ACADEMIC AFFAIRS OFFICE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

No. Acd./ 3723 /IAPC-83 Dated: April 24, 2020

Head, Department of Civil Engineering

The IAPC in its 83rd meeting held on 15.04.2020 vide **Item No. 83.2.3(iv)** considered and accepted the revision in structure and syllabi of B.Tech. and following M.Tech. programs of Department of Civil Engineering:

(a) Geotechnical Engineering
(b) Environmental Engineering

The approved structure and syllabi are attached as **Appendix-A**.

Reeti

Assistant Registrar (Curriculum)

Encl: as above

Copy to (through e mail):-

1. All faculty
2. All Heads of Departments/ Centres
3. Dean, Academic Affairs
4. Associate Dean of Academic Affairs (Curriculum)
5. Channel I/ Academic webpage of iitr.ac.in

Appendix-A
IAPC/83.2.3(iv)

DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

No.CED/DFC-2.3.20/
Date: March ,2020

DEAN, Academic Affairs

It is to inform that as per the DFC meetings held on March 02, 2020 and March 17, 2020, the following decisions have been taken:

(i) CEN-104 Water Supply Engineering will be offered in Autumn Semester of Second Year and CEN-291 Engineering Graphics will be offered in the Spring Semester of First Year. The new course number for Engg. Graphics will CEN-104 and for Water Supply Engineering, it will be CEN- 209.

(ii) CEN-210 has been renamed as Highway Engineering. The course content is modified in the light of advances in the field and new information available on the subject. Traffic Engineering portion is taken out of this course which if interested, the students can take from M Tech courses. (**Appendix-A**)

(iii) Two elective courses, CEN-431: Advanced Highway Engineering and CEN-434: Traffic Engineering and Management are dropped.

(iv) DFC also approved the following modifications/proposals with respect to M Tech courses:

a) FEM in geotechnical Engg as a compulsory subject. It will replace the Continuum Mechanics course currently being offered to M Tech Geotech I Year students in Autumn semester. **(Appendix-B)**
b) Earthquake Resistant Design of geotechnical structures (Elective) shall be an additional elective to M Tech Geotech I Year students in Spring semester **(Appendix-C)**
c) Statistics and Instrumentation for Environmental Engineers to replace Environmental hydraulics- CEN 505 **(Appendix-D)**
d) CEN 502 Environmental Separation Processes to replace M.Tech. Course on Water Treatment CEN 502**(Appendix-E)**
e) Environmental Remediation of Contaminated sites CEN 606 an elective for MTech **(Appendix-F)**
f) New Syllabus for Environmental Chemistry course CEN 504**(Appendix-G)**

(v) All the M.Tech. courses pertaining to Civil Engineering shall be available as electives to the UG students.

(vi) A new Institute Elective course titled Simulation in Transportation Engineering at B Tech level **(Appendix-H)**

(vii) DFC also approved the following modifications/proposals with respect to B Tech and M Tech courses:

i. CEN-308 **(Appendix-I)**
ii. CEN-102 **(Appendix-J)**
iii. CEN-207 **(Appendix-K)**
iv. CEN-206 **(Appendix-L)**
v. CEN-101 **(Appendix-M)**
vi. CEN-106 **(Appendix-N)**
vii. CEN-192 **(Appendix-O)**
viii. CEN-203 **(Appendix-P)**
ix. CEN-511 **(Appendix-Q)**
x. CEN-652 (**Appendix-R**)

(viii) CEN-307 be titled as Railway Engineering. The course has been modified based on the continuous feedback of students wherein they felt that the course be divided into two courses. Further content on High Speed Rails, which is also emphasized by the Government, is also included. The course on Airport Planning and Design is available in electives basket of M Tech Transportation Engineering program and can be taken by students as an elective**. (Appendix-S)**

It is requested that all the above DFC approved items be placed in the forthcoming IAPC for consideration and approval.

(S.K. Ghosh)
Head of the Deptt.

Appendix-A

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. Subject Code: CEN-210 **Course Title:** Highway Engineering

