface notes, and reflective workflow report.

COs mapped: CO4, CO5, CO6 **Number of Hours: 08**

PRACTICAL COMPONENTS OF IPCC (LI-28 Hrs)

LIST OF EXPERIMENTS

Students shall perform practical exercises related to:

1. GIS and BIM-GIS workspace setup using a selected river basin case.
2. Coordinate system selection, georeferencing, and base map preparation.
3. DEM import, contour generation, terrain visualization, slope/profile extraction.
4. Drainage network, river alignment, floodplain/context layer preparation.
5. Basin infrastructure asset mapping: canal, culvert, embankment, barrage, dam, tunnel, powerhouse, pump station, or related asset.
6. Basic BIM/civil asset modelling or model review of selected basin infrastructure elements.
7. BIM-GIS alignment and asset information linking using IDs, location, type, status, capacity, condition, and risk attributes.
8. Spatial risk and coordination review: exposure, encroachment, access, bottleneck, and interface issues.
9. Preparation of maps, model views, issue log, schedules, and final portfolio presentation.

Suggested Learning Resources:

Text Books:

1. Eastman, C. et al., BIM Handbook, John Wiley & Sons.
2. Burrough, P. A. and McDonnell, R. A., Principles of Geographical Information Systems, Oxford University Press.
3. Maidment, D. R., Handbook of Hydrology, McGraw-Hill.
4. Standard texts/manuals on hydrology, water resources engineering, hydraulic structures, GIS, remote sensing, and infrastructure asset management.

Reference Books / Manuals:

1. ISO 19650 introductory resources for information management using BIM.
2. buildingSMART resources on openBIM, IFC, BCF, IDS, bSDD and interoperability.
3. GIS and hydrology practice notes from official software documentation and academic manuals.
4. Government basin planning, flood management, dam safety, and water infrastructure reports.
5. Industry resources on BIM/VDC for hydropower, hydraulic structures, dams, tunnels, powerhouses, and BIM-on-site workflows.
6. Open-source modelling references for basin planning and managed water systems, including QGIS, HEC-HMS, HEC-RAS, SWMM, Ribasim, GRASS GIS and SAGA GIS documentation.
7. GIS learning and hydrology teaching materials such as introductory GIS texts and open hydrological courseware.

Web links and Video Lectures (e-Resources) & Software tools:

1. ISO 19650 introductory resources for BIM information management.
2. buildingSMART resources on openBIM, IFC and interoperability.
3. Official QGIS, GRASS GIS and SAGA GIS documentation for spatial analysis, raster processing and DEM workflows.
4. HEC-HMS, HEC-RAS and EPA SWMM documentation/tutorials for basic hydrologic and hydraulic modelling exposure
5. Government basin planning, flood mapping, dam safety and water infrastructure manuals.

6. Industry case studies on BIM/VDC in hydropower, dams, tunnels, hydraulic structures, powerhouses and BIM-on-site workflows.
7. GIS learning and hydrology teaching materials from NPTEL/SWAYAM, official agencies and open educational repositories.

SOFTWARE TOOLS:

Tool selection shall remain vendor-neutral. Core practical exercises shall preferably use open/free tools where possible, with exposure to industrial tools only where institutional access, faculty capability and project relevance exist. No single vendor platform shall be mandatory for achieving the course outcomes.

Open/free teaching tools and formats:

1. QGIS — GIS mapping, spatial analysis, thematic layers, georeferencing and map layouts.
2. GRASS GIS / SAGA GIS — raster, DEM, terrain, slope, drainage and basin preprocessing.
3. HEC-HMS — introductory rainfall-runoff and watershed simulation exposure.
4. HEC-RAS — introductory river hydraulics, water levels and floodplain/inundation exposure.
5. EPA SWMM — introductory stormwater and drainage network modelling exposure.
6. Ribasim — river basin planning and managed water systems exposure.
7. BlenderBIM / Bonsai, FreeCAD BIM Workbench or IFC viewers — openBIM and IFC-based asset information review where applicable.
8. Python with QGIS plugins — data cleaning, preprocessing, automation and reproducible workflows.
9. GeoPackage, GeoTIFF, CSV, LandXML, CityGML, IFC where applicable, and BCF/structured issue logs — exchange and reporting formats.

Industrial exposure tools, subject to availability:

1. ArcGIS Pro / ArcGIS Online — enterprise GIS, spatial analysis, 3D scenes and asset/context mapping.
2. Civil 3D / OpenRoads / OpenSite / InfraWorks or equivalent — civil terrain, alignments, profiles, corridors, embankments, canals and infrastructure documentation.
3. InfoWorks, MIKE+, WaterGEMS/SewerGEMS or equivalent — water, stormwater, sewer and hydraulic network modelling exposure.
4. iTwin, ProjectWise, BIMcollab, Solibri, Revizto, Dalux, Navisworks or equivalent — model coordination, issue management, design review and BIM-on-site workflows.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk-and-talk 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

Suggested strategies:

1. Flipped classroom segments for WBS, CPM, 4D linking and model-readiness review.
2. Problem-based planning exercises using one live-hypothetical building project throughout the semester.
3. Simulation and portfolio labs for 4D sequencing, resource planning, site logistics, progress reporting and issue tracking.

4. Guest lectures by planning engineers, BIM/VDC coordinators, project-control engineers or site managers.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(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 of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

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 the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
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**

Students' activities for TW/SL under NCrF:

As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics

developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	Hydro-GIS mini-project: terrain, asset layers, model views and issue log.	25
2	Spatial risk and asset exposure portfolio for a selected river basin reach or facility.	25
3	Open-book team challenge on basin coordination, information quality and issue identification.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	MOOCs / online certification on GIS, hydraulic infrastructure, information management or digital construction	25
2	Tool and software exploration using approved GIS, hydraulic, openBIM or civil infrastructure tools.	25
3	Competitive aptitude and concept practice in GIS, hydraulic infrastructure and BIM-GIS information workflows.	25

Rubric for mini-project

Criterion	Exemplary	Proficient	Basic
Problem definition and scope	Clear objective, appropriate basin scope, complete assumptions and data sources	Objective mostly clear with minor gaps	Scope vague; assumptions incomplete or inconsistent
Modeling quality	Accurate spatial layers, terrain/context data, asset information and logical model organization	Mostly correct with minor errors	Frequent modelling errors or incomplete workflow
Coordination and interpretation	Meaningful identification of spatial, drainage, asset exposure, constructability and interface issues with practical insight	Basic issue identification and limited interpretation	Minimal or unclear coordination review
Documentation and presentation	Well-structured maps, model views, schedules, issue logs, analysis/interface notes and reflection	Organized but some sections are weak	Poorly organized or incomplete portfolio

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D	Student has good knowledge of some topics related to construction	Student is capable of narrating the answer but not capable to show in depth	Student has not understood the concepts clearly. (1)

	workflows, project controls and site logistics. (4)	planning and BIM workflows. (3)	knowledge. (2)	
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output. (3)	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio 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)

BIM FOR INFRASTRUCTURE ENGINEERING AND MANAGEMENT			
Course Code	**1MCV104G**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 - Understand): Explain BIM for infrastructure as an information-management and site-delivery workflow across planning, design, construction, handover and operation.
2. CO2 (L3 - Apply): Identify and request survey, GIS, utility, geotechnical, reality-capture and asset information required for infrastructure projects, including accuracy, format, status and responsibility.
3. CO3 (L3 - Apply): Develop or inspect fit-for-purpose infrastructure models using terrain, alignment, corridor, drainage, utility and bridge/culvert/tunnel interface information.
4. CO4 (L4 - Analyze): Structure and check infrastructure information using naming, classification, metadata, revision/status control, IFC/BCF/LandXML/GIS exchange awareness and CDE workflows.
5. CO5 (L4 - Analyze): Analyze coordination, constructability, quantity, schedule, site logistics, temporary-works awareness and progress-verification issues in infrastructure projects.

1. 6. CO6 (L5 - Evaluate): Evaluate as-built evidence, handover information, asset data, operation and maintenance needs and digital-twin readiness for lifecycle infrastructure management.

Module-1

BIM Fundamentals and Infrastructure Information Management:

- BIM for infrastructure as information management, not only 3D modelling or software use.
- Traditional workflow versus BIM enabled workflow for Greenfield and brownfield infrastructure projects.
- Infrastructure systems in an airport: roads, bridges, culverts, tunnels, utilities, drainage, side works. Conveyor belts and public assets.
- Information requirements: purpose, decision, responsible party, format, accuracy, status, revision, approval and acceptance.
- CDE workflow, naming, metadata, version control, issue records, OpenBIM awareness and model/data deliverables.

C**Os mapped: CO1, CO2, CO4** **Number of Hours: 10**

Module-2

Site Information, Survey/GIS Inputs and Model Setup:

- Existing-condition information for infrastructure: topographic survey, coordinate system, datum, terrain/DTM, GIS context and alignment/chainage.
- Brownfield data risks: legacy drawings, hidden utilities, live traffic/operations, restricted access, unknown as-built conditions and environmental/site constraints.
- Survey and reality-capture awareness: total station/GNSS, drone imagery, LiDAR/point cloud, 360 capture, GPR/utility detection and condition/progress evidence.
- Preparing data requests and selecting appropriate specialists: surveyor, GIS specialist, utility detection team, geotechnical team, BIM coordinator and site team.
- Project setup in BIM/CDE: alignment, corridor, levels, zones, work packages, model status and assumptions register.

COs **mapped: CO1, CO2, CO3** **Number of Hours: 08**

Module-3

Infrastructure Modeling and Information Structuring:

- Fit-for-purpose modelling of terrain, roads, pavements, junctions, drainage, utilities, culverts, retaining structures and bridge/tunnel interfaces.
- Model breakdown for linear infrastructure: corridor, chainage, zone, system, package, structure and asset object.
- Required information: geometry, levels, clearances, quantities, classification, asset IDs, property data, assumptions and model limitations.
- OpenBIM and exchange awareness: IFC/IFC 4.3 concepts, BCF issue communication, LandXML/GIS context and basic asset-data tables.
- Model quality checks: georeferencing, duplicates, omissions, naming, data completeness, quantity readiness and interoperability.

COs mapped: CO2, CO3, CO4 **Number of Hours: 08**

Module-4

Site Management, Quantity Extraction and Infrastructure Coordination:

- Construction-stage use of BIM information for site management, staging, constructability, coordination and project control.
- Coordination review: utility conflicts, drainage conflicts, clearance issues, bridge/culvert/tunnel interfaces, temporary works awareness and safety/public-interface risks.
- Site logistics: access, work zones, traffic diversion, plant/material movement, excavation zones, environmental controls and phased construction.
- Quantity take-off and project-control outputs: earthwork, pavement, concrete, reinforcement, drainage/utilities, change records and quantity assumptions.
- Progress verification and issue control using model views, field records, drone/point-cloud/360 evidence, RFIs, BCF-style issue logs and closure reports.

COs mapped: CO3, CO4, CO5 **Number of Hours: 08**

Module-5

Infrastructure Documentation, As-built Handover and Portfolio Delivery:

- Infrastructure drawing and documentation outputs: plans, profiles, cross-sections, sheets, schedules, quantities, issue logs and review records.
- As-built and handover information: verified site records, buried utility evidence, asset registers, operation and maintenance data, inspection zones and maintainability attributes.
- PIM to AIM transition: what project information must become usable asset information for owner/FM and operation and maintenance teams.
- Digital twin readiness: linking BIM, GIS, asset data, inspection records, sensors/work orders and dashboards without claiming a full operational twin.
- Final portfolio: information request, model/data package, coordination log, site-management output, quantities, handover table and reflective report.

COs mapped: CO4, CO5, CO6 **Number of Hours: 08**

PRACTICAL COMPONENTS OF IPCC (LI: 28hrs)

LIST OF EXPERIMENTS

1. Students shall perform practical exercises related to:
1. BIM/CDE workspace setup for an infrastructure project: folders, naming, status, revision and responsibility matrix.
2. Prepare an infrastructure information request covering survey, GIS, utility, geotechnical, reality-capture and asset data.
3. Review or create terrain/site-context data using survey/GIS/DEM inputs; document coordinate system, datum and assumptions.
4. Prepare a brownfield information risk register covering utilities, access, live operations, environmental constraints and missing as-built data.
5. Develop a fit-for-purpose corridor model with road/drainage/utility information and one bridge,

culvert or tunnel interface.

6. Add classification, asset IDs, key properties, quantities and model limitations suitable for coordination and reporting.
7. Inspect or export OpenBIM/coordination outputs using IFC/BCF/LandXML/GIS context where available; record exchange issues.
8. Conduct coordination review and prepare clash/clearance/constructability issue logs with responsibility and closure status.
2. 9. Prepare a site-management and handover portfolio including 4D/staging view, logistics note, progress/as-built evidence and asset-data table.

Suggested Learning Resources

Text Books

1. Eastman, C., Teicholz, P., Sacks, R., and Liston, K., BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers, John Wiley & Sons.
2. Hardin, B. and McCool, D., BIM and Construction Management: Proven Tools, Methods, and Workflows, John Wiley & Sons.
3. Baldwin, M., The BIM Manager: A Practical Guide for BIM Project Management.
4. Baldwin, A. and Bordoli, D., A Handbook for Construction Planning and Scheduling.
5. Kumar, B., A Practical Guide to Adopting BIM in Construction Projects, Whittles Publishing.
3. Reference Books / Manuals
1. buildingSMART resources on IFC, BCF, IDS, openBIM and infrastructure data exchange.
2. ISO 19650 / UK BIM Framework / EFCA guidance on information management, CDE, BEP and level of information need.
3. Infrastructure BIM, road, bridge, tunnel, utility, asset handover and digital-delivery guides issued by public authorities or professional bodies.
4. RICS, owner/FM handover, asset information, digital twin readiness and infrastructure information-management references.
4. 5. Indian public-sector BIM/CDE/EIR guidance, CPWD/BIS/NBC/BIM guideline drafts and infrastructure case studies as applicable.

Web links and Video Lectures (e-Resources) & Software tools:

1. NPTEL / SWAYAM modules on BIM, GIS, construction management, surveying, planning and digital construction.
2. buildingSMART International resources on IFC, BCF, IDS, bSDD and openBIM workflows.
3. QGIS, CloudCompare, WebODM/OpenDroneMap, Potree, IfcOpenShell, Bonsai/BlenderBIM and BCF tool documentation.
4. Public infrastructure BIM case studies covering roads, bridges, tunnels, utilities, airports, asset handover and digital delivery.
5. Software Tools:
6. BIM/civil tools: Civil 3D, InfraWorks, Bentley OpenRoads/OpenBridge/OpenBuildings, Revit, Tekla or equivalent.
7. Coordination/site tools: Navisworks, Solibri, BIMcollab, Revizto, Synchro/4D tools, ACC/ProjectWise/CDE platforms or equivalent.
8. GIS/reality-capture tools: QGIS, ArcGIS, CloudCompare, WebODM/OpenDroneMap, Pix4D/Metashape, Potree or equivalent.
9. - Open-source/learning tools: Bonsai/BlenderBIM, IfcOpenShell, FreeCAD, BIM Vision/xBIM viewers, Speckle, spreadsheets and dashboards.

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

Suggested Strategies:

- Use one brownfield infrastructure case throughout the semester, with greenfield workflow used as the simple baseline.
- Conduct role-based exercises where students act as construction manager, surveyor, BIM coordinator, GIS specialist, utility coordinator and asset owner.
- Use sample datasets, issue logs, CDE folders, model snapshots and site constraints instead of relying only on software commands.
- Invite industry speakers from infrastructure construction, surveying/GIS, BIM coordination, site planning and asset management.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(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 of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

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 the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork and independent handling of BIM/GIS datasets, CDE folders, coordination tools and site-information workflows during lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of digital lab record, assumptions, input data, screenshots, issue logs, outputs and timely submission.	10 marks
Subtotal		15
Allotment of marks for CIE practical test		
Laboratory Test /	Ability to set up project files/datasets, follow workflow	5

	Experiment Performance	steps, record assumptions, generate outputs and obtain correct results in the test exercise.	marks
	Viva-Voce	Understanding of theory, information requirements, workflow logic and outputs; ability to explain results and answer related questions.	5 marks
	Subtotal		10
	Total		25

Term work and Self Learning:
Students' activities for TW/SL under NCrF: As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes. The learning activities of TW/SL shall be considered as CCA component of CIE.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Brownfield infrastructure information mini-project: data request, survey/GIS review, CDE setup and risk register.	25
2	Infrastructure coordination and site-management portfolio: corridor model, utility/drainage issue log, staging/logistics and progress evidence.	25
3	Handover and asset-information portfolio: as-built evidence, asset-data table, operation and maintenance fields and digital-twin readiness note.	25

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	MOOCs / online certification on BIM, GIS, surveying awareness, construction planning or infrastructure information management.	25
2	Tool and dataset exploration using approved BIM, GIS, CDE, coordination, reality-capture or OpenBIM tools.	25
3	Case-study review of brownfield infrastructure delivery, utility coordination, site monitoring, handover or asset information workflows.	25

Sample rubrics for Infrastructure Mini-Project:

Criterion	Exemplary (3)	Proficient (2)	Basic (1)
Problem definition, information requirements and scope	Clear brownfield/greenfield context, decision need, data requirements, assumptions, accuracy	Mostly clear with minor gaps in assumptions or information requirements.	Scope vague; assumptions, accuracy needs or information requirements

Criterion	Exemplary (3)	Proficient (2)	Basic (1)
	needs and project scope.		missing.
Model, data and exchange quality	Fit-for-purpose model, georeferencing, classification, metadata, quantities and OpenBIM/coordination outputs are traceable.	Mostly correct with minor model/data/exchange errors.	Incomplete model, weak data structure or unreliable exchange output.
Coordination, site management and constructability	Meaningful identification of utility, drainage, access, staging, safety, constructability and handover issues with clear action logic.	Basic issue identification with limited interpretation or action detail.	Minimal, unclear or generic coordination/site review.
Documentation and presentation	Well-structured portfolio with data request, model files, issue log, quantities, site output, handover table and reflection.	Organized but some sections are weak or incomplete.	Poorly organized or incomplete portfolio.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has strong understanding of infrastructure BIM, information management, survey/GIS inputs, site management, coordination, handover and lifecycle use. (4)	Student has good knowledge of most topics with minor gaps. (3)	Student can explain basic ideas but lacks depth or project application. (2)	Student has not understood the concepts clearly. (1)
Design Of Experiment (5) (PO2 & PO3)	Student can define information requirements, select suitable specialists/data sources and choose a fit-for-purpose workflow with proper reasoning. (5)	Student can discuss a few workflows but has limited justification for selection. (4)	Student can discuss one workflow with basic merits and limitations. (3)	Student can explain the workflow only partly. (1-2)

Implementation (8) (PO3 & PO8)	Student can implement CDE setup, data request, model/data structuring, quantity extraction, issue tracking, site/logistics output and handover table in a traceable workflow. (7-8)	Student can implement the workflow with minor gaps. (5-6)	Student can implement parts of the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)
Result &Analysis (5) (PO4)	Student can compare outputs for coordination, quantity, progress, logistics, issue closure and handover acceptance with proper analysis. (5)	Student can run the workflow and explain most outputs. (4)	Student can run some outputs and provide basic analysis. (3)	Student can run the workflow but cannot analyze outputs. (1-2)
Demonstration (8) (PO9)	Portfolio is well organized with brief, information request, assumptions, model QA, issue log, quantities, site/staging output, handover data and conclusion. (7-8)	Portfolio is organized but some sections are not well developed. (5-6)	Portfolio has weak organization and incomplete sections. (3-4)	Portfolio is poorly organized, with missing or unclear sections. (1-2)

INTEGRATED BIM & COMPUTER AIDED DESIGN FOR TRANSPORTATION SYSTEMS			
Course Code	**1MCV104H**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 Orientation:

The course is organized around transportation information delivery, not proprietary CAD training. The running case is a highway project because it includes alignment, right-of-way, carriageway, shoulders, median, junctions, drainage, utilities, structures, construction phasing, traffic management, and FM needs.

Learning flow: feasibility and system framing -> existing conditions -> GIS/BIM representation -> open information checking -> coordination -> construction logistics/reality capture -> FM, Linked Data awareness, and remodeling. Only free, open-source, open-standard, or freely accessible tools are recommended wherever possible. Assessment is based on workflow quality, information reliability, open exchange, coordination evidence, and decision support.

Course Flow and Integrated Case Logic:

Highway project is used as the main integrated case because it contains alignment, right-of-way, carriageway, shoulders, median, junctions, drainage, utilities, structures, traffic management, construction staging, FM and remodelling needs. Embedded **road, bridge, drainage and utility** cases are used to keep the course relevant beyond a single highway stretch: corridor modelling, junctions, drainage, utility relocation, bridge/culvert interfaces, traffic diversions and asset handover. Advanced topics such as **IFC 4.3, IDS, BCF, bSDD/OTL, CityGML/LandInfra awareness, Linked Data, IoT/Sensor Things and digital twins** are included only where they improve practical workflows.

Course outcome (Course Skill Set):

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

1. CO1 (L2 – Understand): Explain the transportation infrastructure lifecycle from feasibility to FM/remodelling and how BIM, GeoBIM, GIS, openBIM, CDE, and asset-information workflows support highway decisions.
2. CO2 (L3 – Apply): Prepare existing-condition and feasibility information using GIS, survey, terrain, utilities, open data, point clouds, and reality-capture inputs for highway projects.
3. CO3 (L3 – Apply): Develop and interpret BIM/GIS representations of highway assets including corridor alignment, road cross-section elements, drainage, utilities, bridges/culverts, and junctions.
4. CO4 (L4 – Analyze): Analyze documentation, quantity take-off, openBIM exchange, IDS-style information checking, BCF issue workflows, BIM-GIS interoperability, and multidisciplinary interface coordination.
5. CO5 (L4 – Analyze): Analyze construction logistics, site management, 4D/5D staging, traffic diversions, safety risks, field data capture, and model-vs-site verification for highway environments.
6. CO6 (L5 – Evaluate): Evaluate FM handover, asset-information models, Linked Data concepts, digital twin workflows, and remodelling/rehabilitation strategies for highway infrastructure.

Module-1

Feasibility, Transportation System Framing and BIM/GeoBIM Foundations:

- Transportation infrastructure lifecycle from need identification to procurement, construction, handover, operation, maintenance, renewal, and retrofit.
- Highway as a transportation system-of-systems: carriageway, shoulder, median, intersections, service roads, drainage, utilities, structures, traffic control, and stakeholders.
- Feasibility inputs: land/right-of-way, access, safety, environmental constraints, traffic demand, cost, phasing, and future expansion.
- BIM, GIS, and GeoBIM concepts: BIM as structured asset/project information, GIS as spatial/network context,

and GeoBIM as integration of project models, geospatial context, and asset data.

- Information management: CDE-style folders, information containers, naming, revision/status, review/approval, Level of Information Need, asset IDs, classification, object type libraries, and information requirement checklists.
- OpenBIM foundations: IFC/IFC 4.3 awareness, BCF issue exchange, IDS-style checking, neutral model viewing, and vendor-neutral information delivery.

Linked COs: CO1, CO2 **Number of Hours: 08**

Module-2

Existing Conditions, Planning Data and Highway System Modelling:

- Existing-condition information: GIS base maps, terrain/DEM, survey points, land parcels, right-of-way, drainage, utilities, environmental constraints, traffic/access data, open data sources, and legacy records.
- Reality-context inputs: drone imagery, photogrammetry, LiDAR/mobile mapping, laser scanning, point clouds, inspection photographs, and legacy drawings.
- Data architecture: asset IDs, georeferencing, coordinate systems, chainage/linear referencing, GIS layers, relational tables, and spatial databases.
- Highway asset representation: corridor/access road, junction, pavement, drainage, utility corridor, bridge/culvert, service road, and traffic management zone.
- Tool awareness: QGIS/PostGIS, GeoServer, QField/Mergin Maps, OpenStreetMap/open data, pgRouting, GRASS/SAGA GIS, CloudCompare, Bonsai/FreeCAD, and IFC viewers.

Linked COs: CO2, CO3 **Number of Hours: 08**

Module-3

Documentation, Quantities, OpenBIM and Information Checking:

- Model-based deliverables: plans, profiles, sections, sheets, schedules, asset lists, drawings, reports, and design review packages.
- Quantity take-off: pavement, earthwork, drainage, utilities, structures, and selected highway components using schedules, spreadsheets, and IFC data.
- OpenBIM and interoperability: IFC/IFC 4.3 basics, neutral model viewing, BCF issue exchange, BIM-GIS exchange, and checks for geometry, properties, classification, and asset IDs.
- Information checking: IDS-style requirements, required properties, object classification, bSDD awareness, property-set review, and model-quality checklists.
- Coordination and interface management: runway/taxiway-lighting-drainage style logic replaced by highway interfaces such as pavement-drainage, road-utility, access road-structure, junction-drainage, and safety zones.
- Linked information awareness: connect model elements to drawings, specifications, issues, quantities, documents, GIS locations, and future asset records using consistent IDs.

Linked COs: CO3, CO4 **Number of Hours:08**

Module-4

Coordination, Construction Logistics, Site Management and Reality Capture:

- Construction planning for live highway environments: work zones, temporary works, safety zones, material laydown, access routes, equipment movement, emergency access, and inspection points.
- Highway phasing and logistics: lane closures, traffic diversions, temporary access, utility relocation, work sequencing, and night/possession-style planning.
- Road and rail embedded cases are represented in highway context as access-road widening, traffic diversion, utility relocation, bridge/culvert works, precast delivery, earthwork haul routes, and public disruption control.
- 4D/5D workflows: link model/asset IDs to schedule and quantity tables, staging diagrams, progress planning, and cost/schedule impact awareness.
- Coordination workflows: BCF-style issue exchange, interface registers, risk notes, responsibility tracking, decision logs, and coordination meeting outputs.
- Reality capture and field data: point cloud or photo evidence, mobile inspection data, model-vs-site

comparison, deviation reporting, and update of as-built/FM information.

Linked COs: CO4, CO5 **Number of Hours: 08**

Module-5

Handover, FM, Linked Data, Digital Twin Workflows and Remodelling:

- Asset handover: asset registers, asset IDs, location, classification, properties, inspection history, warranties/manual references, maintenance schedule, acceptance data, and Asset Information Model concepts.
- FM and operations: pavement inspections, lighting/drainage maintenance, signage and safety furniture, access-road maintenance, and structure maintenance.
- Linked Data as practical workflow: connect BIM objects, GIS locations, documents, inspection records, work orders, maintenance history, and dashboards using consistent asset IDs and traceable links.
- Digital twin awareness: model + GIS context + live/periodic data + inspection records + maintenance actions + decision dashboard.
- Remodelling and retrofit: scan-to-BIM, widening, rehabilitation, junction improvement, and sustainability upgrades with operational phasing.
- Portfolio evaluation: determine whether the workflow supports lifecycle decisions, not just whether a model looks visually complete

Linked COs: CO5, CO6 **Number of Hours: 08**

PRACTICAL COMPONENTS OF IPCC (LI-28 Hrs)

PART – A: FIXED SET OF EXPERIMENTS

Students shall perform practical exercises related to:

1. Prepare a highway project feasibility and stakeholder map covering alignment, RoW, traffic, drainage, utilities, structures, safety, FM, and remodelling needs.
2. Create an existing-condition package using GIS/open data, terrain/survey data, utilities, and point cloud or simulated reality-capture references.
3. Build a highway asset information matrix with asset IDs, classification, required properties, GIS location, document links, and FM handover fields.
4. Develop a simplified BIM/GIS model for a highway corridor, junction, drainage/utility corridor, or bridge/culvert interface.
5. Prepare drawings, sheets, schedules, and quantity take-off for pavement, earthwork, drainage, utilities, or structure components.
6. Review an IFC/openBIM or neutral model and prepare an interoperability and IDS-style information-check report.
7. Conduct clash/interface review for highway subsystems and prepare a BCF-style issue log.
8. Prepare a 4D construction staging and traffic management plan using work zones, closures, diversions, and safety considerations.
9. Prepare a reality-capture/as-built verification note using survey/point cloud/photo evidence and a model-vs-site deviation table.
10. Prepare a GIS-linked FM/asset handover register and a simple Linked Data relationship map.

Suggested Learning Resources:

Text Books:

1. Rafael Sacks, Charles Eastman, Ghang Lee and Paul Teicholz, BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers.
2. Brad Hardin and Dave McCool, BIM and Construction Management: Proven Tools, Methods, and Workflows.
3. Andrew Baldwin and David Bordoli, A Handbook for Construction Planning and Scheduling.
4. buildingSMART International resources on IFC/IFC 4.3, BCF, IDS, bSDD and openBIM infrastructure workflows.
5. QGIS, PostGIS, GeoServer, QField/Mergin, OpenStreetMap, pgRouting, GRASS/SAGA GIS and CloudCompare documentation.
6. UNECE and public transportation/infrastructure BIM guidance documents where available, plus relevant

IRC/MoRTH/airport/metro/rail references for discipline context.
7. Pieter Pauwels and Kris McGlinn, Buildings and Semantics: Data Models and Web Technologies for the Built Environment - for advanced Linked Data and digital twin reference reading.
8. Nöldgen, Markus, BIM in Bridge and Infrastructure Design, Springer Vieweg.
9. Hoel, Lester A., Garber, Nicholas J., and Sadek, Adel W., Transportation Infrastructure Engineering: A Multimodal Integration, Thomson Nelson / Cengage Learning.

Reference Books / Manuals

1. buildingSMART documentation on openBIM, IFC, and interoperability.
2. BS 1192 collaborative production guidance and BIM information management guidance.
3. ISO 19650 introductory resources.
4. CPWD: Introducing BIM in CPWD, Government of India, 2024.
5. Institutional BIM guidelines, execution planning documents, and project scheduling manuals.
6. GSA National 3D-4D-BIM Program and BIM Guide Series.

Web links and video lectures:

1. NPTEL / SWAYAM modules related to BIM, project planning, construction management, and digital construction.
2. BuildingSMART resources on open BIM, IFC, and collaborative model use in project delivery.
3. Official software learning portals and guided tutorials for BIM-based sequencing, coordination, and construction simulation tools.
4. Public BIM case studies from Norway, Singapore, Europe, the United States and India.

Software Tools:

The course shall be delivered using free, open-source, open-standard or freely accessible educational tools wherever possible. No proprietary software ecosystem shall be treated as mandatory or preferred. Assessment shall be based on workflow understanding, information quality, open exchange, validation, coordination response and decision support, not on proprietary software command mastery.

Workflow Need	Recommended Free / Open / Freely Accessible Tools
GIS and planning context	QGIS, PostgreSQL/PostGIS, GeoServer, QField, Mergin Maps, OpenStreetMap, pgRouting, GRASS/SAGA GIS
OpenBIM/model work	Bonsai, FreeCAD BIM, IfcOpenShell, xBIM, IFC.js/web-ifc, BIMVision/Open IFC Viewer
Coordination and issue exchange	BCF tools, IFC viewers, spreadsheet issue logs, Speckle Community/free use where available
Scheduling/logistics	ProjectLibre, OpenProject, LibreOffice Gantt/work-zone tables, open staging diagrams
Reality capture and FM data	CloudCompare, MeshLab, QGIS, LibreOffice asset registers, Grafana/Metabase dashboards, RDFLib/Protégé/Jena awareness

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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

Suggested Strategies:

1. Use problem-based labs built around one connected project dataset rather than disconnected software exercises.
2. Start each topic with the real project decision, then define the information needed, the model/data workflow, the exchange/checking method and the output evidence.
3. Use demonstrations, guided practice, openBIM/GIS inspection, peer review, issue-response cycles, role-play and portfolio submissions.
4. Industry guest lectures may be used to discuss workflow, information requirements and decision-making, not brand-specific command training.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(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 of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

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 the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
	Allotment of marks for regular classwork	
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**

Term work and Self Learning:

Students' activities for TW/SL under NCrF: As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Transportation BIM modeling mini-project: alignment, profile, corridor, and sections.	25
2	Quantity and schedule portfolio: earthwork, pavement, and drainage mapping.	25
3	Open-book team challenge on transportation coordination and review comments.	25

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	MOOCs / online certification on BIM and transportation design.	25
2	Tool and software exploration using approved BIM / transportation design tools.	25
3	Competitive aptitude and concept practice in highway geometry, corridor design, and BIM workflows.	25

Sample rubrics for Structural BIM Mini-Project rubric:

Criterion	Excellent (4)	Very Good (3)	Good (2)	Satisfactory (1)
Problem understanding	Fully understands the task, scope, and expected output; objective is clearly defined.	Understands most of the task with minor gaps.	Basic understanding; some parts of the task are unclear.	Limited understanding of the task.
Method / workflow	Uses a logical, correct, and complete workflow; steps are well sequenced.	Workflow is mostly correct with minor omissions.	Workflow is partially correct but lacks completeness.	Workflow is weak or incomplete.
Technical accuracy	Model, drawing, calculation, or output is technically correct and consistent.	Mostly correct with few errors.	Several technical errors but task is still partly usable.	Major technical errors; output has little validity.
Application of tools	Uses BIM/CAD/software tools efficiently and appropriately.	Uses tools correctly with minor support.	Uses tools with difficulty and limited efficiency.	Minimal tool usage or heavy assistance required.

Criterion	Excellent (4)	Very Good (3)	Good (2)	Satisfactory (1)
Data / model quality	Clean, organized, well-labeled, and properly structured output.	Generally organized with small issues.	Organization is uneven; several missing details.	Poorly organized; major missing elements.
Documentation / record	Record is complete, neat, and properly formatted with all required sections.	Record is mostly complete and neat.	Record is incomplete or inconsistently formatted.	Record is poor or largely incomplete.
Analysis and interpretation	Provides strong analysis, justification, and valid conclusions.	Provides good analysis with minor gaps.	Limited analysis; conclusions are weak.	Very little analysis or interpretation.
Presentation / communication	Explains work clearly and confidently; submission is professional.	Clear presentation with minor issues.	Presentation is understandable but lacks clarity.	Poor presentation and weak communication.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)	Student has good knowledge of some topics related to construction planning and BIM workflows. (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 planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)

Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output. (3)	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio 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)

GEOSPATIAL DATABASE MANAGEMENT SYSTEMS AND PROGRAMMING SKILLS			
Course Code	**1MCV104 I**	Scheme	2026
Type of Course	Integrated Professional Core Courses (IPCC)	Semester	I
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 – Understand): Explain the concepts of geospatial data, spatial databases, database management systems, coordinate reference frameworks, and the role of geospatial information in civil engineering and infrastructure applications.
2. CO2 (L3 – Apply): Create and manage geospatial databases by organizing spatial and non-spatial datasets, defining schemas, importing layers, and applying database operations using suitable GIS and database tools.
3. CO3 (L3 – Apply): Develop basic programs and scripts for querying, processing, validating, and automating geospatial data handling tasks using programming skills relevant to GIS workflows.
4. CO4 (L4 – Analyze): Analyse spatial relationships, data integrity issues, indexing needs, topology constraints, and query performance in geospatial database environments.
5. CO5 (L4 – Analyze): Examine the integration of geospatial databases with desktop GIS, web GIS, remote sensing inputs, and engineering decision-support applications.
6. CO6 (L5 – Evaluate): Evaluate geospatial database design choices, programming approaches, interoperability practices, and data governance considerations for sustainable and scalable geospatial systems.

Module-1

Fundamentals of geospatial data and database systems:

- Introduction to geospatial information systems and their relevance to civil engineering, transportation, urban planning, water resources, environmental monitoring, and infrastructure management.
- Types of geospatial data: vector, raster, attribute data, metadata, temporal data, and 2D/3D geospatial representations.
- Fundamentals of database systems: data models, DBMS concepts, relational databases, tables, keys, relationships, normalization, and transaction basics.
- Spatial data characteristics: location, geometry, topology, scale, accuracy, precision, resolution, and uncertainty in geospatial datasets.
- Coordinate systems, map projections, datums, geo-referencing principles, and the significance of spatial reference management in database environments.

CO linkage: CO1, partial CO2 **Number of Hours = 8 hrs**

Module-2

Spatial database design and geospatial data management:

- Spatial database concepts: geodatabases, spatial tables, geometry types, feature classes, layers, schemas, and attribute domain management.
- Design of geospatial databases for engineering applications involving parcels, utilities, transportation networks, drainage, terrain, land use, and asset inventories.
- Data creation and management: importing shapefiles, CAD layers, CSV data, GPS observations,

remote sensing outputs, and field survey records into a spatial database.

- Entity relationships, primary and foreign keys, constraints, validation rules, topology rules, and methods for maintaining consistency in spatial datasets.
- Storage formats, open standards, interoperability concepts, and introduction to spatially enabled database platforms and open-source GIS database environments.

CO linkage: CO2, partial CO4 **Number of Hours = 9 hrs**

Module-3

Querying, indexing and analysis in geospatial DBMS:

- Structured querying concepts for spatial data: attribute queries, selection operations, filtering, sorting, aggregation, joins, and relationship-based retrieval.
- Spatial queries using location-based conditions such as intersection, containment, proximity, buffering, adjacency, overlay logic, and nearest-neighbour search.
- Concept of spatial indexing and its role in improving the performance of large geospatial datasets and repeated query execution.
- Data integrity and quality review: duplicates, null values, slivers, geometry errors, topology violations, and methods for error detection and correction.
- Generation of thematic outputs, summary tables, query reports, and analytical views to support planning, design, and decision-making.

CO linkage: CO3, partial CO4 **Number of Hours = 8 hrs**

Module-4

Programming skills for geospatial data processing and automation:

- Introduction to programming logic for GIS applications: variables, data types, operators, control structures, functions, file handling, and modular scripting concepts.
- Scripting for geospatial workflows using appropriate programming environments for reading, transforming, filtering, and exporting spatial and tabular data.
- Automation of repetitive GIS tasks such as batch layer processing, coordinate conversion, attribute updates, field calculations, and data validation.
- Basic use of libraries or tools for spatial data manipulation, map layer handling, database connectivity, and simple geospatial analysis.
- Script-based generation of outputs, logs, summaries, and reproducible workflows for engineering data management.

CO linkage: CO3, CO4, partial CO5 **Number of Hours = 8 hrs**

Module-5

Integration, applications and governance of geospatial information systems:

- Integration of geospatial databases with desktop GIS, web GIS, remote sensing products, surveying workflows, BIM/GIS linkages, and infrastructure information systems.
- Applications in civil engineering: utility mapping, urban infrastructure planning, terrain and watershed studies, transportation asset management, environmental analysis, and disaster management support.
- Multi-user editing, versioning concepts, data sharing, interoperability, metadata standards, and collaborative geospatial project practices.
- Data governance issues including data security, privacy, ethics, ownership, quality assurance, backup, and sustainable maintenance of geospatial repositoriesresponsible use of geospatial information.

- Emerging directions such as cloud geodatabases, digital twins, real-time geospatial systems, AI-assisted spatial analytics, and smart-city decision support.

CO linkage: CO5, CO6 **Number of Hours =9 hrs**

PRACTICAL COMPONENTS OF IPCC

LIST OF EXPERIMENTS **LI: 28 hrs**

1. Create a geospatial database schema for sample spatial and attribute data.
2. Import spatial and non-spatial datasets into a database or GIS environment.
3. Write SQL queries for spatial and attribute data retrieval.
4. Perform spatial operations such as buffer, intersect, and overlay using scripts.
5. Read, clean, and transform geospatial data using Python.
6. Generate thematic maps and exploratory visualizations from geospatial data.
7. Automate a repetitive geospatial task using a script.
8. Integrate database queries with a programming workflow for analysis.

Suggested Learning Resources Text Books

1. Elmasri, R., and Navathe, S. B. *Fundamentals of Database Systems*.
2. Shekhar, S., and Xiong, H. *Encyclopedia/Handbook of Geospatial Database Systems*.
3. Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W. *Geographic Information Systems and Science*.
4. Zandbergen, P. A. *Python Scripting for ArcGIS Pro* or equivalent programming reference.

Reference Books / Manuals

1. Date, C. J. An Introduction to Database Systems.
2. Obe, R. O., and Hsu, L. S. PostGIS in Action.
3. Open-source GIS and Python geospatial documentation.
4. Government and agency manuals on spatial data management and geospatial standards.

Web links and Video Lectures (e-Resources) & Software tools

1. NPTEL courses on database management systems and GIS programming.
2. SWAYAM resources on Python programming and data analytics.
3. PostgreSQL/PostGIS documentation for spatial database operations.
4. Python geospatial documentation and tutorials for spatial data processing.
5. Open-source GIS software tutorials for automation and scripting.

Software Tools:

Core software tools:

- PostgreSQL / PostGIS or equivalent spatial DBMS.
- QGIS or ArcGIS for spatial data handling and visualization.
- Python with geospatial libraries.
- Jupyter Notebook or equivalent IDE.
- Excel / LibreOffice Calc for tabulation and reporting.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE)
The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:
(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 constitut the test marks for a maximum of 25 marks.
(ii) Laboratory component
Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.
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 the practical test as indicated in the Tabl – ICs/IPCCs 1.
To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component		
Component	Description	Marks
Allotment of marks for regular classwork		
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

Students' activities for TW/SL under NCrF:
As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of

rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	**Design a spatial database for a real or sample application.** Define entities, attributes, keys, relationships, and schema for a GIS application such as land records, water supply, solid waste, or environmental monitoring. Prepare ER diagram and relational schema.	25
2	**Develop SQL-based geospatial queries.** Write queries for selection, filtering, joins, proximity search, attribute analysis, and spatial retrieval. Include query explanation and result interpretation.	25
	Build a Python geospatial preprocessing workflow. Read spatial files, clean data, convert formats, handle missing values, and generate derived layers or summary tables using scripts or notebooks.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**Explore PostgreSQL/PostGIS basics.** Learn database creation, table design, geometry types, and simple spatial queries. Prepare a short note with examples.	25
2	**Study Python libraries for geospatial work.** Explore pandas, geopandas, shapely, matplotlib, or equivalent tools and summarize their uses with one mini example	25
3	**Create a mini case study.** Choose one application such as flood mapping, land-use analysis, transport routing, or utility network analysis and explain how database and programming support the solution.	12

Sample rubrics for TW activities:

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Problem understanding	Clearly identifies the problem, scope, and objectives; shows strong domain understanding.	Identifies the problem and objectives well, with minor gaps.	Basic understanding of the problem and objectives.	Problem statement is unclear or incomplete.
Design / workflow planning	Presents a complete, logical, and well-structured workflow or database design.	Workflow/design is mostly complete and logical.	Workflow/design is partially complete.	Workflow/design is weak, incomplete, or incorrect.
Technical implementation	Implements the task accurately with correct	Implementation is mostly correct	Implementation works partially	Implementation is incorrect or missing

Criterion	Excellent	Good	Satisfactory	Needs Improvement
	database structure, queries, or scripts.	with minor errors.	and needs support.	major parts.
Output quality	Outputs are accurate, relevant, and well presented.	Outputs are mostly correct and clear.	Outputs are acceptable but limited in detail.	Outputs are poor, inaccurate, or missing.
Documentation and presentation	Submission is neat, well organized, and clearly documented.	Good documentation with minor formatting issues.	Adequate documentation, but not well polished.	Poorly documented or difficult to follow.

Sample rubrics for Self-Learning activities:

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Concept understanding	Demonstrates strong understanding of the topic learned independently.	Shows good understanding with minor gaps.	Shows basic understanding of the topic.	Understanding is weak or unclear.
Learning effort	Shows thorough exploration beyond classroom content.	Shows good effort in exploring the topic.	Limited but acceptable learning effort.	Very little learning effort evident.
Application / example	Gives a relevant and correct example or mini application.	Gives a suitable example with minor issues.	Example is simple or partially relevant.	Example is missing or irrelevant.
Reflection and analysis	Provides thoughtful reflection and analysis of learning.	Provides reasonable reflection.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Mostly organized with minor issues.	Acceptable organization.	Poorly organized or difficult to read.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of construction planning, BIM-enabled 4D/5D workflows, project controls and site logistics. (4)	Student has good knowledge of some topics related to construction planning and BIM workflows. (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 planning workflow/design for the problem statement and selecting the best suitable approach with proper reason. (5)	Student is capable of discussing a few workflows but not fully capable of selecting the best. (4)	Student is capable of discussing a single planning workflow with merits and demerits. (3)	Student can explain the planning/design approach only partly. (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing WBS, schedule logic, model linkage, resource mapping and issue tracking with an optimal and traceable workflow. (7-8)	Student is capable of implementing the workflow and explaining it with minor gaps. (5-6)	Student is capable of implementing the workflow with partial explanation. (3-4)	Student can implement only limited parts of the workflow. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the workflow for various cases and compare 4D sequence, resource, progress and logistics results with proper analysis. (5)	Student will be able to run the workflow for all the cases. (4)	Student will be able to run the workflow for a few cases and analyze the output. (3)	Student will be able to run the workflow but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record/portfolio is well organized, with clear sections such as brief, method, WBS, schedule, model QA, 4D output, resource sheet, issue log, results and conclusion. (7-8)	The lab record/portfolio 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)

1MCV105X: Professional Elective Courses-I

ADVANCED REMOTE SENSING AND GIS			
Course Code	**1MCV105A**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L4 - Analyze): Analyze electromagnetic spectrum interactions and sensor data for feature extraction in civil engineering applications like land use mapping.
2. CO2 (L5 - Evaluate): Evaluate advanced satellite missions and hyperspectral/multispectral data processing techniques for infrastructure monitoring.
3. CO3 (L4 - Analyze): Analyze raster and vector data models, spatial analysis operations, and database management in GIS for civil projects.
4. CO4 (L6 - Create): Create geospatial models integrating RS and GIS data for applications in hydrology, transportation, and urban planning.
5. CO5 (L6 - Create): Design GNSS/GPS surveys, LiDAR/Photogrammetry workflows, and 3D modeling for topographic and structural analysis.
6. CO6 (L5 - Evaluate): Evaluate RS-GIS integration with AI/ML, cloud platforms, and decision support systems for sustainable infrastructure aligned with SDGs (e.g., SDG 11, 13).

Module-1

Fundamentals of RS & Sensors:

Introduction to remote sensing principles, electromagnetic radiation (EMR), spectral signatures of earth features (soil, water, vegetation, urban), platforms (airborne/spaceborne), sensors (optical, thermal, microwave - SAR), resolution types (spectral/spatial/temporal/radiometric), orbit types. Indian missions: IRS, Cartosat, RISAT; international: Landsat, Sentinel, MODIS. Image acquisition, preprocessing (geometric/radiometric correction).