2. Contact Hours: **L:** 3 **T:** 1 **P:** 2

3. Examination Duration (Hrs.): **Theory:** 3 **Practical:** 0

4. Relative Weightage: **CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0

5. Credits: 5 **6. Semester:** Spring **7. Subject Area:** PCC

8. Pre-requisite: Nil

9. Objective: To introduce the fundamentals of highway engineering including development plans, geometric design and construction processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Highway Development Plans:** Historical Development; Functional classification of rural and urban roads; Planning Visions – 2021 (Rural Highways), 2025 (Rural roads), National Urban Transport Policy (NUTP), PMGSY; Components of Detailed Project Report (DPR) of roads; Public Private Partnership Models.	6
2.	**Geometric Design:** Design factors; Cross-section elements, Sight distances; Road Alignment - Horizontal and Vertical profiles; Combination of profiles; Placement of utilities and services; Design considerations in hill areas; Design software.	6
3.	**Highway Materials and Mix Design:** Soil – Desirable properties, Tests – Atterburg limits, Proctor values, CBR, Modulus (k); Stone Aggregates – Desired properties, Tests; Asphalt – Classification, properties, routine tests and modifiers; Cement and Cement Concrete – Desirable properties for pavements; Bituminous Mix design and Concrete Mix design.	8
4.	**Pavement Design:** Factors affecting design; Traffic volume and Axle load survey; Flexible pavements – Layers, design requirements and IRC-37 based design; Rigid pavements: Layers, design requirements, stresses in layers, Design based on IRC-58.	8
5.	**Highway Construction:** Design specification and construction steps of subgrade, embankments, granular layers (GSB, WBM, WMM), bituminous sub-bases, bases, binder and surface courses, concrete pavement (DLC and PQC), Joints in bituminous and rigid pavements; Guidelines for Externally funded Road Projects.	8
6.	**Highway Maintenance:** Types of surface and sub-surface failures, Evaluation and remedial measures; Drainage – surface and sub-surface, Filter design criteria; Design of overlays based on Benkelman Beam and Falling Weight Deflectometer (FWD)	6
	Total	**42**

List of Practical:

1. Atterburg limits
2. Proctor Density Test
3. California Bearing Ratio Test
4. Stone Aggregate Los Angeles Abrasion value Test
5. Stone Aggregate Impact value test
6. Stone Aggregate crushing value test
7. Stone Aggregate Flakiness and Elongation Index test
8. Stone Aggregate water absorption and specific density test
9. Stone Aggregate Soundness test
10. Bitumen Penetration Test
11. Bitumen Softening Point test
12. Bitumen ductility test
13. Bitumen Flash and Fire Point test
14. Bitumen Viscosity test
15. Bitumen specific gravity test
16. Bituminous Mix design – 2 turns
17. Concrete Mix design – 2 turns
18. Concrete Cube compression test

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Wright, Paul H. and Dixon, Karen K., "Highway Engineering", John Wiley and Sons Inc.	**2004**
2.	Khanna, S.K. and Justo, C.E.G., "Highway Material Testing Manual", Nem Chand & Bros.	**2004**
3.	Khanna, S.K. and Justo, C.E.G., "Highway Engineering", Nem Chand & Bros.	**2004**
4.	Papacostas, C.S. and Prevedouros, P.D., "Transportation Engineering and Planning", Prentice Hall.	**2002**
5.	Jotin Khisty, C. and Kent Lall, B., "Transportation Engineering – An Introduction", Third edition, Pearson India	**2016**
6.	Relevant Indian Roads Congress Codes – Geometric Aspects: IRC:38, 69, 73, 86, SP-23. Pavements: IRC:37, 58, 15, 44 Others: IRC:SP-42, SP-88, MORT&H Specifications	**Latest publication as available**

Appendix-B

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. **Subject Code:** CEN-525 **Course Title:** FEM in Geotechnical Engineering
2. **Contact Hours:** **L:** 3 **T:** 0 **P:** 2
3. **Examination Duration (Hrs):** **Theory:** 3 **Practical:** 0
4. **Relative Weight: CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** PCC
8. **Pre-requisite:** Nil
9. **Objective of Course:** To gain knowledge of the key concepts of linear finite element analysis and application in modelling geotechnical problems. To make students conversant with a geotechnical FEM software during practical classes which will help in their current and future research as well as industrial practice.
10. **Details of Course:**

S. No.	Contents	Contact Hours
1	Role of Finite Element Modelling in Geotechnical Engineering, Basic Concepts in Elasticity, Introduction to key concepts of linear finite element method, Basic Steps, Direct Equilibrium Approach, Direct Stiffness Approach, Energy Approach,	03
2	One-dimensional Elements: 2-node Rod, 3-node Rod, Natural (Normalized) Coordinates, Gauss Quadrature	04
3	Two-dimensional Elements: triangular elements, Constant strain Triangle(3-node), Linear strain triangle (6-node)	03
4	Bilinear quadrilateral element: Traditional formulation, Iso-parametric formulation, Interpolation functions	05
5	Plane strain, plane stress and axisymmetric problems	02
6	Principle of effective stress, undrained and drained concepts, total and effective stress matrix, undrained analysis using effective stress approach	06
7	Basics of plasticity model: yield criteria, flow rule, hardening rule, Types of yield surfaces, e.g. Von Mises, Tresca, Drucker Prager, Mohr Coulomb, Hardening soil, Cam Clay, Elastic-plastic stress strain matrix (finite element formulation)	08
8	Finite element modelling of settlement under circular footing, seepage, soil consolidation, excavation and tunnel problems: geometry, mesh size, boundary conditions, material models & parameters, modelling procedure	11
	Total	**42**