Linked COs: CO1. **Number of Hours: 08 hrs**

Module-2

Advanced Image Processing:

Digital image processing: enhancement (contrast stretch, filtering), classification (supervised/unsupervised, ML-based), change detection, accuracy assessment. Hyperspectral RS: data cubes, unmixing, anomaly detection. SAR processing: speckle filtering, interferometry (InSAR for DEM/ subsidence). Softwares: ERDAS, ENVI, SNAP. **Linked COs: CO2.** **Number of Hours: 10 hrs**

Module-3

GIS Data Models & Analysis:

GIS components, spatial data (raster/vector/hybrid), topology, data structures (shapefile, geodatabase). Spatial analysis: overlay, buffer, network, hydrology modeling. Attribute data management, queries (SQL), projections (UTM, Lambert), map algebra. Softwares: ArcGIS, QGIS.

Linked COs: CO3. **Number of Hours: 10 hrs**

Module-4

RS-GIS Applications:

Land use/land cover mapping, urban sprawl, watershed management, flood/landslide hazard zoning, transportation planning, infrastructure asset management. Integration models: cellular automata, agent-based. Case studies: ISRO/NRSC projects in engineering domain.

Linked COs: CO4. **Number of Hours: 08 hrs**

Module-5

Emerging Geospatial Technologies:

GNSS/GPS/DGPS surveys, LiDAR (airborne/mobile), UAV/drone RS, Photogrammetry (SfM), 3D city modeling, BIM-GIS integration. Web-GIS, cloud (Google Earth Engine), AI/ML in geospatial (CNN for classification), Big Data handling.

Linked COs: CO5, CO6. **Number of Hours: 06 hrs**

Suggested Learning Resources:

Text Books

1. Lillesand, T. M., Kiefer, R. W., Chipman, J. W. (2015). *Remote Sensing and Image Interpretation*. 7th ed. Wiley.
2. Kang-tsung Chang (2020). *Introduction to Geographic Information Systems*. 10th ed. McGraw-Hill.
3. ISRO NRSC (2023). *Remote Sensing and GIS Applications*. NRSC Publications.

Reference Books:

1. Burrough, P. A., McDonnell, R. A. (2015). Principles of Geographical Information Systems. Oxford.
2. Gupta, R. P. (2018). Remote Sensing Geology. Springer.
3. Longley, P. A. et al. (2015). Geographic Information Science & Systems. Wiley.

Web links and Video Lectures (e-Resources) & Software tools:

1. **ISRO NRSC:** https://www.nrsc.gov.in
2. **Bhuvan Portal:** https://bhuvan.nrsc.gov.in
3. **NPTEL RS-GIS:** https://nptel.ac.in
4. **QGIS Tutorials:** https://www.qgistutorials.com

Software Tools:

Open-source GIS and Remote Sensing tools

1. QGIS — general GIS, mapping, spatial analysis, and plugin-based remote sensing workflows.
2. GRASS GIS — advanced spatial analysis, raster processing, modelling, and terrain analysis.
3. SAGA GIS — terrain analysis, raster tools, geomorphology, and spatial modelling.
4. SNAP (Sentinel Application Platform) — ESA's toolbox for Sentinel and other satellite image processing.
5. Orfeo Toolbox (OTB) — advanced image classification, segmentation, and processing.
6. WhiteboxTools — hydrology, terrain, LiDAR, and geospatial analysis tools.
7. GeoServer — web GIS publishing and map services.
8. PostgreSQL/PostGIS — spatial database management and geospatial queries.
9. GDAL/OGR — raster/vector data conversion and geoprocessing libraries.
10. R with packages like terra, raster, sf, stars — spatial analysis and remote sensing workflows.
11. Python with libraries like rasterio, geopandas, xarray, numpy, scikit-learn — scripting, automation, and GeoAI.
12. Google Earth Engine — cloud-based geospatial analysis and time-series processing; free for many non-commercial uses

Commercial tools:

- ArcGIS Pro — industry-standard GIS, spatial analysis, and geoprocessing.
- ERDAS IMAGINE — remote sensing image processing and classification.
- ENVI — advanced hyperspectral, multispectral, and SAR image analysis.
- Global Mapper — GIS, LiDAR, and terrain tools.
- Trimble eCognition / Esri products / Hexagon tools — common in professional workflows.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity A – Thematic RS–GIS project:** Students select a theme (e.g., LULC change, urban expansion, flood mapping) for a chosen study area, perform data acquisition, preprocessing, classification, and map preparation; submit a technical report and maps.	24
2	**Activity B – Geospatial database and spatial analysis exercise:** Students design a geospatial database for an engineering application (e.g., urban utilities, transportation, watershed), perform spatial analysis (buffer, overlay,	24

	network/terrain analysis) and present results using maps and dashboards.	
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Completion of selected NPTEL/MOOC modules on Remote Sensing, GIS, and Web GIS; submission of reflective notes or quiz scores as evidence.	24
2	Preparation of technical notes, workflow diagrams, and a digital portfolio demonstrating RS–GIS processing chains for at least two engineering applications.	24

Sample rubrics for TW activities:

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Problem understanding and objective formulation	Clearly defines geospatial problem, objectives, and study area with strong justification.	Mostly clear with minor gaps in problem framing.	Basic attempt with limited clarity.	Problem and objectives poorly defined.
Data acquisition and processing	Appropriate selection of datasets, correct preprocessing and documentation.	Mostly appropriate data and processing with minor issues.	Limited data or partial preprocessing.	Inadequate data and incorrect processing.
Analysis and technical soundness	Robust methodology, correct analysis, and meaningful use of RS–GIS tools.	Generally sound analysis with minor technical errors.	Partially correct analysis with noticeable technical gaps.	Weak or incorrect analysis, improper use of tools.
Interpretation, mapping, and reporting	Insightful interpretation, high-quality maps (layout, legend, scale), and well-structured report.	Adequate interpretation and maps with minor formatting issues.	Acceptable but limited interpretation and basic maps.	Poor interpretation, incomplete maps, and/or weak report.

Sample rubrics for Self-Learning activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear and accurate understanding of the assigned concept.	Shows good understanding with minor gaps.	Basic understanding with limited detail.	Understanding is weak or incorrect.
Independent learning	Explores beyond the minimum requirement and shows initiative in learning.	Shows good initiative with some additional effort.	Completes the assigned task with limited exploration.	Relies heavily on guidance or shows little effort.
Task completion	Activity is completed fully, correctly, and on time.	Activity is mostly complete with minor omissions.	Activity is partially complete.	Activity is incomplete or missing.
Technical accuracy	Workflow, tool use, or analysis is correct and well justified.	Mostly correct with few technical errors.	Contains noticeable errors but shows partial correctness.	Major technical errors or no meaningful attempt.
Reflection and analysis	Provides strong reflection, interpretation, and learning outcomes.	Gives reasonable reflection with some analysis.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Organized well with minor formatting issues.	Acceptable presentation with several issues.	Poorly organized or difficult to read.

APPLIED STATISTICS & UNCERTAINTY MODELING			
Course Code	**1MCV105B**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L3): Apply concepts of probability, random variables, and common probability distributions to model variability in civil and infrastructure engineering parameters.
2. CO2 (L4): Analyze and interpret engineering data using descriptive statistics, estimation, confidence intervals, and hypothesis testing for decision making.
3. CO3 (L4): Develop statistical models (correlation, regression, ANOVA) for prediction and calibration of civil engineering systems and material behavior.
4. CO4 (L4): Quantify and propagate uncertainty using reliability indices, limit state functions, and Monte Carlo simulation for safety assessment.
5. CO5 (L5): Formulate and solve decision problems under risk using Bayesian updating, decision trees, and utility theory in civil engineering contexts.
6. CO6 (L5): Critically evaluate uncertainty modeling results and communicate risk-informed recommendations for performance-based and sustainable infrastructure design.

Module-1

Fundamentals of Probability and Random Variables:

Review of set theory, axioms of probability, conditional probability, law of total probability, Bayes' theorem. **Random variables:** discrete and continuous; probability mass function, probability density function, cumulative distribution function. expectation, variance, covariance,
binomial, Poisson, exponential, normal distributions. selection of problems appropriate distributions for civil engineering data.

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Statistical Inference for Engineering Data:

Sampling concepts, sampling distributions, central limit theorem; point and interval estimation.
Confidence intervals for means, variances, and proportions; determination of sample size for experiments and field investigations. Hypothesis testing: formulation of null and alternative hypotheses, Type I and Type II errors, p-values, power of a test. Tests on means and variances (t-test, F-test), goodness-of-fit tests (chi-square),.
Applications related to Civil engineering applications: strength testing of concrete and soils, quality control of materials, calibration of empirical factors**.**

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Regression, ANOVA, and Multivariate Statistical Methods:

Simple and multiple linear regression: model formulation, estimation of parameters, residual analysis, detection of outliers and influence points. One-way and two-way ANOVA: fixed-effects models, multiple comparison procedures; applications in mix design and experimental studies. Introduction to multivariate analysis: covariance and correlation matrices, principal component analysis (PCA) for dimensionality reduction.

Civil engineering case studies: prediction of concrete strength, pavement performance models, water demand forecasting, and environmental quality indices.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Reliability Analysis and Uncertainty Propagation:

Concept of reliability and risk in engineering design; safety factor versus reliability-based design. Limit state functions, failure domains, and performance functions for structural and geotechnical systems. Reliability indices (Hasofer–Lind), first-order reliability method (FORM) and second-order reliability method (SORM) – basic ideas and engineering interpretation. Monte Carlo simulation: random sampling, variance reduction (brief overview); estimation of probability of failure and reliability.

Applications: reliability of beams, foundations, retaining structures, slope stability, hydraulic structures, and environmental systems.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Bayesian Methods, Decision Analysis, and Advanced Topics

Bayesian probability: prior, likelihood, posterior; Bayesian updating of model parameters using monitoring data. Decision analysis under uncertainty: decision trees, payoff tables, expected value and expected utility; value of information. Risk-based design and management: risk matrices, societal and individual risk, ALARP concept; performance-based and resilience-based approaches. Time-variant reliability concepts (overview), Markov chains and stochastic processes (introductory ideas) for deterioration modelling.

Integrated case studies: risk-informed decision making for flood management, urban drainage, traffic safety, and lifecycle cost analysis of infrastructure.

Linked COs: CO5, CO6 **Number of Hours: 8 hrs**

Suggested Learning Resources :

Textbooks:

1. Haldar, A., & Mahadevan, S. – *Probability, Reliability and Statistical Methods in Engineering Design*, Wiley (latest edition).
2. Ang, A. H.-S., & Tang, W. H. – *Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering*, Wiley (latest edition).
3. Montgomery, D. C., & Runger, G. C. – *Applied Statistics and Probability for Engineers*, Wiley (latest edition).
4. Melchers, R. E., & Beck, A. T. – *Structural Reliability Analysis and Prediction*, Wiley (latest edition).
5. Benjamin, J. R., & Cornell, C. A. – *Probability, Statistics, and Decision for Civil Engineers*, Dover (or equivalent reprint).
6. Muraleedharan, K., and Syamsundar, A., Statistical Methods for Quality, Reliability and Maintainability, PHI Learning.
7. Bahga, Supreet Singh, Experimental Uncertainty Analysis: A Textbook for Science and Engineering Students, White Falcon Publishing.
8. Maurya, V. N., Advanced Probability Theory and Statistical Techniques.

Reference Books:

1. Ayyub, B. M., & McCuen, R. H. – Probability, Statistics, and Reliability for Engineers and Scientists, CRC Press (latest edition).
2. Faber, M. H. – Statistics and Probability Theory: In Pursuit of Engineering Decision Support, Springer.

Web links and Video Lectures (e-Resources) & Software tools:

1. NPTEL: *Probability and Statistics for Engineers*, *Risk and Reliability of Offshore Structures*, and *Uncertainty and Reliability Analysis of Structures* (IITs).
2. NPTEL / SWAYAM courses on *Applied Multivariate Statistical Modeling*, *Data Analytics for Civil Engineering*, and related topics.
3. Coursera / edX: Courses on *Statistical Inference*, *Bayesian Statistics*, and *Uncertainty Quantification* from reputed universities.

4. R, Python (SciPy, NumPy, pandas, PyMC) and MATLAB tutorials for statistical analysis, regression, and Monte Carlo simulation.
5. Public civil engineering datasets (e.g., concrete strength, traffic, hydrological and environmental data) from Kaggle, government open-data portals, and research repositories.

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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Statistical characterization of engineering data:** Collect or use provided datasets (e.g., concrete strength, rainfall, traffic flow). Perform descriptive statistics, distribution fitting, and hypothesis tests.	24
2	**Regression and ANOVA mini-project:** Develop regression/ANOVA models for a chosen civil engineering problem (e.g., pavement performance, settlement prediction). Evaluate model adequacy and prepare a short technical report.	24
3	**Reliability and Monte Carlo case study:** Formulate a limit state function for a structural or geotechnical component. Implement Monte Carlo simulation and estimate probability of failure and reliability index.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Completion of selected NPTEL / MOOC modules on probability, statistics, or reliability and submission of reflective summaries or concept maps	24
2	Independent implementation in R/Python/MATLAB of at least two methods: Regression/ANOVA, Monte Carlo simulation, FORM/SORM (basic), or Bayesian updating, with documentation and result interpretation	24

Sample rubrics for TW activities:

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Problem understanding and objective formulation	Clearly defines geospatial problem, objectives, and study area with strong justification.	Mostly clear with minor gaps in problem framing.	Basic attempt with limited clarity.	Problem and objectives poorly defined.
Data acquisition and processing	Appropriate selection of datasets, correct preprocessing and documentation.	Mostly appropriate data and processing with minor issues.	Limited data or partial preprocessing.	Inadequate data and incorrect processing.
Analysis and technical soundness	Robust methodology, correct analysis, and meaningful use of RS–GIS tools.	Generally sound analysis with minor technical errors.	Partially correct analysis with noticeable technical gaps.	Weak or incorrect analysis, improper use of tools.
Interpretation, mapping, and reporting	Insightful interpretation, high-quality maps (layout, legend, scale), and well-structured report.	Adequate interpretation and maps with minor formatting issues.	Acceptable but limited interpretation and basic maps.	Poor interpretation, incomplete maps, and/or weak report.

Sample rubrics for Self-Learning activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear and accurate understanding of the assigned concept.	Shows good understanding with minor gaps.	Basic understanding with limited detail.	Understanding is weak or incorrect.
Independent learning	Explores beyond the minimum requirement and shows initiative in learning.	Shows good initiative with some additional effort.	Completes the assigned task with limited exploration.	Relies heavily on guidance or shows little effort.
Task completion	Activity is completed fully, correctly, and on time.	Activity is mostly complete with minor omissions.	Activity is partially complete.	Activity is incomplete or missing.
Technical accuracy	Workflow, tool use, or analysis is correct and well justified.	Mostly correct with few technical errors.	Contains noticeable errors but shows partial correctness.	Major technical errors or no meaningful attempt.
Reflection and analysis	Provides strong reflection, interpretation, and learning outcomes.	Gives reasonable reflection with some analysis.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Organized well with minor formatting issues.	Acceptable presentation with several issues.	Poorly organized or difficult to read.

CLIMATE CHANGE MODELING & DISASTER RISK REDUCTION			
Course Code	**1MCV105C**	Scheme	2026
Type of Course	Professional Elective Course	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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: Explain the fundamentals of climate system, climate variability, and climate change drivers.
2. CO2: Analyze climate data and identify trends, extremes, and anomalies relevant to hazard assessment.
3. CO3: Develop basic climate change models and interpret simulation outputs for engineering and environmental applications.
4. CO4: Assess vulnerability, exposure, and risk for selected natural hazards using appropriate frameworks.
5. CO5: Apply disaster risk reduction concepts, mitigation, adaptation, and resilience strategies in real-world contexts.
6. CO6: Critically evaluate integrated climate-risk scenarios and propose sustainable, evidence-based interventions.

Module-1

Climate System and Climate Change Fundamentals:

- Climate system components, atmosphere, hydrosphere, cryosphere, biosphere, and lithosphere.
- Weather, climate, climate variability, and climate change; natural and anthropogenic drivers.
- Greenhouse effect, carbon cycle, radiative forcing, aerosols, and feedback mechanisms.
- Observed trends in temperature, precipitation, sea level, glacier retreat, and extreme events.
- Introduction to climate indicators and global climate assessment reports.

Linked COs: CO1 **Number of Hours: 8 hrs**

Module-2

Climate Data Analysis and Trend Detection:

- Sources of climate data: observations, reanalysis products, satellites, and station records.
- Data preprocessing, quality control, missing data handling, and anomaly calculation.
- Descriptive statistics, moving averages, variability measures, and trend analysis.
- Extreme value concepts, return period, and basic analysis of droughts, floods, and heatwaves.
- Statistical tools for climate interpretation using graphs, indices, and time-series summaries.

Linked COs: CO2 **Number of Hours: 9 hrs**

Module-3

Climate Change Modeling:

- Introduction to climate models: conceptual, statistical, and process-based models.
- Energy balance models, simple greenhouse models, and scenario-based projections.
- General circulation models and regional climate models: structure and outputs.
- Emission scenarios, uncertainty, model validation, and interpretation of projections.
- Applications of climate models in water resources, agriculture, urban systems, and infrastructure planning.

Linked COs: CO3 **Number of Hours: 9 hrs**

Module-4

Hazard, Vulnerability, and Risk Assessment:

- Concepts of hazard, exposure, vulnerability, capacity, and risk.
- Disaster types: hydro-meteorological, geophysical, climatological, and biological hazards.
- Risk assessment frameworks, risk mapping, and multi-criteria prioritization.
- Vulnerability assessment of people, infrastructure, ecosystems, and services.
- Sectoral risk examples: floods, landslides, cyclones, droughts, coastal inundation, and urban heat stress.

Linked COs: CO4 **Number of Hours: 8 hrs**

Module-5

Disaster Risk Reduction, Adaptation, and Resilience:

- Disaster risk reduction concepts, prevention, preparedness, response, and recovery.
- Mitigation and adaptation strategies for climate-resilient development.
- Structural and non-structural measures, early warning systems, and evacuation planning.
- Community-based disaster risk reduction, institutional frameworks, and policy instruments.
- Resilience, climate justice, sustainable development, and integrated risk-informed planning.

Linked COs: CO5, CO6 **Number of Hours: 8 hrs**

Suggested Learning Resources:

Textbooks:

1. IPCC Assessment Reports, latest available edition.
2. P. K. Das, Climate Change and Disaster Management, McGraw Hill, latest edition.
3. A. Ahmadi, Climate Change Modeling and Impact Assessment, Wiley, latest edition.
4. J. T. Houghton, Global Warming: The Complete Briefing, Cambridge University Press, latest edition.
5. R. A. Pielke Jr., Climate Vulnerability and Disasters, latest edition

Reference Books:

1. M. C. Lemos and others, Climate Risk and Resilience, Springer, latest edition.
2. C. D. Lee and N. J. Singh, Disaster Risk Reduction and Management, latest edition.
3. R. W. Katz and others, Statistics of Extremes in Climate and Weather, latest edition.
4. K. J. Beven, Rainfall-Runoff Modelling, latest edition.
5. B. C. Bates, Z. W. Kundzewicz, S. Wu, and J. P. Palutikof, Climate Change and Water, latest edition.

Web links and Video Lectures (e-Resources):

1. IPCC reports and summaries for policymakers.
2. NDMA and SDMA guidelines on disaster risk reduction.
3. IMD climate and weather datasets and climate services.
4. NASA Earthdata and Copernicus Climate Data Store.
5. NPTEL/SWAYAM courses on climate change, hydrology, hazard assessment, and disaster management.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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):

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- Simulation and Virtual Labs

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

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Climate data analysis exercise:** Analyze temperature or rainfall data, compute trends, anomalies, and variability metrics.	24
2	**Climate impact case study:** Prepare a case study on flood, drought, cyclone, or heatwave risk for a chosen region.	24
3	**Risk assessment and mapping assignment:** Develop a simple hazard-vulnerability-risk matrix for a local community or infrastructure asset.	24
4	**Adaptation plan mini-project:** Propose adaptation and resilience measures for an urban, coastal, or agricultural system.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Read selected IPCC summary sections and prepare a reflective note.	24
2	Develop a concept map on risk, vulnerability, and resilience.	24
3	Complete a MOOC module on climate change or disaster risk reduction.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem understanding	Clear problem framing with strong justification.	Mostly clear with minor gaps.	Basic attempt with limited clarity.	Poorly defined problem.
Data and method	Appropriate data and sound methodology.	Mostly appropriate with minor issues.	Limited data or partial method.	Inadequate or incorrect method.
Analysis	Robust interpretation and valid results.	Generally sound with minor errors.	Partial analysis with gaps.	Weak or incorrect analysis.
Recommendations	Strong, feasible, and context-specific.	Relevant with minor limitations.	Generic recommendations.	Incomplete or unrealistic.
Presentation	Well organized and professional.	Good organization with minor issues.	Acceptable but uneven.	Poorly presented.

SUSTAINABLE MATERIALS & CIRCULAR ECONOMY			
Course Code	**1MCV105D**	Scheme	2026
Type of Course	Professional Elective Course	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L4) - Explain sustainability concepts, resource efficiency, and circular economy principles relevant to civil engineering materials and construction systems.
2. CO2 (L4) - Analyze environmental impacts, embodied carbon, and life-cycle performance of construction materials using suitable assessment methods.
3. CO3 (L5) - Evaluate the suitability of sustainable, recycled, and low-carbon materials for civil engineering applications based on performance and durability.
4. CO4 (L6) - Design circular material strategies for buildings and infrastructure using reuse, recycling, redesign, and waste minimization principles.
5. CO5 (L5) - Assess policy, procurement, construction waste management, and end-of-life strategies for circular construction implementation.
6. CO6 (L6) - Develop integrated sustainable-material solutions for civil engineering projects aligned with circular economy, carbon reduction, and sustainability goals.

Module-1

Sustainability and Circular Economy Basics:

Introduction to sustainability, SDGs, resource depletion, environmental footprints, circular economy principles, linear-to-circular transition, systems thinking, product life cycle, material loops, urban mining, and circularity in the built environment. Overview of civil engineering relevance in planning, materials selection, and infrastructure development.

Linked COs: CO1. **Number of Hours: 08 hrs**

Module-2

Sustainable Construction Materials:

Conventional and alternative construction materials, embodied energy, embodied carbon, low-carbon cementitious systems, supplementary cementitious materials, recycled aggregates, industrial by-products, geopolymer concrete, sustainable steel, timber, bamboo, earth-based materials, recycled plastics, and bio-based materials. Performance, durability, and serviceability considerations in civil engineering applications.

Linked COs: CO2, CO3. **Number of Hours: 10 hrs**

Module-3

Life-Cycle Thinking and Environmental Assessment:

Life-cycle assessment, life-cycle costing, material flow analysis, carbon footprint estimation, water footprint, environmental product declarations, selection criteria for sustainable materials, durability and maintenance impacts, circular performance indicators, and interpretation of environmental metrics. Basic tools and spreadsheet-based assessment methods for material evaluation.

Linked COs: CO2, CO3. **Number of Hours: 10 hrs**

Module-4

Circular Design, Reuse, and Waste Management:

Design for reuse, repair, refurbishment, remanufacturing, and disassembly; modular construction; prefabrication; construction and demolition waste management; source segregation; recovery pathways; recycling processes; material passports; reverse logistics; and circular planning for buildings and infrastructure. Strategies for reducing waste during construction, operation, renovation, and demolition.

Linked COs: CO4, CO5. **Number of Hours: 08 hrs**

Module-5

Policy, Case Studies, and Project Applications:

Circular economy policies, green procurement, standards and codes, incentive mechanisms, extended producer responsibility, carbon regulation trends, institutional frameworks, and implementation barriers. Integrated case studies on sustainable buildings, pavement materials, infrastructure reuse, waste-to-resource systems, and campus-scale circularity planning.

Linked COs: CO5, CO6. **Number of Hours: CI 06 hrs**

Suggested Learning Resources Textbooks:

1. Kibert, C. J. Sustainable Construction: Green Building Design and Delivery. Wiley.
2. Cradle to Cradle-inspired and circular-economy texts on built environment sustainability.
3. McDonough, W. and Braungart, M. Cradle to Cradle. North Point Press.
4. Anastas, P. and Zimmerman, J. Design through the 12 Principles of Green Engineering. ACS.

Reference Books:

1. Ghisellini, P., Ripa, M., and Ulgiati, S. works on circular economy in construction.
2. Ashby, M. Materials and the Environment: Eco-informed Material Choice. Elsevier.
3. BEP / LCA guidance documents on buildings and construction materials.
4. Allen, E. and Iano, J. Fundamentals of Building Construction: Materials and Methods with sustainability add-ons.

e- Resources:

1. Ellen MacArthur Foundation resources on circular economy.
2. IPCC and UNEP resources on embodied carbon and materials.
3. NPTEL courses on sustainable construction materials and circular economy.
4. UN-Habitat, World Green Building Council, and C&D waste guidance documents.

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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA. In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Mini project: Material circularity plan for a civil engineering project	24
2	Case Study: Sustainable Building Materials Case Study	24
3	Field Visit: Visit to recycling facility/green construction site	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Analyze LEED/GRIHA certified building materials	24
2	Design poster on "Circular Economy in Infrastructure"	24
3	Complete a MOOC module on Sustainable Building Materials	24

Sample rubrics for TW activities:

A. Field Activity Report

Performance Criteria	O	A+	A	B+	B
Documentation Quality	Complete photos, diagrams, notes	Good documentation	Adequate documentation	Partial documentation	Incomplete
Process Understanding	Detailed flow diagram with explanations	Clear diagram	Basic diagram	Simplified diagram	Missing
Observations & Analysis	Critical observations, data-driven	Good observations	Adequate observations	Limited observations	Minimal
Recommendations	innovative recommendations	3 recommendations	2 recommendations	1 recommendation	None

PROJECT FEASIBILITY AND REPORT WRITING			
Course Code	**1MCV105E**	Scheme	2026
Type of Course	Professional Elective Course	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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: Explain the concepts of project life cycle, project identification, formulation, and feasibility in the context of civil and infrastructure projects.
2. CO2: Analyse technical, market, financial, economic, environmental, and social aspects to assess project feasibility.
3. CO3: Apply appropriate methods and tools for project cost estimation, risk analysis, and appraisal for different types of engineering projects.
4. CO4: Prepare a structured Detailed Project Report (DPR) complying with institutional, professional, and regulatory standards.
5. CO5: Demonstrate effective technical writing, documentation, and presentation skills for communicating project proposals and outcomes.
6. CO6: Integrate sustainability, safety, and stakeholder perspectives within project feasibility studies and reporting practices.

Module-1

Introduction to Projects and Feasibility:

- Definitions and characteristics of projects; project cycle; types of projects in civil, infrastructure, transportation, water resources, building, and environmental sectors.
- Project identification, screening of project ideas, preliminary studies, pre-feasibility vs detailed feasibility.
- Role of stakeholders, sponsors, consultants, and regulatory bodies in project formulation.
- Overview of project feasibility dimensions: technical, market, financial, economic, environmental, social, legal, and institutional.

Linked COs: CO1, CO6 **Number of Hours: 8**

Module-2

Technical, Market, and Economic Feasibility:

- Technical feasibility: site selection, technology choice, capacity planning, design standards, resource availability, and infrastructure support.
- Market feasibility: demand and supply analysis for infrastructure services, stakeholder needs assessment, service level benchmarks, pricing considerations.
- Economic feasibility: cost–benefit analysis, economic internal rate of return (EIRR), evaluation of tangible and intangible benefits.
- Case illustrations of feasibility assessment for typical urban infrastructure and construction projects.

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

Module-3

Financial Analysis and Risk Assessment:

- Financial feasibility: project cost components, capital and operating costs, working capital, life-cycle costing.
- Time value of money: compounding, discounting, annuities, depreciation basics (conceptual coverage).
- Project appraisal criteria: net present value (NPV), internal rate of return (IRR), benefit–cost ratio

(BCR), payback period, sensitivity analysis.

- Risk and uncertainty in projects: identification of risks, risk classification, qualitative and quantitative risk analysis approaches; risk mitigation strategies.

Linked COs: CO2, CO3, CO6 **Number of Hours: 9**

Module-4

Detailed Project Report (DPR) – Structure and Preparation:

- Purpose and components of a DPR for infrastructure and civil engineering projects.
- Typical DPR structure: executive summary, background and need, objectives, project description and scope, technical details, implementation schedule, cost estimates, financial and economic analysis, environmental and social aspects, risk assessment, institutional arrangements.
- Alignment of DPR with statutory requirements (e.g., environmental clearances, urban development regulations), funding agency formats, and government guidelines (where applicable).
- Use of digital tools (spreadsheets, project management software, templates) for DPR preparation and documentation.

Linked COs: CO3, CO4, CO6 **Number of Hours: 9**

Module-5

Technical Report Writing and Presentation:

- Fundamentals of technical writing: clarity, coherence, objectivity, and ethical practices.
- Structure of technical reports: introduction, literature/context review, methodology, results, discussion, conclusions, recommendations, references, and annexures.
- Writing style for project reports: use of figures, tables, charts, drawings, and appendices; citation and referencing norms; plagiarism awareness.
- Preparation of presentations based on DPRs: slide design, visualization of project data, pitching to technical and non-technical audiences; group presentation and peer feedback.

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

Suggested Learning Resources:

Textbooks:

1. Prasanna Chandra, *Projects: Planning, Analysis, Financing, Implementation, and Review*, latest edition.
2. K Nagrajan, *Project Management*, latest edition.
3. S. Choudhury, *Project Management*, latest edition.
4. R. Panneerselvam, *Engineering Economics*, latest edition.
5. M. E. Van Valkenburg, *Network Analysis* (selected topics where relevant to infrastructure project feasibility), latest edition.

Reference Books and Documents:

1. Guidelines/manuals of national agencies (e.g., CPWD, NHAI, MoRTH, MoHUA, CPHEEO) on preparation of DPRs for infrastructure projects, latest editions.
2. Model DPRs and feasibility reports from government and international agencies (World Bank, ADB, etc.) for civil and infrastructure projects.
3. BIS and IRC codes relevant to cost estimation, planning, and design of civil works (selected provisions).
4. Institutional / state-level project appraisal guidelines and formats, where applicable.

Web Links and e-Resources:

1. NPTEL / SWAYAM courses on project management, infrastructure financing, engineering economics, and technical communication.
2. Government portals hosting DPR templates, standard bidding documents, and appraisal guidelines for infrastructure projects.
3. Open educational resources and case repositories on project feasibility studies and report writing for

civil and infrastructure projects.

Teaching-Learning Process (Innovative Delivery Methods):
The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE)
The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:
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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only
As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Project idea screening note** • Students identify 2–3 project ideas and justify the best one using basic feasibility criteria. • Output: 2–3 page note with problem statement, need, and preliminary feasibility.	24
2	**Feasibility matrix** • Students prepare a comparison matrix covering technical, financial, environmental, social, and institutional feasibility. • Output: weighted matrix with brief justification for each criterion.	24
3	**DPR section writing** • Students draft selected DPR sections such as executive summary, project background, objectives, scope, and implementation plan. • Output: structured report in formal format.	24
4	**Cost and risk analysis sheet** • Students estimate project cost heads and identify key risks with mitigation measures.	24

	• Output: spreadsheet or tabular worksheet.	
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**Seminar on feasibility study** • Each student presents one feasibility dimension, such as technical, financial, or environmental feasibility.	24
2	**Case presentation on a real project** • Students present a real infrastructure project and explain why it is feasible or not.	24
3	**DPR pitch presentation** • Students present their project proposal, emphasizing need, scope, cost, and impact.	24

Sample rubrics for TW activities:

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Problem identification	Clear, specific, and well justified	Clear but partly justified	Basic identification	Vague or unclear
Feasibility analysis	Uses multiple criteria with sound reasoning	Uses relevant criteria with minor gaps	Limited analysis	Minimal or incorrect analysis
Data and calculations	Accurate, complete, and well organized	Mostly accurate	Some errors or omissions	Major errors or missing
Report structure	Logical, complete, professional	Mostly organized	Basic structure	Poorly structured
Language and formatting	Excellent clarity and formatting	Minor language issues	Acceptable but weak	Frequent errors
References / evidence	Relevant and properly used	Adequate use	Limited use	No evidence or references

SUSTAINABLE INFRASTRUCTURE PLANNING & POLICY			
Course Code	**1MCV105F**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 L4 - Explain sustainability concepts, infrastructure life cycle, and policy drivers relevant to sustainable planning of civil engineering systems.
2. CO2 L4 - Analyze environmental, social, economic, and governance impacts in infrastructure planning using suitable assessment approaches.
3. CO3 L5 - Evaluate planning alternatives, technologies, and standards for sustainable infrastructure projects based on performance and resilience.
4. CO4 L6 - Design integrated sustainable infrastructure strategies using circularity, climate adaptation, and resource efficiency principles.
5. CO5 L5 - Assess policy instruments, institutional frameworks, and regulatory mechanisms for sustainable infrastructure implementation.
6. CO6 L6 - Develop policy-informed infrastructure solutions aligned with sustainability goals, resilience, and long-term community benefit.

Module-1

Introduction to Sustainable Infrastructure Planning:

Concept of sustainable infrastructure, infrastructure life cycle, systems thinking, SDGs, resource efficiency, climate-responsive planning, urbanization challenges, and relationship between infrastructure, environment, and society. Overview of transportation, water, sanitation, energy, waste, and public infrastructure systems in the sustainability context.

Linked COs: CO1. **Number of Hours: 08 hrs.**

Module-2

Infrastructure Assessment and Planning Tools:

Sustainability assessment frameworks, environmental impact assessment, social impact assessment, economic appraisal, multi-criteria decision analysis, resilience assessment, risk-based planning, carbon and water footprint concepts, and life-cycle thinking in infrastructure planning. Data-based planning tools, indicators, and decision-support methods.

Linked COs: CO2, CO3. **Number of Hours: 10 hrs.**

Module-3

Sustainable Infrastructure Design Strategies:

Green infrastructure, nature-based solutions, low-impact development, climate adaptation, demand management, energy-efficient systems, water-sensitive urban design, inclusive design, universal accessibility, and resource-efficient infrastructure design. Role of digital tools, BIM, GIS, and smart infrastructure in sustainable planning.

Linked COs: CO3, CO4. **Number of Hours: 10 hrs.**

Module-4

Policy, Governance, and Finance:

National and international sustainability policies, urban and infrastructure policy frameworks, regulatory mechanisms, standards and codes, public-private partnerships, green procurement, climate policy, incentives, financing models, institutional roles, and governance challenges in implementation. Integration of policy with planning, monitoring, and compliance.

Linked COs: CO5. **Number of Hours: 08 hrs**

Module-5

Case Studies and Project Applications:

Case studies on sustainable transport systems, water supply and sanitation planning, resilient urban drainage, solid waste infrastructure, energy-efficient public facilities, and climate-resilient community infrastructure. Project-based applications for campus, town, and city-scale sustainable infrastructure planning with policy alignment and stakeholder engagement.

Linked COs: CO5, CO6. **Number of Hours: 06**

Suggested Learning Resources Textbooks

1. Kibert, C. J. Sustainable Construction: Green Building Design and Delivery. Wiley.
2. McDonough, W. and Braungart, M. Cradle to Cradle. North Point Press.
3. Mays, L. W. Water Resources Engineering. Wiley.
4. Newman, P. and Jennings, I. Cities as Sustainable Ecosystems. Island Press.

Reference Books

1. Ashby, M. Materials and the Environment: Eco-informed Material Choice. Elsevier.
2. Rogers, R. Cities for a Small Planet. Westview Press.
3. Black, W. R. Sustainable Transportation: Problems and Solutions. Guilford Press.
4. UN-Habitat and World Bank reports on sustainable infrastructure planning.

e- Resources:

1. World Bank sustainable infrastructure resources.
2. UN-Habitat urban sustainability and resilience resources.
3. IPCC reports on climate adaptation and infrastructure.
4. NPTEL courses on sustainable infrastructure, urban planning, and policy.

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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA. In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only		
As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	Sustainable infrastructure case study analysis	24
2	Campus infrastructure sustainability audit	24
3	Mini project on resilient infrastructure planning	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Analyze sustainability policy of an urban infrastructure project	24
2	Prepare a comparative report on green infrastructure strategies	24
3	Complete a MOOC module on sustainable infrastructure planning	24

Sample rubrics for TW activities:

A. Case Study / Field Activity Report

Performance Criteria	O	A	B	C	D
Documentation Quality	Complete photos, drawings, data, and notes	Good documentation	Adequate documentation	Partial documentation	Incomplete
Process Understanding	Detailed explanation and logical flow	Clear explanation	Basic explanation	Simplified explanation	Missing
Observations and Analysis	Critical, data-based analysis	Good observations	Adequate observations	Limited observations	Minimal
Recommendations	Innovative and feasible recommendations	3 recommendations	2 recommendations	1 recommendation	None

OCCUPATIONAL HEALTH AND SAFETY ENGINEERING			
Course Code	**1MCV105G**	Scheme	2026
Type of Course	Professional Elective Course	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L4 - Analyze): Analyze occupational health hazards, toxic exposures, ergonomics, and disease prevention measures in engineering workplaces.
2. CO2 (L4 - Analyze): Analyze workplace safety principles, accident causation, hazard identification, and risk control techniques.
3. CO3 (L5 - Evaluate): Evaluate fire safety, electrical safety, machine safety, and emergency response systems for engineering environments.
4. CO4 (L6 - Create): Create safety plans, inspection checklists, and personal protective equipment strategies for construction and industrial sites.
5. CO5 (L6 - Create): Design occupational safety management practices integrating legal compliance, audit methods, and sustainability considerations.
6. CO6 (L5 - Evaluate): Evaluate case studies and safety performance indicators to improve health and safety outcomes in civil engineering practice.

Module-1

Fundamentals of Occupational Health:

Introduction to occupational health and safety, historical development, importance of safety in engineering practice, occupational health hazards, routes of entry of toxic substances into the human body, permissible exposure limits, threshold limit value, acute and chronic exposure, occupational diseases caused by dusts, fumes, gases, metals, and chemicals. Ergonomics: principles, workplace design, fatigue, posture, manual handling, and preventive measures.

Linked COs: CO1. **Number of Hours: 08 hrs.**

Module-2

Safety Management and Hazard Control:

Safety concepts and principles, accident causation theories, incident reporting, accident investigation, hazard identification, risk assessment, job safety analysis, safe work procedures, hierarchy of controls, safety signage, behavioral safety, and emergency preparedness. Introduction to industrial hygiene and control measures for physical, chemical, biological, and mechanical hazards.

Linked COs: CO2 **Number of Hours: 10 hrs.**

Module-3

Fire, Electrical and Machine Safety:

Fire triangle, causes and classes of fire, fire detection and suppression systems, fire extinguishers, evacuation planning, and emergency drills. Electrical safety: shock hazards, grounding, insulation, lockout-tagout principles, safe use of electrical equipment. Machine safety: guards, interlocks, safe operating procedures, and common causes of equipment-related accidents.

Linked COs: CO3. **Number of Hours: 10 hrs.**

Module-4

Construction Site Safety and PPE:

Safety in construction sites, excavation safety, scaffolding safety, lifting operations, formwork safety, working at heights, confined space safety, and material handling. Personal protective equipment: selection, use, limitations, maintenance, and training. Safety documentation: permit-to-work, toolbox talks, inspection formats, and site safety plans.

Linked COs: CO4. **Number of Hours: 08 hrs.**

Module-5

Safety Audit, Laws and Emerging Practices:

Occupational safety legislation, statutory provisions, employer and employee responsibilities, safety audit, inspections, monitoring, compliance records, and safety management systems. Introduction to environmental health, sustainability in safety practice, incident metrics, and digital tools for safety monitoring. Case studies from civil engineering, construction, and infrastructure sectors.

Linked COs: CO5, CO6. **Number of Hours: 06 hrs.**

Suggested Learning Resources

Textbooks:

1. A. M. Sarma, Industrial Safety, Health and Environment Management, latest edition.
2. R. K. Jain and Sunil S. Rao, Industrial Safety, Health and Environment Management Systems, latest edition.
3. David G. Shillingford, Occupational Safety and Health Management, latest edition.
4. John Ridley, Safety at Work, latest edition.
5. Frank R. Spellman and Revonna M. Bieber, Handbook of Safety Principles, latest edition.

Reference Books:

1. Relevant provisions of the Factories Act, Building and Other Construction Workers legislation, and allied safety rules.
2. BIS standards related to safety, PPE, scaffolding, fire protection, and electrical safety.
3. ILO guidelines on occupational safety and health.
4. National and international codes of practice for construction safety and health.
5. Case manuals and safety audit checklists from reputed infrastructure and industrial organizations.

Web Links and E-resources

1. NPTEL/SWAYAM courses on industrial safety, occupational health, and risk management.
2. Government portals and regulatory sites providing safety rules, acts, and notifications.
3. Online training modules on fire safety, emergency preparedness, and workplace safety.
4. Open educational resources on risk assessment, HAZOP, and safety audits.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Hazard identification sheet:** Identify hazards in a civil/industrial workplace and classify them as physical, chemical, electrical, mechanical, ergonomic, or fire hazards.	24
2	**Risk assessment matrix:** Prepare a risk matrix with likelihood, severity, risk ranking, and control measures for a selected site activity.	24
3	**Emergency response plan:** Prepare an emergency evacuation and first-aid response plan for a project site.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**Seminar on safety laws and standards:** Present one act, rule, code, or standard related to occupational safety and health.	24
2	**PPE selection presentation:** Present appropriate PPE for a selected operation, including selection criteria and limitations.	24
3	**Safety plan pitch presentation:** Present a site safety plan covering hazards, controls, emergency response, and monitoring.	24

Sample rubrics for TW activities:

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Problem identification	Identifies all relevant hazards/issues clearly and accurately.	Identifies most hazards/issues with minor gaps.	Identifies basic hazards/issues with limited depth.	Misses major hazards/issues or shows unclear understanding.
Technical accuracy	Analysis and controls are fully correct and appropriate.	Mostly correct with minor errors.	Partially correct, but several omissions.	Major errors or poor technical understanding.
Application of safety concepts	Applies safety principles, laws, and controls effectively.	Applies most concepts properly.	Applies a few concepts, but weak linkage to practice.	Fails to apply safety concepts meaningfully.
Documentation quality	Report is well-structured, neat,	Mostly well-structured with	Basic structure with noticeable	Poorly organized and incomplete.

Criterion	Excellent	Good	Satisfactory	Needs Improvement
	complete, and professional.	minor issues.	formatting problems.	
Timeliness and completeness	Submitted on time and fully complete.	Minor delay or minor missing elements.	Noticeable delay or partial completion.	Late and/or largely incomplete.

SUSTAINABLE GEO-MECHANICS AND ENGINEERING			
Course Code	**1MCV105H**	Scheme	2026
Type of Course	Professional Elective Course	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L4) - Analyze geotechnical properties of soils and rocks for sustainable engineering applications.
2. CO2 (L4) - Analyze slope stability, settlement, and ground improvement needs using environmentally responsible methods.
3. CO3 (L5) - Evaluate foundation and earth-retaining systems with emphasis on safety, durability, and resource efficiency.
4. CO4 (L6) - Create sustainable solutions for soil stabilization, ground improvement, and site development.
5. CO5 (L5) - Evaluate geotechnical risks and environmental impacts in infrastructure projects using appropriate assessment tools.
6. CO6 (L6) - Design sustainable geo-engineering strategies integrating climate resilience, construction management, and life-cycle considerations.

Module-1

Fundamentals of Sustainable Geo-mechanics:

Introduction to geo-mechanics and sustainability in geotechnical engineering, role of geotechnics in infrastructure development, soil formation and mineralogy, phase relationships, index properties, soil classification, engineering behavior of soils and rocks, environmental concerns in geotechnical works, life-cycle thinking in ground engineering, and overview of sustainable materials and practices in geo-engineering.

Linked COs: CO1 **Number of Hours: 08 hrs**

Module-2

Soil Behavior, Compaction and Ground Improvement:

Stress distribution in soils, permeability and seepage, consolidation and compression characteristics, shear strength parameters, compaction theory and field control, settlement analysis, geosynthetics in sustainable geotechnics, ground improvement methods such as drainage, vibro-compaction, stone columns, and stabilization using eco-friendly additives.

Linked COs: CO2, CO4 **Number of Hours: 10 hrs.**

Module-3

Slope Stability and Earth Retaining Systems:

Stability of natural and cut slopes, modes of failure, factor of safety, stability analysis methods, drainage in slopes, reinforced earth, retaining walls, crib walls, gabions, and sustainable slope protection measures, erosion control, bioengineering approaches, and green infrastructure solutions for slope management.

Linked COs: CO2, CO3 **Number of Hours: 08 hrs.**

Module-4

Sustainable Foundations and Underground Works:

Shallow and deep foundations, bearing capacity, pile foundations, raft foundations, sustainable design considerations, foundation settlement control, excavation support systems, tunnels and underground openings, groundwater issues, dewatering methods, reuse of excavated material, and low-impact construction practices in foundation engineering.

Linked COs: CO3, CO6 Number of Hours: 08 hrs.
Module-5
Geo-environmental Risk and Resilient Infrastructure: Geo-environmental impacts of construction, contaminant transport in soils, landfill liners and barriers, waste utilization in geotechnical works, climate-resilient geotechnical design, seismic effects on soils, risk assessment and mitigation, monitoring methods, instrumentation, digital tools in geotechnics, case studies on sustainable infrastructure and disaster-resilient ground engineering. **Linked COs: CO5, CO6 Number of Hours: 08**

Suggested Learning Resources Textbooks

1. B. M. Das, *Principles of Geotechnical Engineering*, **8th ed.**, Cengage Learning, latest edition.
2. R. F. Craig, *Soil Mechanics*, **8th ed.**, Spon Press, latest edition.
3. Braja M. Das and Sivakugan, *Principles of Foundation Engineering*, **9th ed.**, Cengage Learning, latest edition.
4. C. V. S. Kumar and others, *Geotechnical Engineering Practice for Sustainable Infrastructure*, **latest edition**, McGraw Hill Education, latest edition.
5. P. Purushothama Raj, *Ground Improvement Techniques*, **2nd ed.**, Laxmi Publications, latest edition.