List of Practicals

1. Solving some basic problems using concept of linear finite element analysis (w/o software)
2. Introduction to Finite element software – getting familiar with the user interface
3. Getting acquaintance with various material sets and material models available in software
4. Creating geometry, assigning material sets and generating mesh
5. Modelling settlement of a circular footing
6. Modelling embankment on soft soil
7. Flow around a sheet pile wall
8. Modelling single-strut excavation
9. Modelling tunnel construction

11. Suggested Books:

S.No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1	David M Potts and Lidija Zdravkovic, "Finite Element Analysis in Geotechnical Engineering: Theory", Thomas Telford.	1999
2	David M Potts and Lidija Zdravkovic, "Finite Element Analysis in Geotechnical Engineering: Application", Thomas Telford.	2001
3	Andrew Lees, "Geotechnical Finite Element Analysis: A practical guide", ICE publishing.	2016
4.	Reddy, J.N. "An Introduction to the Finite Element Method", McGraw Hill.	2006
5.	O. C. Zienkiewicz., R. L. Taylor & J. Z. Zhu., "The Finite Element Method Its Basis & Fundamentals", Elsevier Publications.	2007
6.	David Muir Wood, "Soil Behaviour and Critical State Soil Mechanics", Cambridge University Press	1991

Appendix-C

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. Subject Code: CEN-629 **Course Title:** Earthquake Resistant Design of Geotechnical Structures

2. Contact Hours: **L:** 3 **T:** 1 **P:** 0

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weight: **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0

5. Credits: 4 **6. Semester:** Spring **7. Subject Area:** PEC

8. Pre-requisite: NIL

9. Objective of Course: To understand the basics of geotechnical earthquake engineering and application of the same in design of geotechnical structures

10. Details of Course:

Sl. No.	Content	Contact Hours
1	Introduction to Geotechnical Earthquake Engineering: Earthquake Hazards Related to Geotechnical Engineering, Seismology and Earthquakes, Different scales of Measuring Earthquake Magnitudes	3
2	Strong Ground Motion: Ground Motion Parameters, Measurement of Ground Acceleration, Attenuation Relationships	3
3	Hazard Analysis: Deterministic Seismic Hazard Analysis, Probabilistic Seismic Hazard Analysis, Return Period, G-R Relationship.	4
4	Seismic Slope Stability: Terzaghi's Pseudo-static Approach, Newmark's Sliding Block Method, Yield Acceleration, Behaviour of reinforced soil slope under seismic conditions.	6
5	Earth Pressure Theory: Seismic Design of Retaining Walls, Force based Pseudo-Static and Pseudo-Dynamic Analysis, Mononobe-Okabe Method, Design Considerations	6
6	Shallow Foundations: Bearing capacity and Settlement, Allowable Differential and Total Settlements, Pseudo-static Analysis of Footings with Eccentric and Inclined Loads, Combined Footings, Raft Foundations, IS Code Approach	6
7	Pile Foundations: Bearing Capacity, Dynamic Pile Formulae, Group Action, Laterally Loaded Piles, Reese and Matlock Theory, Beams on Elastic Foundations	6
8	Well Foundations: Types, Scour Depth, Bearing Capacity, Pseudo-static Analysis of Well Foundations with Earthquake Induced Loads, Lateral Load Resistance of Well Foundations	4
9	Soil Improvement for Remediation of Seismic Hazards	3
10	Recommendations of Seismic Design Codes related to Geotechnical Earthquake Engineering	1
	Total	**42**

11. Suggested Books

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1	Bowles, J.E. "Foundation Analysis and Design", McGraw Hill International Editions.	2005
2	Chopra, A.K. "Dynamics of Structures", PHI Learning.	2006
3	Day, R.W. "Geotechnical Earthquake Engineering Handbook", McGraw Hill Book Company.	2001
4	IS 1893: Part 1 "Criteria for earthquake resistant design of structures – Part 1: General provisions and buildings", Bureau of Indian Standards, New Delhi	2002
5	Kameshwara Rao, N.S.V. "Dynamic Soil Tests & Applications", Wheeler Publications.	2000
6	Kramer, S.L. "Geotechnical Earthquake Engineering", Pearson Education.	2005
7	Prakash, S. "Soil Dynamics", McGraw Hill Book Company	1981
8	Saran, S. "Reinforced Soil and its Engineering Applications", IK International.	2006
9	Saran, S. "Soil Dynamics & Machine Foundation", Galgotia Publication.	2006
10	International and National Journals and Conference Papers.	