Reference Books

1. Ghisellini, P., Ripa, M., and Ulgiati, S. works on circular economy in construction.
2. Ashby, M. Materials and the Environment: Eco-informed Material Choice. Elsevier.
3. BEP / LCA guidance documents on buildings and construction materials.
4. Allen, E. and Iano, J. Fundamentals of Building Construction: Materials and Methods with sustainability add-ons.
5. Relevant BIS codes for geotechnical investigation, foundations, retaining structures, and slope stability, Bureau of Indian Standards, latest applicable editions.
6. FHWA and IRC guidelines on soil stabilization, earth retaining structures, and foundations, Federal Highway Administration and Indian Roads Congress, latest editions.
7. Manuals on geosynthetics, environmental geotechnics, and slope protection, published by ICE Publishing / CRC Press / Springer, latest editions.
8. Research reports on sustainable ground improvement and resilient geotechnical design, published by Elsevier / Springer / ASCE Press, latest editions.
9. Case manuals from infrastructure projects involving difficult soil conditions and eco-friendly ground treatment, published by reputed technical agencies and institutions, latest editions.

Web links and video lectures:

1. IIT/NPTEL Geotechnical Engineering: https://nptel.ac.in
2. IRC / Geotechnical guidance resources
3. IS 1498, IS 2720 series, IS 1893, and related BIS standards
4. Ground improvement and sustainable infrastructure lecture resources

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Soil sustainability audit:** Assess a site soil condition and suggest eco-friendly geotechnical interventions.	24
2	**Ground improvement comparison:** Compare conventional and sustainable ground improvement methods for a selected site.	24
3	**Slope stabilization plan:** Prepare a slope protection and erosion control plan using bioengineering measures.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**Seminar on sustainable geotechnics:** Present a topic on eco-friendly soil improvement or resilient foundation systems.	24
2	**Case study presentation:** Present a case study on slope failure, soil contamination, or sustainable ground treatment.	24
3	**Mini project pitch:** Present a sustainable geotechnical solution for a selected infrastructure site.	24

Sample rubrics for TW activities:

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Problem identification	Identifies all relevant site/geotechnical issues clearly and accurately.	Identifies most issues with minor gaps.	Identifies basic issues with limited depth.	Missing major issues or shows unclear understanding.

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Technical accuracy	Analysis and recommendations are fully correct and appropriate.	Mostly correct with minor errors.	Partially correct with several omissions.	Major errors or poor technical understanding.
Sustainability integration	Integrates sustainability principles effectively in design and selection.	Uses sustainability concepts appropriately in most parts.	Mentions sustainability with weak application.	Little or no sustainability linkage.
Documentation quality	Report is well-structured, neat, complete, and professional.	Mostly well-structured with minor issues.	Basic structure with noticeable formatting problems.	Poorly organized and incomplete.

GEOSPATIAL DATA STANDARD AND POLICY			
Course Code	**1MCV105I**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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: Explain geospatial data concepts, data models, metadata, and quality requirements.
2. CO2: Interpret geospatial standards and interoperability requirements for data exchange.
3. CO3: Analyze India's geospatial policy, governance structure, and enabling regulations.
4. CO4: Apply standards and policy provisions to geospatial data management and sharing.
5. CO5: Evaluate the role of geospatial data infrastructure in governance, planning, and service delivery.
6. CO6: Develop policy-compliant geospatial data strategies for academic, institutional, or sectoral use.

Module-1

Fundamentals of Geospatial Data:

Introduction to geospatial information, spatial and non-spatial data, coordinate reference systems, map projections, data types, raster and vector models, spatial resolution, accuracy, precision, completeness, and consistency. Concepts of geospatial data lifecycle, data sources, and typical applications in governance, planning, and engineering.

Linked COs: CO1 **Number of Hours: 08 hrs**

Module-2

Geospatial Standards and Interoperability:

Need for standards in geospatial data management, interoperability, data sharing, and reuse. Overview of metadata standards, data content standards, geodetic reference frameworks, feature catalogues, naming conventions, web services, APIs, and encoding formats. Introduction to ISO-based geospatial standards and their relevance to national data infrastructure.

Linked COs: CO1, CO2 **Number of Hours: 10 hrs**

Module-3

National Geospatial Policy and Governance:

Evolution of geospatial policy in India, National Geospatial Policy 2022, key provisions, objectives, and institutional framework. Role of DST, GDPDC, Survey of India, BIS, NSDI, and sectoral agencies. Liberalization of geospatial data access, public data sharing, and the role of academia and industry. Policy directions for national geospatial missions, digital economy, and citizen services.

Linked COs: CO3, CO5 **Number of Hours: 10 hrs**

Module-4

Geospatial Data Sharing, Registry, and Compliance:

National geospatial data registry, harmonization of datasets, data publishing workflows, compliance requirements, metadata registration, and data governance practices. Concepts of FAIR principles, data security, sensitive data handling, licensing, open data, and institutional data-sharing protocols. Discussion on practical implementation challenges and compliance mechanisms.

Linked COs: CO2, CO4, CO5 **Number of Hours: 08 hrs**

Module-5

Applications, Case Studies, and Emerging Directions:

Applications of geospatial standards and policy in land records, urban planning, infrastructure development, agriculture, disaster management, utilities, and environmental monitoring. Case studies on national missions and geospatial-enabled programs. Emerging themes such as digital twins, geospatial AI, open geospatial platforms, and sector-specific standards. Student project on policy-compliant geospatial data framework for a chosen application.

Linked COs: CO4, CO5, CO6 **Number of Hours: 08 hrs**

Suggested Learning Resources Textbooks:

1. Burnett, M., and others. Geospatial Data Standards and Interoperability. Springer Nature.
2. Crompvoets, J., and Bregt, A. Spatial Data Infrastructure and Geospatial Policy. CRC Press.
3. Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W. Geographic Information Systems and Science. Wiley.
4. Zeiler, M. Modeling Our World: The ESRI Guide to Geodatabase Concepts. ESRI Press.

Reference Books:

1. Rajabifard, A., Williamson, I., and Feeney, M. Developing Spatial Data Infrastructures. Taylor & Francis.
2. Committee on Geo-information, ISO standards, and geospatial governance reports. Elsevier.
3. National Geospatial Policy 2022 and related government policy documents. Government of India publications.
4. Longley, P. A., and others. Geospatial Analysis. Wiley.

e- Resources:

1. Department of Science & Technology, Government of India, Geospatial Policy resources.
2. Press Information Bureau release on National Geospatial Policy implementation.
3. Open Geospatial Consortium standards portal.
4. UN-GGIM standards guide on geospatial information management

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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):

- Lectures and interactive discussions.
- Case-based learning.
- Problem-based learning.
- Demonstrations of geospatial portals and open data platforms.
- Seminar presentations on policy and standards.
- Mini-project or term-work on data governance and standards compliance.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

Students' activities for TW/SL under NCrF: Samples only		
As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	Prepare metadata for a sample geospatial dataset	24
2	Compare two geospatial standards used for interoperability	24
3	Prepare a policy note on National Geospatial Policy 2022	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Analyze a national geospatial portal and its standards compliance	24
2	Design a poster on "Geospatial Data Standards for Governance"	24
3	Complete a MOOC module on geospatial data management	24

Sample rubrics for TW activities:

A. Field / Policy Analysis Report

Performance Criteria	O	A+	A	B+	B
Documentation Quality	Complete and well-structured	Good documentation	Adequate documentation	Partial documentation	Incomplete
Concept Understanding	Excellent understanding	Clear understanding	Basic understanding	Limited understanding	Missing
Analysis	Critical, data-driven analysis	Good analysis	Adequate analysis	Limited analysis	Minimal
Recommendations	Innovative and feasible	Strong recommendations	Acceptable recommendations	Weak recommendations	None

1MCV106X: Professional Elective Courses-II

DIGITAL TWIN TECHNOLOGIES			
Course Code	**1MCV106 A**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L4) - Explain the concepts, architecture, and enabling technologies of digital twins in civil engineering and infrastructure systems.
2. CO2 (L4) - Analyze data acquisition, sensor systems, data integration, and model updating methods used in digital twin environments.
3. CO3 (L5) - Evaluate simulation, predictive analytics, and performance monitoring approaches for civil infrastructure applications.
4. CO4 (L6) - Design digital twin frameworks for buildings, transportation, water systems, and construction projects.
5. CO5 (L5) - Assess interoperability, cybersecurity, lifecycle management, and decision-support aspects of digital twin implementation.
6. CO6 (L6) - Develop integrated digital twin solutions for resilient, sustainable, and intelligent civil infrastructure management.

Module-1

Introduction to Digital Twin Concepts and Architecture:

Definition and evolution of digital twins, difference between digital model, digital shadow, and digital twin, core components, physical asset representation, data-flow architecture, real-time synchronization, lifecycle perspective, and enabling technologies. Overview of BIM, CPS, IoT, cloud, edge computing, AI/ML, and visualization platforms. Civil engineering relevance in built assets, infrastructure monitoring, and smart cities.

Linked COs: CO1. **Number of Hours: 08 hrs**

Module-2

Data Acquisition, IoT, and Connectivity for Digital Twins:

Sensors, smart devices, data sources, telemetry, communication protocols, data quality, preprocessing, storage, and integration. IoT-based monitoring systems, wireless networks, gateways, cloud platforms, digital twin databases, and dashboard concepts. Data acquisition from structures, transportation assets, water infrastructure, and construction sites. Introduction to data fusion, calibration, and synchronization.

Linked COs: CO2. **Number of Hours: 09 hrs**

Module-3

Modeling, Simulation, and Analytics in Digital Twins:

Physics-based modeling, data-driven modeling, hybrid models, simulation lifecycle, model calibration, validation, updating, and uncertainty handling. Predictive analytics, condition monitoring, anomaly detection, performance forecasting, and scenario analysis. Applications of AI/ML, time-series analysis, and optimization in digital twin environments. Interpretation of model outputs for engineering decision-making.

Linked COs: CO3. **Number of Hours: 09 hrs**

Module-4

Digital Twin Applications in Civil Engineering:
Digital twins for buildings, bridges, highways, metro systems, water supply networks, drainage systems, dams, and construction projects. Asset health monitoring, structural performance tracking, construction progress control, energy efficiency, maintenance planning, and resilience assessment. Integration with BIM, GIS, SCADA, and smart city platforms.

Linked COs: CO4. **Number of Hours: 08 hrs**

Module-5

Implementation, Interoperability, and Case Studies:
Digital twin deployment strategy, data governance, interoperability standards, cybersecurity, scalability, and lifecycle management. Cost-benefit aspects, implementation challenges, institutional requirements, and future trends. Case studies on infrastructure monitoring, smart buildings, transport systems, and water infrastructure. Digital twins for sustainability, resilience, and asset management.

Linked COs: CO5, CO6. **Number of Hours: 08 hrs**

Suggested Learning Resources
Textbooks:

1. Grieves, M. and Vickers, J. Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems.
2. Kritzinger, W. et al. Digital Twin in Manufacturing and Engineering Systems. Springer.
3. Tao, F. and Qi, Q. Digital Twin and Big Data Toward Smart Manufacturing and Engineering.
4. Antonino, J. and others. Smart Infrastructure and Digital Twin Applications in Civil Engineering.

Reference Books

1. Fuller, A., Fan, Z., Day, C., and Barlow, C. Digital Twin: Enabling Technologies, Challenges and Open Research.
2. Wang, K. and others. BIM, IoT and Digital Twin Integration for Infrastructure.
3. Booth, C. and Pistor, M. Smart Cities and Infrastructure Digitalization.

16. Liu, Y. and others. Structural Health Monitoring and Digital Twin Concepts with sustainability add-ons.

e- Resources:

1. NPTEL courses on BIM, IoT, AI/ML, and smart infrastructure.
2. IEEE and Springer articles on digital twin technologies.
3. Bentley, Autodesk, and Siemens digital twin learning resources.
4. Smart city and infrastructure digitalization resources from government and industry portals.
5. Research datasets and dashboards for structural health monitoring, traffic, and water systems.

Teaching-Learning Process (Innovative Delivery Methods):
The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE) :
The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:
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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Students' activities for TW/SL under NCrF: Samples only
As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Mini Project: Digital twin framework for a civil infrastructure asset. Deliverables: Report, architecture diagram, dashboard prototype	24
2	Predictive maintenance model for a civil asset: Report, simulation output, recommendations	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	NPTEL/industry module reflections on digital twins	24
2	Seminar on Digital twin case studies in transportation and water systems	24

Sample rubrics for TW activities:

B. Rubric for Micro-project

Criterion	Excellent	Good	Satisfactory	Needs Improvement
Problem Definition	Clear, focused, context-specific	Mostly clear	Basic problem statement	Vague or missing
Methodology	Appropriate and systematically applied	Mostly appropriate	Partially applied	Weak or absent
Technical Accuracy	Correct analysis and calculations	Minor errors	Some errors	Major errors
Innovation / Originality	Strong initiative and creative solution	Some originality	Limited originality	No originality
Sustainability / DRR Integration	Strong adaptation and resilience focus	Good integration	Basic integration	Missing

OPTIMIZATION TECHNIQUES FOR CIVIL SYSTEMS			
Course Code	**1MCV106 B**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L4) - Explain the fundamentals of optimization, mathematical formulation, objective functions, constraints, and design variables relevant to civil engineering problems.
2. CO2 (L4) - Apply linear programming, graphical methods, and simplex-based concepts to solve civil engineering optimization problems.
3. CO3 (L5) - Analyze transportation, water resources, structural, and construction-related systems using suitable deterministic optimization techniques.
4. CO4 (L6) - Design optimal solutions for civil systems considering cost, time, safety, sustainability, and performance constraints.
5. CO5 (L5) - Evaluate nonlinear, integer, dynamic, and network optimization approaches for infrastructure and project planning problems.
6. CO6 (L6) - Develop integrated optimization-based civil engineering solutions using analytical tools and computational methods for decision-making.

Module-1

Optimization Fundamentals and Problem Formulation:

Introduction to optimization, role of optimization in civil engineering, decision variables, objective functions, constraints, feasible region, optimal solution, single-variable and multivariable optimization, classification of optimization problems, model formulation, engineering design interpretation, basics of convexity, and sensitivity concepts. Civil applications in structural, transportation, water resources, and construction systems.

Linked COs: CO1. **Number of Hours: 08 hrs**

Module-2

Linear Programming and Engineering Applications:

Linear programming formulation, standard form, graphical method, simplex method concepts, duality, shadow price, reduced cost, sensitivity analysis, and optimization of resources. Applications to mix design, material allocation, land use planning, irrigation scheduling, project budgeting, and resource distribution in civil systems. Introduction to spreadsheet-based LP solving and basic computational tools.

Linked COs: CO2. **Number of Hours: 09 hrs**

Module-3

Transportation, Assignment and Network Models:

Transportation problem, balanced and unbalanced models, initial basic feasible solutions, optimality tests, assignment problem, Hungarian method concepts, shortest path, minimum spanning tree, maximum flow, transshipment, and network representation. Applications in logistics, construction material movement, utility networks, traffic routing, and infrastructure service optimization.

Linked COs: CO3. **Number of Hours: 09 hrs**

Module-4

Nonlinear, Integer and Dynamic Optimization:

Nonlinear programming concepts, unconstrained and constrained optimization, Lagrange multipliers, KKT basics, integer programming, binary variables, branch-and-bound concepts, dynamic programming, goal programming, and multi-objective optimization. Civil engineering applications in design optimization, project sequencing, equipment selection, cost-time trade-offs, and facility location.

Linked COs: CO4, CO5. **Number of Hours: 08 hrs**

Module-5

Computational Methods and Civil Case Studies:

Optimization algorithms overview, heuristic and metaheuristic methods, genetic algorithms, simulated annealing, particle swarm optimization, gradient-based methods, software tools for optimization, interpretation of results, and model validation. Integrated case studies on structural design optimization, water distribution systems, traffic signal timing, construction planning, and sustainable infrastructure decision-making.

Linked COs: CO5, CO6. **Number of Hours: 08 hrs**

Suggested Learning Resources

Textbooks:

23. Taha, H. A. Operations Research: An Introduction. Pearson.
24. Rao, S. S. Engineering Optimization: Theory and Practice. Wiley.
25. Hillier, F. S. and Lieberman, G. J. Introduction to Operations Research. McGraw-Hill.
26. Deb, K. Optimization for Engineering Design: Algorithms and Examples. PHI.

Reference Books:

17. Arora, J. S. Introduction to Optimum Design. Academic Press.
18. Bazaraa, M. S., Jarvis, J. J., and Sherali, H. D. Linear Programming and Network Flows. Wiley.
19. Chong, E. K. P. and Zak, S. H. An Introduction to Optimization. Wiley.
20. Winston, W. L. Operations Research: Applications and Algorithms. Cengage.

e- Resources:

28. NPTEL courses on optimization methods, operations research, and engineering design.
29. MIT Open Courseware resources on optimization and linear programming.
30. COURSERA and SWAYAM resources on optimization and decision science.
31. MATLAB, Python, Excel Solver, and other open-source optimization tool documentation.
32. Case studies and notes from professional bodies and civil engineering research portals.

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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:
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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA. In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Formulation of a civil engineering optimization problem:** Problem statement, variables, objective function, constraints, assumptions	24
2	**Linear programming case study:** LP model, solution steps, interpretation	24
3	**Mini-project using MATLAB / Python / spreadsheet:** Working model, results, and presentation	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Review of one research paper on optimization in civil engineering	24
2	Study of one software / solver tool	24
3	Case study on a real civil system	24

Sample rubrics for TW activities:

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs improvement
Problem understanding and formulation	Problem is clearly understood; variables, objective, and constraints are precise and complete.	Minor gaps in formulation, but technically sound.	Basic understanding shown; formulation has some omissions.	Poor understanding; incorrect or incomplete formulation.
Method selection and application	Correct method selected and applied systematically with strong reasoning.	Method is mostly correct with minor procedural errors.	Method is partially appropriate; steps are incomplete.	Wrong method or weak application.
Accuracy of solution	Solution is accurate, well-checked, and logically interpreted.	Mostly accurate with minor calculation or interpretation errors.	Some correct steps, but notable errors remain.	Major errors in solution and interpretation.
Technical	Well-organized, neat,	Clear presentation	Acceptable	Poorly

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs improvement
presentation	and professionally presented.	with minor formatting issues.	presentation but lacks consistency.	organized and difficult to follow.
Analysis and interpretation	Insightful discussion of results, limitations, and civil engineering relevance.	Good interpretation with some analysis.	Limited interpretation of results.	Very little or no interpretation.
Timely completion and submission	Submitted on time with complete documentation.	Slight delay or minor missing elements.	Delayed submission or incomplete documentation.	Late submission with major missing parts.

SMART CITIES AND URBAN ANALYTICS			
Course Code	**1MCV106C**	Scheme	2026
Type of Course	Professional Elective Course	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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:** Explain the concepts, evolution, components, and governance frameworks of smart cities.
2. **CO2:** Analyze urban data sources, indicators, and data quality issues for city-level decision-making.
3. **CO3:** Apply GIS, remote sensing, IoT, and statistical methods for urban analytics and visualization.
4. CO4: Evaluate urban infrastructure systems using spatial, temporal, and multi-criteria approaches.
5. **CO5:** Develop data-driven solutions for mobility, energy, water, environment, and public services.
6. **CO6**: Critically assess ethics, privacy, sustainability, and resilience in smart city planning and operations.

Module-1

Smart Cities Fundamentals:

- Introduction to smart cities, sustainable urbanization, smart city dimensions, global and Indian initiatives, city systems, stakeholders, and governance models.
- Urban challenges: mobility, housing, water, energy, sanitation, environment, public safety, digital divide, and inclusion.
- Concepts of urban intelligence, smart services, data-driven governance, and human-centred planning.

Linked COs: CO1. **Number of Hours: 08 hrs**

Module-2

Urban Data Ecosystem:

- Sources of urban data: census, surveys, administrative records, open data, IoT sensors, satellite data, social media, and citizen-generated data.
- Data formats, data cleaning, quality control, metadata, interoperability, and urban indicators.
- Statistical summaries, trend analysis, anomaly detection, and data ethics in city analytics.

Linked COs: CO2, CO3. **Number of Hours: 09 hrs**

Module-3

GIS and Spatial Analytics:

- Basics of GIS, geocoding, layering, thematic mapping, spatial queries, spatial interpolation, and network analysis.
- Remote sensing for land use/land cover, urban growth, heat island mapping, and infrastructure monitoring.
- Introduction to dashboarding, spatial visualization, and geospatial decision support for city applications.

Linked COs: CO2, CO3, CO5. **Number of Hours: 09 hrs**

Module-4

Urban Modeling and Simulation:

- Urban systems modeling, demand forecasting, scenario analysis, agent-based concepts, and digital twins.
- Applications in transport, land use, utilities, environmental quality, and disaster preparedness.
- Multi-criteria decision making, performance metrics, and prioritization of smart city interventions.

Linked COs: CO4, CO6. **Number of Hours: 08 hrs**

Module-5

Applications and Governance:

- Smart mobility, smart energy, smart water, smart waste, e-governance, public health, and urban resilience applications.
- Cybersecurity, privacy, data governance, policy, financing, and institutional frameworks for smart cities.
- Case studies and project-based analysis of an urban problem using data-driven approaches.

Linked COs: CO5, CO6. **Number of Hours: 08 hrs**

Suggested Learning Resources:

Text Books:

1. Anthony M. Townsend, *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*.
2. Carlo Ratti and Matthew Claudel, *The City of Tomorrow: Sensors, Networks, Hackers, and the Future of Urban Life*.
3. Michael Batty, *The New Science of Cities*.
4. Robert K. Yin, *Case Study Research and Applications*, for applied urban case study structure.

Reference Books:

1. Michael Goodchild and others, texts on GIS and spatial analysis for urban applications.
2. Urban data analytics and smart city planning references from standard academic sources.
3. Technical communication and report writing guides for engineering students.
4. Urban infrastructure and smart governance manuals.
5. Smart city implementation and policy documents from government and professional sources.

e- Resources

1. VTU syllabus and academic guidelines portal.
2. NPTEL/SWAYAM resources on GIS, urban planning, and data analytics.
3. Smart city mission and urban data resources from government/open-data portals.
4. Online GIS platforms, dashboards, and urban analytics tutorials.
5. Academic case studies and reports on smart cities and urban analytics.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA. In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Urban Data Profiling Exercise**: Activity: Collect and clean a small city dataset, compute indicators, identify missing values, and present trends using tables or charts. Linked COs: CO2, CO3.	24
2	**GIS Thematic Mapping Assignment:** Activity: Prepare a thematic map for land use, transport access, heat island, or service availability using GIS or open geospatial tools. Linked COs: CO3, CO4.	24
3	**Mini-Project on Urban Service Analytics:** Activity: Develop a brief solution for one urban service such as water, waste, energy, or flood monitoring with data-driven recommendations. Linked COs: CO5, CO6.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Read a smart-city policy and prepare a reflective note	24
2	Review one city dashboard or urban data portal and summarize its usefulness.	24
3	Watch a MOOC/video module on GIS, IoT, or urban analytics and submit a learning note.	24

Sample rubrics for TW activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Problem understanding	Clear problem framing with strong justification.	Mostly clear with minor gaps.	Basic attempt with limited clarity.	Poorly defined problem.
Data and method	Appropriate data and sound methodology.	Mostly appropriate with minor issues.	Limited data or partial method.	Inadequate or incorrect method.
Analysis	Robust interpretation and valid results.	Generally sound with minor errors.	Partial analysis with gaps.	Weak or incorrect analysis.
Recommendations	Strong, feasible, and context-specific.	Relevant with minor limitations.	Generic recommendations.	Incomplete or unrealistic.
Presentation	Well organized and professional.	Good organization with minor issues.	Acceptable but uneven.	Poorly presented.