Appendix-D

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. Subject Code: CEN-505 **Course Title:** Statistics and Instrumentation for Environmental Engineers

2. Contact Hours: **L:** 3 **T:** 1 **P:** 1

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weightage: **CWS:** 15-30 **PRS:** 20 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0

5. Credits: 4 **6. Semester:** Autumn **7. Subject Area:** PCC

8. Pre-requisite: Nil

9. Objective of Course: To familiarize the student with the principles and usage of advanced analytical instruments

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction	1
2.	Molecular spectroscopy :UV-Visible	2
3.	Chromatography (gas chromatography, liquid chromatography) importance of column technology (packing, capillaries); separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field) detection: simple vs. specific (gas and liquid)	5
4.	Mass spectroscopy: Ion, Gas and Liquid Chromatography	5
5.	High Performance Liquid Chromatography Various sample preparation techniques, including SPE The isolation of compounds from mixtures. The identification of compounds using various detectors The limitation and advantages of the technique	6
6.	Experimental design and hypothesis testing; Comparing a Mean with a Standard; Paired t -Test for Assessing the Average of Differences; Independent t-Test for Assessing the Difference of Two Averages, Tolerance, Intervals and Prediction Intervals; Experimental Design, Sizing the Experiment	8
7.	Environmental monitoring, sampling, testing; Accuracy, Bias, and Precision of Measurements; Precision of Calculated Values; Laboratory Quality Assurance; Fundamentals of Process Control Charts	7
8.	Regression and data analysis: The Method of Least Squares;Precision of Parameter Estimates in Linear Models; Precision of Parameter Estimates in Nonlinear Models; Calibration; Weighted Least Squares; Empirical Model Building by Linear Regression; The Coefficient of Determination, R^2	8
	Total	42

List of Experiments:

1. Analysis of organics and dyes in water by spectrophotometer
2. Analysis of inorganics such as perchlorate and nitrate by IC
3. Analysis of disinfection by products by GC-MS
4. Analysis of Antibiotics by LC-MS
5. Analysis of Trace Metals in Water and Wastewater by AAS
6. Usage of qPCR

12. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	Statistics for Environmental Engineers, 2nd Edition, Linfield C. Brown, Paul Mac Berthouex, Lewis Publishers	2002

Appendix-E

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. Subject Code: CEN-502 **Course Title:** Environmental Separation Processes

2. Contact Hours: **L:** 3 **T:** 1 **P:** 0

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weightage: CWS: 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0

5. Credits: 4 **6. Semester:** Autumn **7. Subject Area:** PCC

8. Pre-requisite: Nil

9. Objective of Course: To develop fundamental understanding of different environmental separation processes and applications

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction to environmental contaminants, unit operations and processes in water and wastewater treatment processes	2
2.	Separation of suspended impurities. coagulation and flocculation fundamentals, rapid mixing, different types of mixers and flocculators; sedimentation: fundamentals, different types of settling, types of sedimentation tanks, effect of short circuiting, dispersion, re-suspension of settled particles, advanced sedimentation devices; granular filtration: fundamentals, rapid and slow sand filters, filter media, hydraulics of filtration and backwashing, efficiency of filtration, pressure filtration.	8
3.	Adsorption. fundamentals, different types of adsorption, factors affecting adsorption, adsorption isotherms, activated carbon as adsorbent: types, preparation and reactivation, batch and column processes, multi-component isotherm, fixed-bed column analysis, concept of bed volumes, rate kinetics of adsorption, film and intra-particle diffusion controlled process, chromatographic elution; Metal oxides as adsorbents: fundamentals, surface complexation mechanism, role of pH, regeneration, selectivity, role in ligand sorption, Lewis acid/base interaction.	8
4.	Ion exchange. types of ion exchangers, organic-based ion exchange resins: types, synthesis, different functionalities, acidity and basicity, exchange capacity, selectivity and factors influencing them, ion exchange isotherms, multi-component ion exchange and chromatographic elution, trace ion exchange, Donnan membrane equilibrium, kinetics of ion exchange, introduction to ion exchange membranes; Hybrid adsorbents; fixed-bed applications, case studies.	12
5.	Gas-liquid separation. Fundamentals. Henry's law, mass balance, mass transfer fundamentals, equilibrium considerations, stripping of volatile gases, Packed tower design: design equations, concept of HTU and NTU, design of aeration towers	3

6.	Membrane-based processes. Types of membrane, processes of synthesis, osmosis and reverse osmosis, reverse osmosis membranes: fundamentals, yield, rejection, salt and water flux, transport models, concentration polarization, membrane fouling and prevention, pre-treatment and cleaning methods, forward osmosis, applications, new developments; electrodialysis: fundamentals. transport of ions, design of ED systems, electrodes, electrodialysis reversal systems, applications	9
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	MWH Water Treatment- Principles and Design, 3rd Edition, John Crittenden et al., John Wiley and Sons, Inc., Hoboken, NJ, USA	2012
2.	Membrane Technology and Applications, R W Baker, John Wiley and Sons, Inc., Hoboken, NJ, USA. (Also available on Wiley online library)	2004
3.	Ion Exchange in Environmental Processes – Fundamentals, Applications and Sustainable Technology, Arup K SenGupta, John Wiley and Sons, Inc., Hoboken, NJ, USA	2017