Sample rubrics for Self-Learning activities:

Criteria	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs Improvement
Concept understanding	Demonstrates clear and accurate understanding of the assigned concept.	Shows good understanding with minor gaps.	Basic understanding with limited detail.	Understanding is weak or incorrect.
Independent learning	Explores beyond the minimum requirement and shows initiative in learning.	Shows good initiative with some additional effort.	Completes the assigned task with limited exploration.	Relies heavily on guidance or shows little effort.
Task completion	Activity is completed fully, correctly, and on time.	Activity is mostly complete with minor omissions.	Activity is partially complete.	Activity is incomplete or missing.
Technical accuracy	Workflow, tool use, or analysis is correct and well justified.	Mostly correct with few technical errors.	Contains noticeable errors but shows partial correctness.	Major technical errors or no meaningful attempt.
Reflection and analysis	Provides strong reflection, interpretation, and learning outcomes.	Gives reasonable reflection with some analysis.	Reflection is brief and descriptive.	Reflection is minimal or absent.
Presentation and organization	Work is neat, well structured, and easy to follow.	Organized well with minor formatting issues.	Acceptable presentation with several issues.	Poorly organized or difficult to read.

ROBOTICS & AUTOMATION IN CONSTRUCTION			
Course Code	**1MCV106 D**	Scheme	2026
Type of Course	Professional Elective Course	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L4) - Explain the fundamentals of robotics, automation, sensing, and control relevant to construction applications.
2. CO2 (L4) - Apply robotic system concepts, actuators, and control methods to construction-related tasks and operations.
3. CO3 (L5) - Analyze automated construction processes, site operations, and material handling systems using suitable technologies.
4. CO4 (L6) - Design automation strategies for construction planning, monitoring, execution, and safety improvement.
5. CO5 (L5) - Evaluate autonomous and semi-autonomous systems, AI-enabled tools, and digital workflows for construction productivity.
6. CO6 (L6) - Develop integrated robotics and automation solutions for smart construction and infrastructure delivery.

Module-1

Robotics and Automation Fundamentals:
Introduction to robotics, automation in construction, historical development, need for robotics in the construction industry, classification of robots, robot anatomy, degrees of freedom, coordinate systems, end effectors, sensors, actuators, and basic control concepts. Overview of construction automation, safety, productivity, quality, and human-robot interaction in construction environments.

Linked COs: CO1. **Number of Hours: 08 hrs**

Module-2

Sensing, Control and Navigation:
Construction sensing technologies, vision systems, LiDAR, GNSS, IMU, proximity sensors, force and torque sensors, signal processing basics, feedback control, path planning, localization, mapping, obstacle detection, and navigation concepts. Applications in surveying, site inspection, layout marking, earthwork monitoring, and autonomous site vehicles.

Linked COs: CO2. **Number of Hours: 09 hrs**

Module-3

Construction Robotics and Automated Equipment:
Robotic excavators, automated cranes, bricklaying robots, 3D concrete printing systems, demolition robots, rebar tying robots, finishing robots, material handling robots, and exoskeletons. Automated machinery for earthmoving, tunneling, road construction, and precast operations. Performance parameters, advantages, limitations, and field deployment challenges.

Linked COs: CO3. **Number of Hours: 09 hrs**

Module-4

Digital Integration and Smart Construction:
Building Information Modelling (BIM), digital twins, IoT-enabled monitoring, cloud platforms, computer vision, AI-based inspection, machine learning for progress tracking, safety analytics, and data-driven decision-making. Integration of robotics with BIM, site logistics automation, schedule monitoring, and quality control in construction projects.

Linked COs: CO4, CO5. **Number of Hours: 08 hrs**

Module-5

Autonomous Systems and Case Studies:
Autonomous and semi-autonomous construction systems, swarm robotics concepts, drone applications, robotic inspection, asset monitoring, predictive maintenance, safety management, and sustainability considerations. Case studies on automated building construction, infrastructure inspection, highway works, and smart site management. Future trends in construction robotics, Industry 4.0, and AI-assisted project execution.
Linked COs: CO5, CO6. **Number of Hours: 08 hrs**

Suggested Learning Resources
Textbooks:
1. Bock, T., & Linner, T. Robot-oriented design: Design and management tools for the deployment of automation and robotics in construction. 2015, Cambridge University Press.
2. Bock, T., & Linner, T.. Site automation: Automated and robotic on-site factories. 2016, Cambridge University Press.
3. Sawhney, A., Riley, M., & Irizarry, J. (Eds.). Construction 4.0: An Innovation Platform for the Built Environment. 2020, Routledge.
4. Siegwart, R., Nourbakhsh, I. R., & Scaramuzza, D. (2018). Introduction to Autonomous Mobile Robots (2nd ed.). MIT Press.
5. Craig, J. J. (2018). Introduction to Robotics: Mechanics and Control (4th ed.). , 2018, Pearson.
6. Siciliano, B., & Khatib, O. (Eds.). Springer Handbook of Robotics (2nd ed.). 2016, Springer

.Reference Books:
1. Craig, J. J., Introduction to Robotics: Mechanics and Control, Pearson.
2. Recent journal articles and conference proceedings on construction robotics, automation, and digital construction.

e- Resources:
1. NPTEL courses on robotics, automation, mechatronics, and construction management.
2. IEEE and ASCE digital libraries for construction robotics research.
3. BIM and digital twin tutorials from Autodesk and other professional platforms.
4. MATLAB, Python, ROS, and computer vision documentation.
5. MOOC content from SWAYAM, Coursera, and open educational resources on robotics and smart construction.

Teaching-Learning Process (Innovative Delivery Methods):
The following are sample strategies that educators may adopt in addition to chalk to talk 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)
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- Simulation and Virtual Labs
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- Role Play

Assessment Structure (both CIE and SEE)
The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.
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Continuous Internal Evaluation:
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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only
As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can
also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Case study on robotic execution of a construction task: task planning, workflow, benefits, and limitations.	24
2	Mini-project using MATLAB / Python / simulation software / BIM tool on robotic site automation.	24
3	Formulations of a robotics-based construction problem: problem statement, system components, sensing, control, and constraints.	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Review of one research paper on construction robotics.	24
2	Study of one software or simulation tool related to robotics or automation.	24

Sample rubrics for TW activities:

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs improvement
Problem understanding and formulation	Problem is clearly understood; variables, objective, and constraints are precise and complete.	Minor gaps in formulation, but technically sound.	Basic understanding shown; formulation has some omissions.	Poor understanding; incorrect or incomplete formulation.
Method selection and application	Correct method selected and applied systematically with strong reasoning.	Method is mostly correct with minor procedural errors.	Method is partially appropriate; steps are incomplete.	Wrong method or weak application.
Accuracy of solution	Solution is accurate, well-checked, and logically interpreted.	Mostly accurate with minor calculation or interpretation errors.	Some correct steps, but notable errors remain.	Major errors in solution and interpretation.

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs improvement
Technical presentation	Well-organized, neat, and professionally presented.	Clear presentation with minor formatting issues.	Acceptable presentation but lacks consistency.	Poorly organized and difficult to follow.
Analysis and interpretation	Insightful discussion of results, limitations, and civil engineering relevance.	Good interpretation with some analysis.	Limited interpretation of results.	Very little or no interpretation.
Timely completion and submission	Submitted on time with complete documentation.	Slight delay or minor missing elements.	Delayed submission or incomplete documentation.	Late submission with major missing parts.

IOT AND SMART SENSORS FOR CIVIL ENGINEERING			
Course Code	**1MCV106E**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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: Explain the fundamentals of IoT architecture, communication protocols, and sensor systems used in civil engineering applications.
2. CO2: Select appropriate sensors and data acquisition methods for structural, environmental, hydraulic, and geotechnical monitoring.
3. CO3: Develop simple IoT-based monitoring solutions for civil infrastructure using microcontrollers, wireless communication, and cloud concepts.
4. CO4: Interpret sensor data for condition assessment, safety monitoring, and maintenance planning of civil engineering systems.
5. CO5: Evaluate the role of smart sensors and IoT in sustainable, resilient, and intelligent infrastructure management.

Module-1

Introduction to IoT and Smart Sensing:

Overview of IoT, evolution of smart infrastructure, components of IoT systems, sensing and actuation, data flow in IoT, edge and cloud concepts, and relevance of IoT in civil engineering. Applications in smart buildings, bridges, roads, water distribution, smart cities, and environmental monitoring.

Linked COs: CO1. **Number of Hours: 08 hrs**

Module-2

Sensor Technology for Civil Engineering;

Principles of measurement, sensor characteristics, calibration, accuracy, precision, sensitivity, range, and response time.

Types of sensors: strain gauges, accelerometers, displacement sensors, pressure sensors, temperature sensors, humidity sensors, tilt sensors, vibration sensors, flow sensors, level sensors, and corrosion sensors.

Sensor selection criteria for structural and infrastructure applications.

Linked COs: CO2. **Number of Hours: 10 hrs**

Module-3

IoT Hardware and Communication:

Microcontrollers and embedded platforms such as Arduino, ESP32, and Raspberry Pi.

Signal conditioning, analog-to-digital conversion, data logging, and power management.

Communication technologies: Wi-Fi, Bluetooth, Zigbee, LoRa, NB-IoT, and GSM; introduction to MQTT and HTTP protocols.

Linked COs: CO2, CO3. **Number of Hours: 10 hrs**

Module-4

Civil Engineering Monitoring Applications

IoT-based structural health monitoring of buildings, bridges, and towers. Monitoring of pavements, slopes, retaining walls, dams, tunnels, and pipelines. Smart water supply monitoring, leakage detection, flood monitoring, air quality monitoring, and noise monitoring.

Linked COs: CO3, CO4. **Number of Hours: 08 hrs**

Module-5

Data Analytics, Visualization, and Smart Infrastructure:

Sensor data storage, preprocessing, visualization, threshold-based alerts, and introduction to analytics for condition monitoring.
Basic concepts of dashboards, cloud platforms, predictive maintenance, and digital twins for civil infrastructure.
Cybersecurity, data reliability, scalability, sustainability, and ethical issues in IoT-enabled infrastructure systems

Linked COs: CO5, CO6. **Number of Hours: 06 hrs**

Suggested Learning Resources Textbooks:

5. Grieves, M. and Vickers, J. Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems.
6. Kritzinger, W. et al. Digital Twin in Manufacturing and Engineering Systems. Springer.
7. Tao, F. and Qi, Q. Digital Twin and Big Data Toward Smart Manufacturing and Engineering.
8. Antonino, J. and others. Smart Infrastructure and Digital Twin Applications in Civil Engineering.

Reference Books

1. Fuller, A., Fan, Z., Day, C., and Barlow, C. Digital Twin: Enabling Technologies, Challenges and Open Research.
2. Wang, K. and others. BIM, IoT and Digital Twin Integration for Infrastructure.
3. Booth, C. and Pistor, M. Smart Cities and Infrastructure Digitalization.
4. Liu, Y. and others. Structural Health Monitoring and Digital Twin Concepts with sustainability add-ons.

e- Resources:

1. NPTEL courses on BIM, IoT, AI/ML, and smart infrastructure.
2. IEEE and Springer articles on digital twin technologies.
3. Bentley, Autodesk, and Siemens digital twin learning resources.
4. Smart city and infrastructure digitalization resources from government and industry portals.
5. Research datasets and dashboards for structural health monitoring, traffic, and water systems.

Teaching-Learning Process (Innovative Delivery Methods):

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Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	Mini-project on IoT-based monitoring of a civil structure	24
2	Case study on smart water leakage detection using sensors and remote alerts.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	NPTEL/online modules related to IoT and smart infrastructure.	24
2	Survey and presentation on sensor technologies used in structural health monitoring.	24

Sample rubrics for TW activities:

C. Rubric for Micro-project

Criterion	4 - Excellent	3 - Good	2 - Fair	1 - Needs Improvement
Problem identification and relevance	Clearly identifies a civil engineering problem suitable for IoT/smart sensing and explains its relevance well.	Identifies a relevant problem with minor gaps in explanation.	Problem is partially relevant or weakly defined.	Problem is unclear, irrelevant, or not identified properly.
Sensor selection and justification	Selects appropriate sensors and justifies choice based on application, range, accuracy, and suitability.	Sensor selection is mostly appropriate with limited justification.	Sensor choice is partly correct but justification is weak.	Sensor selection is inappropriate or not justified.
System design and integration	Presents a logically designed IoT setup with clear integration of sensors, microcontroller, communication, and data flow.	Design is mostly correct with minor missing elements.	Design is incomplete or lacks clear integration.	System design is incorrect or missing major parts.
Data collection and analysis	Data is collected systematically and analyzed correctly using suitable methods or tools.	Data collection and analysis are mostly correct with minor errors.	Data handling is partial, with limited analysis.	Data is missing, incorrect, or not analyzed.
Civil engineering interpretation	Interprets results clearly in the context of structural, water, transport, or environmental applications.	Interpretation is mostly correct with limited depth.	Interpretation is weak or partially relevant.	No meaningful civil engineering interpretation.
Innovation and application	Shows original thinking and practical usefulness for real	Some originality and practical	Limited innovation;	No originality or practical

Criterion	4 - Excellent	3 - Good	2 - Fair	1 - Needs Improvement
	civil engineering monitoring.	relevance are evident.	application is basic.	relevance.
Presentation and documentation	Report is well-organized, neat, properly labeled, and technically sound.	Report is clear with minor formatting issues.	Report is readable but poorly organized in places.	Report is incomplete, unclear, or poorly presented.

SMART SOLID WASTE MANAGEMENT AND CIRCULAR ECONOMY SYSTEMS			
Course Code	**1MCV106 F**	Scheme	2026
Type of Course	**Professional Elective Course**	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	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 (L4) - Explain the principles of solid waste generation, classification, collection, segregation, processing, and disposal in urban and engineering contexts.
2. CO2 (L4) - Analyze waste generation patterns, composition data, and operational performance using suitable quantitative and digital tools.
3. CO3 (L5) - Evaluate waste management systems, source segregation practices, logistics, and environmental impacts using standard performance and sustainability indicators.
4. CO4 (L6) - Design smart waste collection, treatment, recovery, and monitoring solutions for urban and institutional applications.
5. CO5 (L5) - Assess circular economy principles, resource recovery pathways, and policy instruments for sustainable waste management.
6. CO6 (L6) - Develop integrated smart solid waste management and circular economy solutions aligned with sustainability goals, public health, and municipal planning

Module-1

Solid Waste Fundamentals and Urban Waste Streams:

Introduction to solid waste management, municipal solid waste, commercial waste, institutional waste, construction and demolition waste, biomedical waste, plastic waste, e-waste, and industrial wastes. Waste generation sources, composition, quantity estimation, density, moisture content, and calorific value. Waste hierarchy, 3R principles, segregation at source, collection systems, storage, transfer stations, and disposal options. Public health, environmental, and engineering relevance of solid waste management.

Linked COs: CO1. **Number of Hours: 09 hrs**

Module-2

Waste Characterization, Data Analysis and Smart Monitoring:

Waste sampling and characterization methods, physical and chemical properties, waste audit procedures, generation trend analysis, seasonal variation, per-capita waste estimation, and diversion indicators. Data collection from households, institutions, and municipalities. Use of spreadsheets, dashboards, GIS, IoT sensors, QR/RFID-based tracking, and simple analytics for route and facility monitoring.

Linked COs: CO2. **Number of Hours: 09 hrs**

Module-3

Collection Systems, Segregation, Transport and Processing:

Primary and secondary collection systems, source segregation methods, material recovery facilities, manual and mechanized handling, transfer and transport optimization, route planning, and fleet management.

Processing technologies including composting, vermicomposting, biomethanation, refuse-derived fuel, recycling, incineration, pyrolysis, and sanitary landfill design. Occupational safety, leachate control, odour management, and lifecycle environmental impacts.

Linked COs: CO3. **Number of Hours: 09 hrs**

Module-4

Circular Economy, Resource Recovery and Waste-to-Value Planning:

Circular economy concepts, sustainable production and consumption, product life extension, design for reuse and recycling, industrial symbiosis, extended producer responsibility, and zero-waste planning. Resource recovery from organic waste, plastics, paper, metals, construction waste, and e-waste. Life cycle thinking, carbon footprint basics, material flow analysis, cost-benefit considerations, and planning of waste-to-value systems for urban and institutional settings.

Linked COs: CO4. CO5. **Number of Hours: 08 hrs**

Module-5

Integrated Smart Waste Management and Circular Economy Case Studies:

Smart city waste management concepts, digital platforms, community participation, behavioural change, decentralised systems, performance monitoring, and policy implementation. National and international frameworks related to solid waste management and circular economy. Case studies on decentralized composting, ward-level segregation, smart collection models, construction waste recycling, and circular campus or smart city waste management plans.

Linked COs: CO5, CO6. **Number of Hours: 07 hrs**

Suggested Learning Resources

Textbooks

1. Tchobanoglous, G., Theisen, H., and Vigil, S. A. Integrated Solid Waste Management. McGraw-Hill.
2. S. Kumar and A. Bhattacharyya, Smart Waste Management Systems, latest edition.
3. Ghosh, S. K. Municipal Solid Waste Management in India. CRC Press.
4. P. Agamuthu, Solid Waste Management in Asia, Springer, latest edition.
5. R. C. Gupta, Solid and Hazardous Waste Management, Khanna Publishers, latest edition.
6. T. M. Letcher and D. A. Vallero, Waste: A Handbook for Management, Academic Press, latest edition.
7. W. R. Stahel, The Circular Economy: A User's Guide, latest edition.
8. E. Worrell and M. A. Reuter, Handbook of Recycling, Elsevier, latest edition.

Reference Books

1. Wilson, D. C., Rodic, L., and others. Waste Management and Circular Economy. Routledge.
2. White, P. R., Franke, M., and Hindle, P. Integrated Solid Waste Management: A Lifecycle Inventory. Blackie Academic.
3. UNEP. Global Waste Management Outlook. United Nations Environment Programme.
4. Ellen MacArthur Foundation. Circular Economy Reports and Toolkits.
5. M. R. Verma, Municipal Solid Waste Management, latest edition.
6. N. J. Themelis and others, Waste to Energy: Technologies and Applications, latest edition.

e- Resources:

1. CPCB and MoHUA resources on municipal solid waste management.
2. CPHEEO manuals and urban local body waste management guidelines.
3. NPTEL courses on waste management, sustainability, and circular economy.
4. UNEP, UN-Habitat, and Ellen MacArthur Foundation learning resources.
5. Smart city mission resources, municipal dashboards, and waste analytics portals.

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 (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

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

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Waste audit and composition analysis for a local site/campus	24
2	Design of solid waste management system for a campus/local area	24

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

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	MOOC course on Solid waste management	24
2	Waste-to-energy recovery techniques	24

Sample rubrics for TW activities:

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs improvement
Problem understanding and formulation	Problem is clearly understood; variables, objective, and constraints are precise and complete.	Minor gaps in formulation, but technically sound.	Basic understanding shown; formulation has some omissions.	Poor understanding; incorrect or incomplete formulation.
Method selection and application	Correct method selected and applied systematically with strong reasoning.	Method is mostly correct with minor procedural errors.	Method is partially appropriate; steps are incomplete.	Wrong method or weak application.
Accuracy of solution	Solution is accurate, well-checked, and logically interpreted.	Mostly accurate with minor calculation or interpretation errors.	Some correct steps, but notable errors remain.	Major errors in solution and interpretation.
Technical presentation	Well-organized, neat, and professionally presented.	Clear presentation with minor formatting issues.	Acceptable presentation but lacks consistency.	Poorly organized and difficult to follow.
Analysis and interpretation	Insightful discussion of results, limitations, and civil engineering relevance.	Good interpretation with some analysis.	Limited interpretation of results.	Very little or no interpretation.

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs improvement
Timely completion and submission	Submitted on time with complete documentation.	Slight delay or minor missing elements.	Delayed submission or incomplete documentation.	Late submission with major missing parts.

CLOUD PLATFORMS & BIG DATA FOR GEOSPATIAL APPLICATIONS			
Course Code	**1MCV106G**	Scheme	2026
Type of Course	Professional Elective Course	Semester	I
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI (L /T): LI(P):TW&SL	90 (42:0:0:48)	SEE Marks	50
Credits	3	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

1. **Course outcome (Course Skill Set):**
2. At the end of the course, the student will be able to:
3. CO1 (L4 - Analyze): Analyze geospatial data characteristics and data lifecycle requirements for cloud-based processing and storage.
4. CO2 (L5 - Evaluate): Evaluate cloud platforms, distributed computing models, and big data frameworks for geospatial applications.
5. CO3 (L4 - Analyze): Analyze spatial data management, indexing, and query methods in cloud-enabled geodatabases.
6. CO4 (L6 - Create): Create scalable workflows for geospatial analytics using cloud tools, APIs, and distributed processing engines.
7. CO5 (L6 - Create): Design big data pipelines for satellite, sensor, UAV, and IoT geospatial datasets.
8. CO6 (L5 - Evaluate): Evaluate cloud-integrated geospatial intelligence solutions for smart cities, environmental monitoring, and sustainable infrastructure.

Module-1

Foundations of Cloud Computing for Geospatial Data:
Introduction to cloud computing concepts, service models (IaaS, PaaS, SaaS), deployment models, virtualization, containers, and serverless computing. Geospatial data types and characteristics: raster, vector, point clouds, spatiotemporal and streaming data. Data life cycle, metadata, data governance, and cloud storage basics. Overview of cloud security, access control, cost models, and scalability requirements for geospatial workloads.

Linked COs: CO1 **Number of Hours: 08 hrs**

Module-2

Distributed Computing and Big Data Frameworks:
Big data characteristics, distributed computing principles, parallelism, partitioning, and fault tolerance. Hadoop ecosystem: HDFS, MapReduce, YARN, Hive, HBase, and Spark for geospatial analytics. Data ingestion from remote sensing, GNSS, UAV, and IoT sources. Batch versus stream processing, ETL pipelines, and performance considerations for large spatial datasets. Introduction to cloud-native geospatial processing architecture.

Linked COs: CO2 **Number of Hours: 10 hrs**

Module-3

Cloud Geospatial Data Management:

Cloud-enabled spatial databases, object storage, data lakes, and Lakehouse concepts. Spatial indexing, tiling, pyramids, partitioning, and compression techniques for large geodata. Cloud geodatabases, geospatial metadata catalogs, and web services for data access. Query processing for raster and vector data, spatial joins, proximity search, and distributed query optimization. Introduction to PostGIS on cloud platforms and geospatial APIs.

Linked COs: CO3 **Number of Hours: 10 hrs**

Module-4

Scalable Geospatial Analytics:
Cloud-based geospatial analysis workflows for land use mapping, urban growth analysis, flood monitoring, and transportation planning. Use of Python, Jupyter, GeoPandas, Rasterio, xarray, and Spark-based geospatial processing. Cloud execution of image classification, time-series analysis, change detection, and hotspot detection.

Workflow automation using notebooks, functions, and workflow orchestration tools. Integration of open geospatial standards and interoperable services.

Linked COs: CO4 **Number of Hours: 08 hrs**

Module-5

GeoAI, IoT, and Decision Support:

Big data pipelines for satellite, LiDAR, UAV, and IoT streams. Cloud-supported GeoAI using machine learning and deep learning for classification, segmentation, anomaly detection, and prediction. Decision support systems for smart cities, disaster management, infrastructure monitoring, and environmental sustainability. Case studies using cloud geospatial platforms, open data portals, and web dashboards. Ethical issues, reproducibility, data privacy, and sustainable computing.

Linked COs: CO5, CO6 **Number of Hours: 06 hrs**

Suggested Learning Resources:

Textbooks:

1. P. K. Biswas and S. K. Bhatia, Cloud Computing and Big Data Technologies.
2. Ian Foster, Dennis B. Gannon, and Jack Dongarra, Cloud Computing for Science and Engineering.
3. Shashi Shekhar and Hui Xiong, Encyclopedia of GIS / spatial data analytics references.
4. Michael Stonebraker, Big Data and Data Science for Geospatial Applications or equivalent advanced GIS analytics text.
5. Buyya, R., Broberg, J., & Goscinski, A. (Eds.). *Cloud Computing: Principles and Paradigms*. Wiley
6. .Demirkan, H., & Delen, D. *Managing Big Data Analytics*. Springer.
7. Chang, K. *Introduction to Geographic Information Systems*. McGraw-Hill.
8. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. *Geographic Information Systems and Science*. Wiley.

Reference Books:

1. Craig, J. J., Introduction to Robotics: Mechanics and Control, Pearson.
2. Nourbakhsh, I. et al., Robotics for Construction and Infrastructure, selected reference material.
3. Khatib, O. and co-authors, robotics and automation reference texts.
4. Recent journal articles and conference proceedings on construction robotics, automation, and digital construction.
5. Li, S., Dragicevic, S., & Zhou, X. Geospatial Big Data: Principles and Applications. Springer.
6. Pajarola, R., & Sinha, S. Geospatial Big Data Analytics. CRC Press.

e- Resources:

1. Google Earth Engine: https://earthengine.google.com
2. AWS Open Data Registry: https://registry.opendata.aws
3. Microsoft Planetary Computer: https://planetarycomputer.microsoft.com
4. NPTEL Cloud Computing: https://nptel.ac.in

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk 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 (both CIE and SEE) :

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall

be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

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. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

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

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can
also give their own TW/SL activities as per the course outcomes.

Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1	Students identify and map IaaS, PaaS, SaaS for a given geospatial workflow.	24
2	Draw a cloud-based workflow for satellite image ingestion, processing, and output generation.	24
3	Write and explain queries for buffer, overlay, and spatial join in cloud geodatabase	24

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

Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Present a geospatial AI/cloud decision-support solution for smart city or sustainability use.	24
2	Prepare and present a report on cloud-based flood monitoring, urban growth, or transport planning.	24

Sample rubrics for TW activities:

Criterion	4	3	2	1
Workflow logic	End-to-end flow is complete and logical.	Mostly logical with minor omissions.	Basic flow, several gaps.	Disorganized or incomplete.
Component selection	Appropriate tools and stages included.	Mostly appropriate.	Limited tool-stage alignment.	Inappropriate or missing components.
Clarity of diagram	Easy to read and interpret.	Fairly clear.	Somewhat unclear.	Difficult to read.

1MCVL107X: Professional Core Course Lab (PCCL)

COMPUTATIONAL STRUCTURAL MODELING AND ANALYSIS LABORATORY			
Course Code	**1MCVL107A**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	I
Teaching Hours/Week (L:T:P)	28(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:28:2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 -- L3 Develop and use structural modeling software tools to create geometry, assign materials, supports, and load cases for structural systems.
2. CO2 -- L4 Analyze structural components and systems using linear static analysis for typical loading conditions.
3. CO3 -- L4 Interpret analysis results such as reactions, shear force, bending moment, stress, displacement, and stability indicators.
4. CO4 -- L3 Model and evaluate structural behavior of beams, trusses, frames, and slabs using computational tools for civil engineering applications.
5. CO5 -- L6 Formulate and solve real-world structural engineering problems through simulation-based workflows and report the results effectively

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 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 **80 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 **20 marks.**

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.

PRACTICLE COMPONENTS

PART – A

FIXED EXPERIMENTS

1. Introduction to structural analysis software interface, model creation, units, material properties, supports, and load assignment. (CO1)
2. Modeling and analysis of simply supported and cantilever beams under point load, UDL, and varying load conditions. (CO1, CO2)
3. Structural analysis of pin-jointed trusses under different loading patterns and evaluation of member forces. (CO2, CO3)
4. Modeling and analysis of plane frames for reactions, internal force diagrams, and displacement response. (CO2, CO3, CO4)
5. Computation of bending moment, shear force, and deflection for beams using finite element or matrix methods. (CO2, CO3)
6. Analysis of continuous beams and rigid frames for support reactions, moment distribution, and load effects. (CO2, CO3, CO4)
7. Modeling and analysis of two-way slab or floor system subjected to gravity loading. (CO3, CO4)
8. Comparison of analytical and computational results for a selected structural system and interpretation of discrepancies. (CO4, CO5).

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. Students may be assigned any one problem statements during assessment as decided by the course coordinator. **The sample open-ended problems are provided as reference. Course coordinators are encouraged to design and assign context-specific open-ended problem statements aligned with the defined Course Outcomes (COs), ensuring relevance to contemporary practices and learner needs.**

1. Develop a complete computational model for a multi-bay frame subjected to dead and live loads and interpret design-critical output. (CO2, CO4, CO5)
2. Modify boundary conditions and load combinations for a given structural system and study the sensitivity of results. (CO2, CO3, CO5)
3. Prepare a simulation-based workflow for analyzing a steel truss or roof system and report governing member forces. (CO3, CO4, CO5)
4. Design and analyze an irregular building frame and identify critical displacement and force response zones. (CO3, CO4, CO5)
5. Create a comparative study of beam or frame behavior using different support conditions, materials, or member sections. (CO2, CO4, CO5)
6. Generate a complete computational structural analysis report including modeling assumptions, results, interpretation, and engineering recommendations. (CO3, CO4, CO5)

Suggested Learning Resource:

Textbooks:

1. McGuire, W., Gallagher, R. H., and Ziemian, R. D., Matrix Structural Analysis, 2nd Edition, Wiley, 2014.
2. Hibbeler, R. C., Structural Analysis, 10th Edition, Pearson, 2017.
3. Cook, R. D., Malkus, D. S., Plesha, M. E., and Witt, R. J., Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley, 2002.
4. Relevant software user manual or equivalent structural analysis software manual

Reference books / Manuals:

1. Ghali, A., Neville, A. M., and Brown, T. G., Structural Analysis: A Unified Classical and Matrix Approach, 6th Edition, CRC Press, 2019.
2. Jindal, R. L., Structural Analysis, 4th Edition, S. Chand Publishing, 2013.
3. Wang, C. K., Indeterminate Structural Analysis, 1st Edition, McGraw-Hill Education, 1983.
4. Relevant IS codes and standards for structural loading and analysis.

Web links and Video Lectures (e-Resources):

1. MIT OpenCourseWare: Free course materials, lecture notes, and videos on structural analysis and finite element methods.
2. OpenSees official resources and tutorials: command manual, examples, and workshop/tutorial materials for structural simulation.
3. NPTEL courses on structural analysis, finite element methods, and computational mechanics.
4. Online tutorials for open-source structural analysis tools such as OpenSeesPy, Pynite, and browser-based structural analysis applications.
5. IS 800:2007 and IS 456:2000 online reference materials for steel and reinforced concrete analysis and design practice.

Software Tools:

- **Commercial software:** STAAD.Pro, ETABS, SAP2000, ANSYS Mechanical, MIDAS Civil, Autodesk Robot Structural Analysis, Tekla Structural Designer.
- **Open-source software**: OpenSees, FreeCAD, Code_Aster, Elmer FEM, CalculiX, SfePy, FRAME3DD.

Assessment Structure (both CIE and SEE) The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.
Continuous Internal Evaluation (CIE): For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks." Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1) Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1. The remaining 15 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 the practical test as indicated in the Table 1. The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
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.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	Students' Level and Rubrics Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	**G**	**F**	**NI**

(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i) Logical structure and progression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii) Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i) Organization and neatness. (ii) Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i) The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii) If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii) The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv) To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

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BIM-BASED PLANNING AND SCHEDULING LABORATORY			
Course Code:	**1MCVL107B**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	I
Teaching Hours/Week (L:T:P)	28(0:2:0)	CIE Marks	50
Total Hours of Pedagogy(L:T:P:TW:SL)	30 (0:0:28:2)	SEE Marks	50
Credits	01	Total	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: Understand construction planning, scheduling, project controls, and BIM/VDC workflows used during construction execution.
2. CO2: Develop WBS/location-based work packages and prepare construction schedules using Primavera P6, MS Project, or equivalent planning tools.
3. CO3: Link schedules with BIM model elements and create 4D construction simulations using Synchro, Navisworks, Fuzor, or equivalent tools.
4. CO4: Analyze critical path, dependencies, resources, site logistics, progress updates, delays, and recovery alternatives.
5. CO5: Prepare baseline/revised schedules, 4D outputs, progress reports, issue views, and coordination sheets for construction communication.

Note:

1. Note:
2. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
3. Both PART-A and PART-B are considered for CIE and SEE.
4. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
5. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for 80 marks out of the maximum 100 marks.
6. 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 20 marks.
7. 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.

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LIST OF EXPERIMENTS (LI = 28 HOURS)

1. Construction Planning and BIM/VDC Basics: Roles of planning/BIM engineers, project stages, construction methods, baseline scheduling, and project control concepts.
2. Planning Tool Setup (Primavera/MS Project): Project calendars, WBS/OBS, activity coding, milestones, constraints, and baseline creation.
3. WBS and Location-Based Planning: Development of WBS using floors, zones, chainages, and work packages aligned with 4D model breakdown.
4. Scheduling Techniques: Gantt charts and network diagrams, activity sequencing, CPM, critical path, float, milestones, and logic checks.
5. Resource Planning: Labour, materials, equipment, productivity, procurement lead times, resource loading, and basic levelling.
6. 4D BIM Model Preparation: Model federation, element classification, IFC/openBIM basics, and schedule–model mapping.
7. 4D BIM Simulation: Linking schedules with models using tools like Synchro/Navisworks to simulate construction sequences.
8. Site Logistics and Constructability: Planning of cranes, access, storage, safety zones, temporary works, and space-time conflict analysis.

9. Progress Tracking and Control: Updating schedules, tracking progress, baseline comparison, delay analysis, and recovery planning.
10. Reporting and Communication: Schedule reports, 4D visuals, dashboards, CDE-based coordination, and professional reporting..

Suggested Learning Resources

Text books

1. Kymmell, Willem — Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations.
2. Hardin, Brad and McCool, Dave — BIM and Construction Management: Proven Tools, Methods, and Workflows.
3. Chitkara, K. K. — Construction Project Management: Planning, Scheduling and Control.
4. Baldwin, Andrew and Bordoli, David — A Handbook for Construction Planning and Scheduling.

Reference books

1. Eastman, Chuck et al. — BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers.
2. RICS — BIM for Project Managers.
3. EFCA — BIM and ISO 19650 from a Project Management Perspective.
4. Relevant software manuals/user guides for Primavera P6, MS Project, Synchro, Navisworks, Fuzor, Trimble, VisiLean, Revizto, Plannerly, CDE platforms, or equivalent BIM-planning tools.

Web links and Video Lectures (e-Resources):

1. NPTEL courses on construction planning, scheduling, construction management, and project control.
2. NPTEL / SWAYAM / institutional resources on BIM, VDC, 4D BIM, lean construction, and digital construction workflows.
3. Software learning resources for Primavera P6/MS Project, Synchro/Navisworks/Fuzor or equivalent 4D simulation tools.
4. Tool-demonstration resources on Fuzor, VisiLean, Trimble, Revizto, Plannerly, CDE platforms, reality capture, and digital twin workflows, used only as workflow examples.
5. • OpenBIM and information management resources covering IFC, BCF, model federation, CDE workflows, and schedule/model exchange.

Teaching–Learning Process

- Demonstration-based lab sessions followed by guided practice on construction scheduling and 4D BIM workflows.
- Problem-based scheduling exercises using building and infrastructure construction cases.
- Hands-on use of Primavera P6/MS Project or equivalent scheduling tools and Synchro/Navisworks/Fuzor or equivalent 4D simulation tools.
- Rubric-based evaluation of schedule logic, model readiness, 4D linking, progress tracking, delay/recovery interpretation, and reporting quality.
- • Use of LMS/CDE/repository for submission of schedule files, model files, screenshots, videos, issue viewpoints, and reports.

Assessment Structure:

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 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 the practical test as indicated in the Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component		
Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
Subtotal		25
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.	10marks
Subtotal		15
Total		40

Table 2 Distribution of marks corresponding to PART -B of the laboratory component				
Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10				
Criteria and Guiding factors	Students' Level and Rubrics			
	Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	G	F	NI
(1) Problem Understanding Criteria: Is the problem understood correctly and framed appropriately? (i) Clarity in interpreting the given problem. (ii) Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge Criteria: Are the chosen methods or concepts valid for this type of problem? (i) Application of appropriate theories, principles, or laws. (ii) Integration of multiple concepts where necessary.	2.0	1.5	1.0	0.5

(iii)Accuracy in stating relevant equations or models.				
(3) Approach and Strategy Criteria: Is the approach well thought out and methodical? (i) Logical structure and progression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii) Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy Criteria: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii) Accuracy of calculations or simulations (if any). (iii) Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth Criteria: Has the student shown original thinking or alternative methods? (i) Novel or efficient solutions. (ii) Consideration of alternate approaches. (iii) Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity Criteria: Is the answer easy to follow and professionally written? (i) Organization and neatness. (ii) Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5
Note: (i) The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work. (ii) If the total score results in a fraction, it should be rounded off to the next higher integer. (iii) The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises. (iv) To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.				

Rubrics suggested for Practical continuous assessment:

Criterion	Excellent	Very Good	Good	Satisfactory
Fundamental knowledge	Strong understanding of construction planning, project controls, BIM/VDC, CPM, resource planning, 4D workflow, and progress tracking.	Good conceptual clarity with minor errors.	Basic familiarity with construction scheduling software and 4D BIM workflow.	Weak conceptual foundation and limited independence.
Observation and experiment design	Correctly selects project activities, construction method, WBS/location breakdown, sequencing logic, and planning assumptions.	Uses appropriate methods with minor omissions.	Partial accuracy in setup and planning.	Poor understanding of planning assumptions.

Criterion	Excellent	Very Good	Good	Satisfactory
Implementation and data handling	Systematic schedule creation, Primavera/MS Project implementation or equivalent, BIM linking, updating, output extraction, and file management.	Mostly correct execution with minor technical issues.	Partial completion with inconsistencies.	Incomplete or flawed execution.
Result and analysis	Correct interpretation of critical path, delays, resources, site logistics, progress status, and 4D/constructability output.	Mostly valid results with limited comparison or checking.	Basic interpretation with minimal validation.	Incorrect or missing analysis.
Demonstration and reporting	Clear professional sheets, schedule exports, 4D screenshots/videos, issue views, and organized reporting of model, schedule, and results.	Well organized with minor presentation gaps.	Basic record with incomplete presentation.	Untidy or missing documentation.

Rubrics for SEE / CIE Test (overall question/answer evaluation)
(Marks distribution across these criteria can follow the CIE–SEE guidelines.)

Criterion	Excellent	Very Good	Good	Satisfactory
Coverage of question parts	Covers setup, construction scheduling logic, resource planning, model readiness, 4D linking, progress/delay analysis, and reporting completely.	Covers most aspects with minor omissions.	Covers partial scope.	Major parts missing or irrelevant.
Design and choices	Selects suitable tools, calendars, activity relationships, WBS/location strategy, sequencing approach, and model-linking method.	Appropriate choices with some justification.	Basic or superficial strategy.	Wrong or unjustified choices.
Implementation and demo	Explains workflow clearly from schedule creation in Primavera/MS Project or equivalent to 4D simulation/report preparation.	Mostly correct explanation with minor gaps.	Partial explanation with misunderstandings.	Incoherent or incomplete process.

Criterion	Excellent	Very Good	Good	Satisfactory
Analysis and evaluation	Interprets schedule performance, critical path, delay/recovery options, site logistics, and construction coordination clearly.	Sound interpretation with some comparison.	Limited interpretation.	Incorrect or absent analysis.
Organization and clarity	Structured files, outputs, and report with clear terminology.	Minor presentation issues.	Some missing or unclear parts.	Disorganized and poorly documented.

GIS-BASED ALIGNMENT AND TRAFFIC ANALYTICS			
Course Code	**1MCVL107C**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	I
Teaching Hours/Week (L:T:P)	28(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:28:2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 -- L3 Develop GIS-based road alignment and traffic analysis models using spatial and traffic datasets.
2. CO2 -- L4 Analyse horizontal and vertical alignment characteristics using GIS and related software tools.
3. CO3 -- L4 Interpret traffic flow, corridor performance, and network characteristics using GIS-based analytics.
4. CO4 -- L3 Evaluate road safety, traffic impact, and alignment consistency using geospatial methods.
5. CO5 -- L6 Formulate and solve real-world alignment and traffic planning problems through simulation-based GIS workflows and report the results effectively.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 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.
   c. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   d. 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 **20 marks.**

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.

PRACTICAL COMPONENTS (LI-28 hrs)

PART – A

FIXED EXPERIMENTS

1. Introduction to GIS software interface, creation of project workspace, map layers, coordinate systems, and data import for road alignment and traffic studies. (CO1)
2. Digitization of road centerline, control points, and basic horizontal alignment using GIS tools. (CO1, CO2)
3. Preparation of elevation profile and vertical alignment using terrain data and road geometry. (CO2)
4. Mapping and analysis of traffic volume data, turning movements, and corridor flow patterns. (CO1, CO3)
5. GIS-based road safety analysis using sight distance, curve consistency, and hazardous location identification. (CO3, CO4)
6. Traffic impact analysis of a selected corridor or junction using spatial and demand data. (CO3, CO4)
7. Comparison of alternative road alignments based on length, terrain constraint, land-use impact, and traffic performance. (CO4, CO5)
8. Preparation of a GIS-based technical report with maps, tables, results, interpretation, and recommendations. (CO5).

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. Students may be assigned any one problem statements during assessment as decided by the course coordinator. **The sample open-ended problems are provided as reference. Course coordinators are encouraged to design and assign context-specific open-ended problem statements aligned with the defined Course Outcomes (COs), ensuring relevance to contemporary practices and learner needs.**

1. Develop a GIS-based model for a new road bypass and evaluate its effect on through traffic and local access. (CO2, CO4, CO5)
2. Create a comparative study of two alternative alignments for a corridor using terrain, land use, and traffic indicators. (CO2, CO3, CO5)
3. Analyse a road junction using GIS and identify possible geometric or traffic control improvements. (CO3, CO4, CO5)
4. Perform a corridor traffic sensitivity study for changes in demand, access points, or development intensity. (CO3, CO4, CO5)
5. Prepare a road safety hotspot map using accident, alignment, and traffic data. (CO3, CO4, CO5)
6. Generate a complete GIS-based alignment and traffic analytics report including modelling assumptions, results, interpretation, and engineering recommendations. (CO4, CO5)

Textbooks:

1. Miller, H. J. and Shaw, S.-L., *Geographic Information Systems for Transportation: Principles and Applications*, 1st Edition, Oxford University Press, 2001.
2. Hensher, D. A., Button, K. J., Haynes, K. E., and Stopher, P. R. (eds.), *Handbook of Transport Geography and Spatial Systems*, 1st Edition, Edward Elgar / Elsevier reference collection, 2004
3. G. K. Mishra, Geographic Information Systems: Concepts, Methodologies, Tools, and Applications, 2nd Edition, IGI Global, 2010.
4. M. A. Rahman and R. B. Singh, Traffic Engineering and Transportation Planning, 1st Edition, Alpha Science International, 2016.
5. Khanna, S. K. and Justo, C. E. G., *Highway Engineering*, 10th Edition, Nem Chand & Bros.
6. John B. Campbel and Randolph H. Wynne, Introduction to Remote Sensing, 5th Edition, Guilford Press, 2011.
7. Anji Reddy, M., Textbook of Remote Sensing and Geographical Information Systems, 4th Edition, BS Publications, 2018.

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

1. ArcGIS Network Analyst and traffic analysis documentation.
2. Relevant civil engineering GIS manuals and lab guides.
3. Publications on highway alignment using GIS and remote sensing.

Web links and Video Lectures (e-Resources):

1. MIT OpenCourseWare: Free course materials, lecture notes, and videos on structural analysis and finite element methods.
2. OpenSees official resources and tutorials: command manual, examples, and workshop/tutorial materials for structural simulation.
3. NPTEL courses on structural analysis, finite element methods, and computational mechanics.
4. Online tutorials for open-source structural analysis tools such as OpenSeesPy, Pynite, and browser-based structural analysis applications.
5. IS 800:2007 and IS 456:2000 online reference materials for steel and reinforced concrete analysis and design practice.

Software Tools:

- Commercial software: ArcGIS Pro, AutoCAD Civil 3D, Autodesk InfraWorks, PTV Vissim, TransCAD.
- Open-source software: QGIS, GRASS GIS, SAGA GIS, OpenStreetMap/JOSM, Python, R.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 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 the practical test as indicated in the Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component

Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
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.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	**Students' Level and Rubrics**
	Excellent: E, Good: G, Fair: F **Needs Improvements: NI**

	E	G	F	NI
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i) Application of appropriate theories, principles, or laws. (ii) Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i) Logical structure and progression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i) Organization and neatness. (ii) Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i) The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii) If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii) The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv) To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

GEOTECHNICAL ENGINEERING STUDIO			
Course Code	**1MCVL107D**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	I
Teaching Hours/Week (L:T:P)	28(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:28:2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 — L3: Perform standard geotechnical laboratory tests to determine index and engineering properties of soils.
2. CO2 — L4: Interpret test results and classify soil behavior for engineering applications.
3. CO3 — L4: Analyze compaction, permeability, consolidation, and shear strength characteristics of soils.
4. CO4 — L5: Design and evaluate geotechnical parameters for foundations, earth retaining systems, and slope-related problems.
5. CO5 — L6: Apply laboratory and design data to develop practical geotechnical solutions and prepare technical reports.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 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.
   e. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   f. 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 **20 marks.**

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.