Appendix-F

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. **Subject Code:** CEN-606 **Course Title:** Environmental Remediation of Contaminated Sites
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage: CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective of Course:** Hazardous waste management and remediation of contaminated sites
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	Introduction	1
2.	Laws, Regulations and Remediation, Legal Concepts, Types of Law, Regulations, Federal Laws/Regulations	4
3.	Risk Assessment-Introduction, Terminology, History; Steps in Human Health Risk Assessment, Data Collection and Evaluation, Exposure Assessment, Toxicity Assessment, Risk Characterization, Risk Management, Risk Communication; Ecological Risk Assessment; Risk-based Corrective Action	10
4.	Remedial Options-Ground water: Introduction, Administrative Options, No Action, Institutional Controls; Groundwater-Plume Containment, introduction, extraction wells, extraction trenches, injection wells/trenches, wells/barriers; Pump and Treat-Introduction, Contaminant behavior, Design considerations; Source Control-Philosophy, Options; Permeable Reactive Barriers-Introduction, Redox reactions, Kinetics, Design considerations; Monitored Natural Attenuation-Introduction, Evaluation, Monitoring, Mechanisms, Plume Types, Lines of Evidence, Case Study	12
5.	Remedial Options-Soils/Sediments: Excavation-Use, Techniques, Control of contaminant transport, Typical costs; Landfill-Hazardous waste landfill, Solid waste landfill; Containment-characteristics of barrier materials, alternatives; Solidification/Stabilization- Introduction, Fundamentals, Chemical, physical; Leaching-single- component, multi-component, Design Considerations, TCLP-based approach, Risk-based approach; Chemical Treatment-Non-redox reactions, Reductive processes, Oxidative processes (ISCO); Surfactant extraction-Introduction, Surfactant properties, Configurations; Soil Vapor Extraction, Introduction, Fundamentals, Design considerations; Bioremediation-Introduction, Fundamentals, Important processes, Examples; Phytoremediation-Mechanisms,	15

	Examples; Thermal Processes-Introduction, Incineration, Thermal Desorption, Aqueous Oxidation; Soil Washing-Introduction, Process Description, Design Considerations	
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	Nemerow, N.L., "Industrial Waste Management", McGraw Hill	2007
2.	Eckenfelder, W.W., "Industrial Water Pollution Control", McGraw Hill	2004
3.	Grega, La, M.D., Buckingham, P.L. and Evans, J.C., "Hazardous Waste Management", McGraw Hill.	2001
4.	Liu, O.H.F. and Liptak, B.G., "Solid and Hazardous Waste Management", Lewis Publishers.	2000
5.	Wentz, C.A., "Hazardous Waste Management", McGraw-Hill.	1995

Appendix-G

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. Subject Code: CEN-504 **Course Title:** Environmental Chemistry

2. Contact Hours: **L:** 3 **T:** 1 **P:** 2

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weightage: **CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0

5. Credits: 5 **6. Semester:** Autumn **7. Subject Area:** PCC

8. Pre-requisite: Nil

9. Objective of Course: To develop understanding of environmental interactions and measurement of water and wastewater quality parameters

10. Details of Course:

S.No.	Contents	Contact Hours
1.	Introduction	1
2.	Equilibrium-Introduction (importance, definitions), Gibbs Free Energy, definition, process feasibility (criteria, driving forces), application to reactions, mixtures, reactions; Calculate Gibbs Energies, standard conditions, non-standard conditions, concentration/activity (concept of activity; effect of activities, reaction quotient, equilibrium coefficient, relationship of activities and concentrations, determining activity coefficients, corrected equilibrium coefficients), temperature (van't Hoff equation), pressure (effect of change in volume); Phase Equilibrium, Introduction, Gas-Liquid, Fluid-Solid, Multiphase; Equilibrium Models, Introduction, Chemical Equilibrium models, Structure, Example, Generalized Approach, species, components, formation equation, tableau, component balance equations, equilibrium equations, solutions	7
	Kinetics-Reactions, introduction (importance, terminology), factors affecting rates of reactions, concentrations of reactants, temperature, stoichiometry; Reactors-general approach (rate equation, material balance), material balances, batch reactor (assumptions, material balances, stoichiometry examples), plug flow reactor (assumptions, material balances, stoichiometry examples), completely mixed reactor (assumptions, material balances, stoichiometry examples), examples; Determination of rate equation, Requirements, form of equation (rates, graph, regression for n), values of coefficients, Approaches, rate-based (rates, regression, linear or nonlinear, one-point), concentration-based (concentration model, regression, one-point), Regression, linear, linearized, non-linear, design of experiments.	5
3.	Acid/Base Reactions, Introduction (importance, terminology), Kinetics; Equilibrium-Single Reaction, Henderson-Haselbach Equation, Ionization Fractions, Models (multiple reactions), Recipe	10

	problems, single acid in water, single base in water, mixture of acid and base, titrations, buffering, Inverse Problems, Computer solutions (VMINTEQ), Alternative approaches (electroneutrality balance), Log C-pH Graphs, introduction, preparation, example; Carbonate System, introduction, closed system, open system, alkalinity, acidity, definitions, theoretical, operational, relationship among ALK,ACD, $C_{t,co3,}$ conservative quantities, Example: Complex Acid/Base Problems	
4.	Aqueous Complex Formation, Introduction-metals as acids, examples, terminology, importance, Kinetics; Equilibrium, Equilibrium Coefficients, stepwise, one-step, Strength of complexes, Models	2
5.	Precipitation, Introduction, Terminology, Applications, Relative Importance, Steps, Nucleation, Crystal Growth, Agglomeration, Ripening, definition, types, Ostwald, more crystalline, less soluble, Controlling precipitation, Promoting precipitation, Inhibiting precipitation; Equilibrium, Coefficients, Important concepts, Models, General approach, Problem types, recipe, solubility, inverse recipe, Competitive Precipitation, Predominance Area Diagram, Calcium carbonate precipitation, Saturation indexes, Caldwell-Lawrence Diagrams, Lime softening calculations	5
6.	Oxidation/Reduction, Introduction, Terminology, Applications, Balancing Redox Reactions, Kinetics, Importance, Models, Equilibrium, Introduction, Alternatives for reaction feasibility, Q/K approach, pe approach, definitions of pe, pe^0, reaction feasibility , models, E_h approach, Galvanic cell, Nernst equation, relationship of E_h, pe, Oxidation-Reduction Potential (ORP) Measurement, introduction, advantages, limitation, Predominance Area Diagrams, introduction, examples, Corrosion, introduction, corrosion cell, types, control methods	9
7.	Fundamentals of Environment Organic Chemistry	1
8.	Surface Complex Adsorption Models, Introduction, Model Development, Basis, Reactions, Effect of Electrostatics, Applications in VMINTEQ	2
	Total	**42**

List of Experiments:

1. Determination of pH, conductivity, TS, TDS, Turbidity, Total coliform, Fecal coliform
2. Determination of major ions : Ca^{++}, Mg^{++}, Na^{+}, $HCO3^{-}$, Cl^{-}, $SO4^{--}$, Checking correctness of analysis : Ion balance, TDS – EC ratio, Determination of Saturation Index and CCPP
3. Determination of Nutrients, BOD, COD, TOC, UV-absorbance, K_{ow}
4. Determination of Residual Cl_2, Available Cl_2 and Chlorine Demand
5. Analysis of Trace Metals in Water and Wastewater

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	Brezonik and Arnold, "Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Aquatic Systems", Oxford University Press	2011
2.	S.W. Stumn and J.J. Morgan, "Aquatic Chemistry", Wiley	1995
3.	Mark M. Benjamin, "Water Chemistry", Waveland Press	2010

Appendix-H

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. **Subject code:** ICE-302 **Course Title:** Simulation in Transportation Engineering
2. **Contact hours:** **L:** 3 **T:** 0 **P:** 2
3. **Examination duration (hrs):** **Theory:** 3 **Practical:** 0
4. **Relative weightage:** **CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits:** 3 **6. Semester:** Both **7. Subject area:** OEC
8. **Pre-requisite:** Basic knowledge of object-oriented programming
9. **Objectives of the course:** To make students familiar with the development of algorithms and application of simulation tools in the field of mobility modelling and simulation.
10. **Details of the course:**

S. No.	Contents	Contact hours
1	**Introduction to Modeling and Simulation:** Importance and necessity of the simulation in traffic and transportation, brief comparison of various available software and their limitations, discrete vs continuous simulation, micro/meso/macroscopic models, advantages and disadvantages of the simulation	4
2	**Basics of mobility systems:** Characteristics of Traffic flow, relationship between fundamental variables, multi-class fundamental diagrams, mixed traffic; Travel demand modeling, user behavior, utility function, basics of transport economics, demand-supply equilibrium, transport negative externalities	10
3	**Data collection, extraction and preparation:** traditional techniques in traffic engineering & transportation planning, use of the advanced technologies like Web APIs, CDR, WiFi/Bluetooth sensors, representation of the physical road-network in the model, processing of the collected and extracted data	8
4	**Simulation Tools:** Modeling – calibration and validation, co-evolutionary algorithms, agent-based models, activity-based models, cellular automata, models for pedestrian simulation, traffic and transport simulation models, suitability for large-scale scenarios	8
5	**Network Simulation and evacuation Systems** – network loading algorithm, simplified kinematic wave model, computational performances**;** evacuation behavior, building evacuation, mass-gathering evacuation, evacuation preparedness**;**	6
6	**Mobility simulations and econometrics:** accessibility vs mobility, importance and computation of accessibility, shared mobility systems (bicycle/car sharing systems), electric vehicles; congestion, air pollution, on-road air pollution exposure, marginal social cost pricing, dynamic road pricing;	6
	Total	42