PRACTICAL COMPONENTS (LI-28hrs)

PART – A

FIXED EXPERIMENTS

1. Determination of water content, specific gravity, and grain size distribution of soil sample. (CO1, CO2)
2. Determination of Atterberg limits and soil classification using IS/standard system. (CO1, CO2)
3. Standard Proctor compaction test and determination of optimum moisture content and maximum dry density. (CO2, CO3)
4. Laboratory permeability test on sandy soil and evaluation of coefficient of permeability. (CO2, CO3)
5. Direct shear test on cohesionless/cohesive soil and determination of shear strength parameters. (CO3, CO4)
6. Unconfined compression test on cohesive soil and interpretation of strength characteristics. (CO3, CO4)
7. One-dimensional consolidation test and estimation of compression index, coefficient of consolidation, and settlement behavior. (CO3, CO4)
8. California Bearing Ratio test and evaluation of subgrade strength for pavement applications. (CO3, CO4)

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. Students may be assigned any one problem statements during assessment as decided by the course coordinator.
The sample open-ended problems are provided as reference. Course coordinators are encouraged to

design and assign context-specific open-ended problem statements aligned with the defined Course Outcomes (COs), ensuring relevance to contemporary practices and learner needs.

1. Develop a complete geotechnical investigation workflow for a proposed site, including sampling, testing plan, and soil profile interpretation. (CO2, CO4, CO5)
2. Prepare a design-based comparison of shallow foundation options using soil test data and select the most suitable footing type. (CO3, CO4, CO5)
3. Analyze settlement and bearing capacity for a given foundation using laboratory-derived soil parameters and recommend safe foundation pressure. (CO3, CO4, CO5)
4. Evaluate the stability of an earth slope using shear strength data and propose suitable improvement measures. (CO3, CO4, CO5)
5. Develop a design note for a retaining wall or basement support system using geotechnical parameters obtained from laboratory tests. (CO3, CO4, CO5)
6. Prepare a comprehensive geotechnical report for a real or simulated project site, including test results, design interpretation, and engineering recommendations. (CO4, CO5)
7. Study the effect of groundwater condition on soil behavior and foundation performance using available field/laboratory data. (CO3, CO4, CO5)

Suggested Learning Resource:

Textbooks:

1. Das, B. M., Principles of Geotechnical Engineering, Cengage.
2. Craig, R. F., Soil Mechanics, CRC Press.
3. Budhu, M., Soil Mechanics and Foundations, Wiley.
4. Gopal Ranjan and A. S. R. Rao, Basic and Applied Soil Mechanics, New Age International.

Reference books / Manuals:

1. Head, K. H., Manual of Soil Laboratory Testing, Whittles Publishing.
2. Lambe, T. W. and Whitman, R. V., Soil Mechanics, Wiley.
3. Das, B. M. and Sobhan, K., Principles of Geotechnical Engineering, Cengage.
4. Relevant IS codes for soil investigation, classification, compaction, shear strength, consolidation, permeability, and CBR.

Lab Manuals:

1. Geotechnical Laboratory Manual from IIT Bombay resources.
2. Geotechnical Engineering Laboratory manuals from reputed engineering institutions.
3. NPTEL Geotechnical Engineering Laboratory course material.

Suggested IS Codes

1. IS 2720 (relevant parts for moisture content, specific gravity, grain size analysis, Atterberg limits, permeability, compaction, shear, consolidation, and CBR).
2. IS 1892 for site investigation, IS 2131 for SPT, and related investigation codes for design-oriented studio problem.

Web links and Video Lectures (e-Resources):

1. Web E-Resources
2. NPTEL course on Geotechnical Engineering Laboratory.
3. IIT Bombay geotechnical lab manual and experiment sheets.
4. Indian Standard test method references under IS 2720 series and related investigation codes.
5. Online lecture materials and video demonstrations on soil testing and geotechnical properties from academic repositories.

Software Tools:

1. Excel, MATLAB, and basic statistical tools for laboratory data processing.
2. PLAXIS 2D/3D for advanced geotechnical simulation.
3. GeoStudio for seepage and slope stability analysis.
4. Rocscience suite for settlement, slope, wall, and pile design problems.
5. gINT/OpenGround for geotechnical data logging and reporting.
6. AutoCAD for drawing soil profiles, foundation sections, and laboratory layouts.

Assessment Structure (both CIE and SEE) The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.
Continuous Internal Evaluation (CIE): For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks." Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1) Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1. The remaining 15 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 the practical test as indicated in the Table 1. The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component

Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
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.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	**Students' Level and Rubrics**			
	Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5

(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i) Logical structure and progression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i) Organization and neatness. (ii) Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i) The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii) If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii) The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv) To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

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HYDRAULIC AND WASTEWATER NETWORK MODELING LABORATORY			
Course Code	**1MCVL107E**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	I
Teaching Hours/Week (L:T:P)	28(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:28:2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 — L3 Prepare and model hydraulic and wastewater network systems using suitable software tools.
2. CO2 — L4 Interpret demand, flow, pressure, and hydraulic grade line behavior in distribution and sewer networks.
3. CO3 — L4 Analyze pipe sizing, node demands, head losses, and operational constraints for network performance.
4. CO4 — L5 Design and evaluate water supply and wastewater network alternatives for engineering applications.
5. CO5 — L6 Apply modeling outputs to prepare technical reports and recommend practical network solutions

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 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.
   g. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   h. 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 **20 marks.**

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.

PRACTICAL COMPONENTS

PART – A

FIXED EXPERIMENTS

1. Introduction to hydraulic and wastewater network modeling software; creation of project, unit settings, node/pipe database, and basic map/geometric setup. [CO1]
2. Preparation of water distribution network layout and assignment of demand patterns, elevations, and boundary conditions. [CO1, CO2]
3. Simulation of steady-state flow in a water supply network and interpretation of discharge, pressure, velocity, and head loss results. [CO2, CO3]
4. Analysis of pipe diameter effects on pressure distribution and pumping requirement in a water distribution system. [CO3, CO4]
5. Modeling of a branched and looped water supply network and comparison of hydraulic performance. [CO2, CO3, CO4]
6. Simulation of a wastewater sewer network and evaluation of flow, depth, slope, and self-cleansing criteria. [CO2, CO3]
7. Hydraulic grade line and energy grade line plotting for a selected network scenario and interpretation of critical sections. [CO2, CO3]
8. Sensitivity study on demand variation, pipe roughness, or node elevation and its effect on network performance. [CO3, CO4]

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. Students may be assigned any one problem statements during assessment as decided by the course coordinator. **The sample open-ended problems are provided as reference. Course coordinators are encouraged to design and assign context-specific open-ended problem statements aligned with the defined Course Outcomes (COs), ensuring relevance to contemporary practices and learner needs.**

1. Develop a hydraulic model for a small-town water supply network and recommend optimal pipe sizes and pressures. **[CO2, CO4, CO5]**
2. Prepare a wastewater network model for a residential layout and identify critical sewer reaches requiring redesign. **[CO2, CO3, CO4]**
3. Compare two network alternatives for water distribution based on cost, pressure adequacy, and energy requirement. **[CO3, CO4, CO5]**
4. Analyze the effect of fire demand or peak hourly demand on a municipal water network and propose improvements. **[CO3, CO4, CO5]**
5. Develop a design note for a pumping main or sewer main using model outputs and engineering assumptions. **[CO4, CO5]**
6. Prepare a comprehensive network design report for a campus or locality including assumptions, model data, results, and recommendations. **[CO4, CO5]**
7. Evaluate the impact of pipe roughness deterioration, leakage, or blockage on hydraulic performance and suggest mitigation measures. **[CO3, CO4, CO5]**

Suggested learning resources:

Textbooks:

1. Mays, L. W., Water Distribution Systems Handbook, McGraw-Hill.
2. Walski, T. M. et al., Advanced Water Distribution Modeling and Management, Haestad Press.
3. Metcalf & Eddy, Wastewater Engineering: Treatment and Resource Recovery, McGraw-Hill.
4. Punmia, B. C., and Jain, A., Water Supply Engineering and Wastewater Engineering, Laxmi Publications.

Reference books:

1. Garg, S. K., Environmental Engineering Vol. I and II, Khanna Publishers.
2. CPHEEO, Manual on Water Supply and Treatment.
3. CPHEEO, Manual on Sewerage and Sewage Treatment.
4. Relevant codes and standards for water supply, sewerage, and building drainage systems.

Lab manuals:

1. Hydraulic network modeling lab manual from reputed engineering institutions.
2. Water distribution and sewer network modeling experiment sheets.
3. NPTEL and online laboratory resources on water supply and wastewater network design.

Web links and Video Lectures (e-Resources):

1. EPANET – US EPA — public-domain software and official learning source for pressurized water distribution network modeling, hydraulic simulation, and water quality analysis.
2. OpenWasteWater — open-source resource for wastewater treatment plant modeling with OpenModelica, useful for conceptual and computational understanding of wastewater systems.
3. AWWA eLearning Course Catalog — online tutorial and professional learning resources related to EPANET and water distribution system design.
4. Autodesk Hydraulic Modeling Resources — free learning series and videos for hydraulic modeling, GIS-based workflows, and stormwater/water network applications.
5. Free Online Course: Hydraulic Modeling with HEC-RAS — useful for supplementing hydraulic concepts and simulation practice.

6. Hydraulic Modeling Resources – Fluidit — collection of hydraulic modeling references, papers, and learning material on pipe network analysis.
7. Wastewater treatment modelling overview — useful overview of wastewater modeling platforms and comparison of available tools.
8. QSDsan platform paper — open-source sanitation and resource recovery modeling platform relevant to advanced wastewater system studies.

Software Tools:

1. EPANET for water distribution network modeling.
2. SWMM for wastewater and stormwater network modeling.
3. AutoCAD or GIS tools for network layout preparation.
4. Excel, MATLAB, or Python for result processing and tabulation.
5. Any equivalent hydraulic modeling or design software approved by the department.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks." Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1). Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1. The remaining 15 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 the practical test as indicated in the Table 1. The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
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.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	Students' Level and Rubrics

	Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i) Application of appropriate theories, principles, or laws. (ii) Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i) Logical structure and progression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii) Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i) Organization and neatness. (ii) Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i) The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii) If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii) The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv) To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

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WATERSHED AND IRRIGATION NETWORK MODELING LABORATORY			
Course Code	**1MCVL107F**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	I
Teaching Hours/Week (L:T:P)	28(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:28:2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 --- L3 Prepare watershed and irrigation network models using suitable software tools.
2. CO2 --- L4 Interpret runoff, discharge, pressure, water level, and hydraulic behavior in watershed and irrigation systems.
3. CO3 --- L4 Analyze canal/pipe sizing, node demands, head losses, and operational constraints for network performance.
4. CO4 --- L5 Design and evaluate watershed and irrigation network alternatives for engineering applications.
5. CO5 --- L6 Apply modeling outputs to prepare technical reports and recommend practical system solutions.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 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.
   i. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   j. 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 **20 marks.**

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.

PRACTICAL COMPONENTS

PART – A

FIXED EXPERIMENTS

1. Introduction to watershed and irrigation network modeling software; creation of project, unit settings, watershed/canal database, and basic map or geometric setup. [CO1]
2. Preparation of watershed boundary, sub-catchment layout, and assignment of rainfall, soil, slope, and land-use parameters. [CO1, CO2]
3. Simulation of runoff generation for a selected rainfall event and interpretation of discharge, peak flow, infiltration, and storage behavior. [CO2, CO3]
4. Analysis of canal or pipeline sizing effects on discharge distribution, water level, and pumping/flow requirements in an irrigation network. [CO3, CO4]
5. Modeling of branched and looped irrigation distribution networks and comparison of hydraulic performance. [CO2, CO3, CO4]
6. Simulation of watershed drainage or farm conveyance network and evaluation of flow, depth, slope, and operational criteria. [CO2, CO3]
7. Hydraulic grade line and water surface profile plotting for a selected watershed or irrigation network scenario and interpretation of critical sections. [CO2, CO3]
8. Sensitivity study on rainfall variation, canal roughness, or node elevation and its effect on network performance. [CO3, CO4]

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. Students may be assigned any one or more of the following problem statements as decided by the course coordinator.

1. Develop a watershed model for a small catchment and recommend suitable runoff mitigation measures. [CO2, CO4, CO5]
2. Prepare an irrigation network model for a command area and identify critical reaches requiring redesign. [CO2, CO3, CO4]
3. Compare two network alternatives for irrigation distribution based on cost, water adequacy, and energy requirement. [CO3, CO4, CO5]
4. Analyze the effect of peak rainfall or peak irrigation demand on a watershed-network system and propose improvements. [CO3, CO4, CO5]
5. Develop a design note for a canal, pipeline, or storage structure using model outputs and engineering assumptions. [CO4, CO5]
6. Prepare a comprehensive network design report for a watershed, campus, or locality including assumptions, model data, results, and recommendations. [CO4, CO5]

Suggested learning resources:

Textbooks:

1. Mays, L. W., Water Resources Engineering, McGraw-Hill Education, 1st edition.
2. Walski, T. M. et al., Advanced Water Distribution Modeling and Management, Haestad Press, 1st edition.
3. Metcalf & Eddy, Wastewater Engineering: Treatment and Resource Recovery, McGraw-Hill Education, 5th edition.
4. Punmia, B. C., Jain, A., and Jain, A., Irrigation and Water Power Engineering, Laxmi Publications, 16th edition..

Reference books:

1. Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers, 12th edition.
2. Garg, S. K., Environmental Engineering: Water Supply Engineering, Khanna Publishers, 10th edition.
3. CPHEEO, Manual on Water Supply and Treatment, Central Public Health and Environmental Engineering Organisation, 3rd edition.
4. CPHEEO, Manual on Sewerage and Sewage Treatment / irrigation-related design manuals as applicable, Central Public Health and Environmental Engineering Organisation, relevant edition as prescribed.

Lab manuals:

1. Watershed and irrigation network modeling lab manual from reputed engineering institutions.
2. Watershed and irrigation network modeling experiment sheets.
3. NPTEL and online laboratory resources on watershed hydrology, canal design, and irrigation network modeling.

Web links and Video Lectures (e-Resources):

1. EPANET official page and user manual.
2. HEC-HMS documentation and downloads.
3. SWMM reference manual.
4. QGIS resources and training material.
5. Python documentation.
6. YouTube lectures on HEC-HMS, HEC-RAS, and watershed modeling.
7. ArcGIS watershed and water-network tutorial
8. Hydraulic Modeling Resources – Fluidit — collection of hydraulic modeling references, papers, and learning material on pipe network analysis.
9. Wastewater treatment modelling overview — useful overview of wastewater modeling platforms and comparison of available tools.

10. QSDsan platform paper — open-source sanitation and resource recovery modeling platform relevant to advanced wastewater system studies.

Software Tools:

1. EPANET or equivalent for pressurized network modeling.
2. SWMM, HEC-HMS, HEC-RAS, or equivalent for watershed/runoff modeling.
3. AutoCAD or GIS tools for network layout preparation.
4. Excel, MATLAB, or Python for result processing and tabulation.
5. Any equivalent hydraulic modeling or design software approved by the department.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1. The remaining 15 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 the practical test as indicated in the Table 1. The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
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.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	Students' Level and Rubrics
	Excellent: E, Good: G, Fair: F

	Needs Improvements: NI			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i) Logical structure and progression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii) Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i) Organization and neatness. (ii) Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i) The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii) If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii) The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv) To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

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BIM FOR BUILDINGS AND INFRASTRUCTURE MODELING LABORATORY			
Course Code	**1MCVL107G**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	I
Teaching Hours/Week (L:T:P)	28(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:28:2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 — L3 Prepare BIM-based digital models for buildings and infrastructure components using suitable software tools.
2. CO2 — L4 Interpret geometric, spatial, and data-linked model elements for planning and coordination.
3. CO3 — L4 Analyze clashes, quantities, and design consistency across architectural, structural, and infrastructure components.
4. CO4 — L5 Develop coordinated BIM workflows for buildings and infrastructure modeling applications.
5. CO5 — L6 Apply BIM outputs to prepare technical reports, schedules, and actionable design recommendations.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 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.
   k. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   l. 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 **20 marks.**

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.

PRACTICAL COMPONENTS

PART – A: FIXED EXPERIMENTS

1. Introduction to BIM software: project creation, units, templates, levels, grids, and basic model setup for a building or infrastructure project. [CO1]
2. Development of a 3D architectural model of a residential or institutional building with walls, doors, windows, slabs, and roof elements. [CO1, CO2]
3. Creation of a structural BIM model including columns, beams, slabs, foundation elements, and framing coordination. [CO2, CO3]
4. Preparation of a coordinated building model integrating architectural and structural components and identification of basic model inconsistencies. [CO2, CO3]
5. Modeling of site components and infrastructure elements such as roads, drainage corridors, utility alignments, or service corridors. [CO2, CO4]
6. Generation of schedules, quantities, and material take-offs from BIM models for selected building components. [CO3, CO5]
7. Clash detection between architectural, structural, and MEP/infrastructure components and documentation of issues observed. [CO3, CO4]
8. Preparation of views, sheets, annotations, and a presentation-ready BIM output for a selected project. [CO4, CO5]

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. Students may be assigned any one or more of the following problem statements as decided by the course coordinator. **The sample open-ended problems are provided as reference. Course coordinators are encouraged to design and assign context-specific open-ended problem statements aligned with the defined Course Outcomes (COs), ensuring relevance to contemporary practices and learner needs.**

1. Develop a BIM model for a small building and produce a coordinated drawing set with schedules, quantities, and key notes. [CO2, CO4, CO5]
2. Prepare a BIM-based infrastructure corridor model for a campus road, utility line, or drainage network and identify coordination issues. [CO2, CO3, CO4]
3. Compare two design alternatives for a building or infrastructure element using BIM outputs such as quantities, spatial efficiency, and constructability. [CO3, CO4, CO5]
4. Analyze a clash scenario in a multidisciplinary model and propose resolution strategies with updated model outputs. [CO3, CO4, CO5]
5. Develop a 4D or phasing-oriented conceptual BIM workflow for a simple project and explain construction sequencing implications. [CO4, CO5]
6. Prepare a comprehensive BIM-based project report for a building or infrastructure model, including assumptions, data, outputs, and recommendations. [CO4, CO5]
7. Evaluate the impact of design changes on model quantities, coordination, and documentation, and suggest mitigation measures. [CO3, CO4, CO5]

Suggested learning resources:

Textbooks:

1. Eastman, C., Teicholz, P., Sacks, R., and Liston, K., *BIM Handbook*, Wiley.
2. Krygiel, E. and Nies, B., *Green BIM*, Wiley.
3. Hardin, B. and McCool, D., *BIM and Construction Management*, Wiley.
4. Menzel, K. and Scherer, R., *Building Information Modeling: Technology Foundations and Industry Practice*, Springer.

Reference books:

1. Autodesk and other official BIM software learning guides.
2. Relevant national and international BIM standards and model coordination guidelines.
3. Publications on digital engineering, infrastructure BIM, and construction information management.
4. Manuals and code references related to building planning, infrastructure design, and documentation.

Lab manuals:

1. BIM laboratory manual from reputed engineering institutions.
2. Building and infrastructure modeling experiment sheets.
3. Online practice resources on BIM workflows, model coordination, and digital delivery.

Web links and Video Lectures (e-Resources):

1. Autodesk BIM learning resources.
2. National and international BIM standards documentation.
3. Open educational resources on Revit, Navisworks, Civil 3D, and related platforms.
4. Video lectures on BIM workflows, clash detection, and model-based delivery.

Software Tools:

1. Autodesk Revit or equivalent BIM authoring software.
2. Navisworks or equivalent model coordination/clash detection software.
3. Civil 3D or equivalent infrastructure modeling software.
4. Excel, MATLAB, or Python for quantity processing and data analysis.
5. Any equivalent BIM software approved by the department.

Assessment Structure (both CIE and SEE) The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.
Continuous Internal Evaluation (CIE): For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks." Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1) Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1. The remaining 15 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 the practical test as indicated in the Table 1. The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
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.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	**Students' Level and Rubrics** **Excellent: E, Good: G, Fair: F** **Needs Improvements: NI**			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem.	2.0	1.5	1.0	0.5

(ii) Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.				
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i) Logical structure and progression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii) Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i) Organization and neatness. (ii) Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i) The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii) If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii) The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv) To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

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DIGITAL SATELLITE IMAGE PROCESSING LABORATORY			
Course Code	**1MCVL107H**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	I
Teaching Hours/Week (L:T:P)	30(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:30:0)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 – L3: Use digital image processing software tools to import, visualize, and preprocess satellite images.
2. CO2 – L4: Apply enhancement, filtering, and bandq combination techniques to analyze satellite imagery.
3. CO3 – L4: Perform geo-referencing, image correction, and thematic image analysis for earth resources studies.
4. CO4 – L3: Prepare classified, annotated, and interpreted satellite image outputs suitable for reporting and presentation.
5. CO5 – L6: Interpret real-world remote sensing problems and convert them into digital image processing workflows.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 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.
   m. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   n. 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 **20 marks.**

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.

PRACTICLE COMPONENTS (LI-28 hrs)

PART – A

FIXED EXPERIMENTS

1. Introduction to satellite image processing software interface, image import, display, band selection, and visualization basics. (CO1)
2. Image enhancement using contrast stretching, histogram equalization, brightness adjustment, and spatial filtering. (CO1, CO2)
3. False colour composite preparation and interpretation using standard band combinations. (CO2, CO4)
4. Geo-referencing and image registration of a satellite image using ground control points. (CO3, CO4)
5. Image correction and sub setting using resampling, clipping, and coordinate system assignment. (CO3, CO4)
6. Supervised classification of a satellite image for land use/land cover mapping. (CO3, CO4, CO5)
7. Unsupervised classification and accuracy assessment using class signature analysis. (CO3, CO4, CO5)
8. Change detection or thematic mapping of an area using multi-date satellite images. (CO4, CO5)

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. Students may be assigned any one problem statements during assessment as decided by the course coordinator. **The sample open-ended problems are provided as reference. Course coordinators are encouraged to design and assign context-specific open-ended problem statements aligned with the defined Course Outcomes (COs), ensuring relevance to contemporary practices and learner needs.**

1. Develop a satellite image processing workflow for land use and land cover analysis of a given region. (CO2, CO5)
2. Modify a satellite image enhancement approach to improve feature visibility in a chosen area. (CO2, CO4, CO5)
3. Prepare a geo-referenced image product for urban, agricultural, or water resource interpretation. (CO3, CO5)
4. Design a classification scheme for extracting terrain, vegetation, or built-up features from satellite data. (CO3, CO4, CO5)
5. Create a change detection study using two satellite images acquired at different time periods. (CO4, CO5)
6. Generate a complete digital remote sensing output set with preprocessing, enhancement, classification, and interpretation. (CO3, CO4, CO5).

Textbooks:

1. Lillesand, T. M., Kiefer, R. W., and Chipman, J., Remote Sensing and Image Interpretation.
2. Richards, J. A. and Jia, X., Remote Sensing Digital Image Analysis.
3. ERDAS Imagine / ENVI / QGIS remote sensing user manual or equivalent software manual.

Reference books / Manuals:

1. NRSC/ISRO remote sensing data interpretation and image processing guides.
2. Relevant standards and technical notes on satellite data products and map preparation.
3. Standard remote sensing laboratory manuals.

Web links and Video Lectures (e-Resources):

1. NPTEL: Remote Sensing and GIS.
2. NPTEL / IIT courses on digital image processing and remote sensing applications.
3. Online resources on satellite image enhancement, classification, and change detection

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 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 the practical test as indicated in the Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component		
Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
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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.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component				
Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10				
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	Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	**G**	**F**	**NI**
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(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i) Application of appropriate theories, principles, or laws. (ii) Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i) Logical structure and progression. (ii) Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5

(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i) Organization and neatness. (ii) Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

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