List of Laboratory Experiments

a. Traffic Volume and Intersection! Turning Movement Study
b. Spot Speed, Travel Time and Delay Study
c. Origin Destination Study and Household Survey
d. Extraction of travel time using Web APIs
e. Scenario preparation
    i. Network preparation
    ii. Demand generation
f. Running an agent-based simulation scenario
g. Running an evacuation scenario
h. Running a scenario from accessibility/shared mobility/congestion/air-pollution

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication
1	Jaume Barceló, "Fundamentals of Traffic Simulation", Springer.	2010
2	Stewart Robinson, "Simulation: The Practice of Model Development and Use",John Wiley & Sons. Ltd	2004
3	Stefania Bandini, Sara Manzoni, Giuseppe Vizzari, "Agent based modeling and Simulation"	2012
4	Klügl, Franziska, Bazzan, Ana, Ossowski, Sascha (Eds.), "Application of agent technology in Traffic and Transportation, Springer.	2005
5	Andreas Horni, Kai Nagel, Kay W. Axhausen, "The multi-Agent Transport Simulation", Ubiquity Press, UK	2016
6	May, A.D., "Fundamentals of Traffic Flow", Prentice Hall, Inc. 2ntJ Ed.	1990
7	Roger P Roess, Elena S Prassas, William R McShane, "Traffic Engineering" 4th Ed, Prentice Hall.	2011
8	Juan de Dios Ortúzar, Luis G. Willumsen, "Modelling Transport", 4th Edition	2011

Appendix-I

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. Subject Code: CEN-308 **Course Title:** Design of Structural Systems

2. Contact Hours: **L:** 3 **T:** 1 **P:** 2

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weightage: CWS: 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0

5. Credits: 5 **6. Semester:** Spring **7. Subject Area:** PCC

8. Pre-requisite: CEN-208 and CEN-305

9. Objective: To introduce the concepts of the analysis and design of concrete and steel structural systems

10. Details of Course:

S.No.	ContentS	Contact Hours
1.	Design loads on buildings, wind and earthquake loads Design of continuous R.C. beams, moment redistribution Approximate methods for the lateral load analysis of building frames	10
2.	Design of solid slab and T-beams bridge, standard specifications and general design considerations	7
3.	Design of overhead water tanks, general design consideration for circular & Intze tanks	6
4.	Prestressed concrete; materials, prestressing systems, stress analysis & losses of prestress, design of simple beams	6
5.	Analysis and design of steel towers	5
6.	Analysis and design of steel truss bridge	8
	Total	**42**

List of Practicals:

A. To study the behaviour of the following RCC members;

1. Under reinforced beams: casting, destructive as well as non-destructive testing.
2. Over reinforced beams: casting, destructive as well as non-destructive testing.
3. Beam without shear reinforcement: casting, destructive as well as non-destructive testing.
4. Pull Out bond strength: casting and testing.

B. Modelling of buildings using different software packages (e.g. STAAD.Pro, ETABS etc.)

11. Suggested Books

S. No.	Name of Books/Author/Publishers
1.	Pillai S. U. and Menon D. , "Reinforced Concrete Design", Tata McGraw Hill
2.	Raju N. K., "Advanced Reinforced Concrete Design", CBS Publishers and Distributors Pvt. Ltd.
3.	Raju N. K., "Pre-stressed Concrete", Tata McGraw Hill
4.	Victor D. J., "Essentials of Bridge Engineering", CBS Publishers and Distributors Pvt. Ltd.
5.	Wight J. K. and Macgregor J. G., "Reinforced Concrete: Mechanics and Design", Prentice Hall
6.	Arya A. S. and Ajmani J. L., "Design of Steel Structures", Nem Chand and Bros.
7.	Subramanian N., "Design of Steel Structures", Oxford Higher Education
8.	Duggal S. K., "Design of Steel Structures", Tata McGraw Hill Education

Appendix-J

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. Subject Code: CEN-102 **Course Title:** Solid Mechanics

2. Contact Hours: **L:** 3 **T:** 1 **P:** 0

3. Examination Duration (Hrs.): **Theory:** 3 **Practical:** 0

4. Relative Weightage: CWS: 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0

5. Credits: 4 **6. Semester:** Spring **7. Subject Area:** ESC

8. Pre-requisite: Nil

9. Objective: To introduce the concepts of equilibrium and deformation in components, and structures for engineering design.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Members in Uniaxial State of Stress:** Uniform cross-section and tapered bars subjected to uniaxial tension and compression, true and engineering stresses and strains, stress composite bars and statically indeterminate bars, thermal stresses; S.E. under axial loading.	6
2.	**Mechanical Properties:** Uniaxial tension test to determine yield and ultimate strength of materials, stress-strain diagram, proof stress, ductile and brittle behavior, impact strength, fatigue.	2
3.	**Statically determinate trusses:** Linear simultaneous equations in member forces, method of joints and sections and a combination of these two.	3
4.	**General state of Stresses and Strains in solids:** Concept of stress, normal stress and shear stress, nine Cartesian components of stress at a point, sign convention and notation, equality of shear stresses on mutually perpendicular planes and their planes of action, principal stresses, stress circle. Concept of strain, normal and shear strain, two-dimensional state of strain, Poisson's ratio, volumetric strain, principal strains, strain circle.	7
5.	**Stress-Strain Relationships:** Hooke's law and its application to isotropic materials, elastic constants and their relationships, plane stress and plane strain conditions, strain energy density.	2
6.	**Members Subjected to Axi-Symmetric Loads:** Stresses and strains in thin cylindrical shells and spheres under internal pressure.	2
7.	**Members Subjected to Torsional Loads:** Torsion of solid, hollow circular shafts and statically indeterminate members, stepped and composite shafts, S.E. in torsion.	3

8.	**Members Subjected to Flexural Loads and axial loads:** Statically determinate beams, shear force and bending moment (SFD and BMD), relationship between load, shear force and bending moment, Theory of flexure for initially straight beams, distribution of bending stresses across the beam cross-section, Composite beams, Transformed section method, Equation of elastic curve for the loaded beam, relationship between bending moment, slope and deflection; Calculation of deflection by integration, moment area and conjugate beam methods, S.E. in flexure. Buckling of columns, short and long columns.	**14**
9.	Analysis of cable structures for vertical loads only.	**3**
	Total	**42**

11. Suggested Books:

- **Relevant additional study materials will be provided as required.**

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	Gere, J.M. and Goodno, B.J., "Strength of Materials", Indian Edition (4th reprint), Cengage Learning India Private Ltd.	2009
2.	Popov, E. P., Engineering Mechanics of Solids, Pearson (Second edition)	2015
3.	Beer, F.P., Johuston, Jr., E.R., Dewolf, J.T. and Mazureu, D.E., "Mechanics of Materials", Fifth Edition, McGraw Hill.	2009
4.	Hibbeler, R.C., "Mechanics of Materials", Sixth Edition, Pearson.	2005
5.	Crandall, S.H., Dahl, N.C. and Lardner, T.J., "An Introduction to the Mechanics of Solids", 2nd Edition, McGraw Hill.	1999
6.	Megson, T. H. G., "Structural and Stress Analysis", 4th Edition, Butterworth-Heinemann	2019
7.	Timoshenko, S.P. and Young, D.H., "Elements of Strength of Materials", Fifth Edition, (In MKS Units), East-West Press Pvt. Ltd.	2009 (reprint)

Appendix-K

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. **Subject Code:** CEN-207 **Course Title:** Structural Analysis – I
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 2/2
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 2
4. **Relative Weightage: CWS:** 15-30 **PRS:** 20 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** PCC
8. **Pre-requisite:** CEN-102
9. **Objective:** To introduce the fundamentals of analysis of statically determinate and indeterminate structures.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Equilibrium of statically determinate structures:** frames, arches drawing Axial Force/Shear Force/Bending Moment diagrams.	4
2.	**Energy methods:** Castigliano's Theorems and Theorem of Least Work and Virtual Work, Determination of slopes and deflections of determinate beams, frames and trusses using Unit Load Method.	9
3.	**Analysis of indeterminate structures:** Flexibility (/force /consistent deformation) method: Basics followed by matrix setup.	10
4.	**Stiffness method (Displacement approach):** Basic principles, Slope deflection equations, Matrix setup Application to planar structures- trusses, beams, frames and arches (force method and stiffness method) Moment distribution method, frame with/without sway, substitutes frame method.	16
5.	Use of symmetry and antisymmetry, reduction of degrees of freedom by equal displacement rigid-body diaphragm specifications and static condensation.	3
	Total	42

List of Practicals:

(a) Analysis of beam:
- Determination of bending moment and shear force
- Determination of bending stress in a cross section
- Determination of the flexural rigidity of beam
- Deflection: Determination of elastic curve
- Verification of the moment area theorem regarding the slopes and deflection of beam
- Determination of the moment required to produce a given rotation at one end of the beam when the other end is (i) Pinned and (ii) Fixed
- Determination of the ratio of the fixed end moment at the end to the moment applied at the other end

(b) Analysis of elastically coupled beam.
(c) Analysis of buckling load in struts.
(d) Analysis of torsion in circular shafts.
(e) Analysis of redundant jointed Truss.

11. Suggested Books:

- **Relevant additional study materials will be provided as required.**

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	Wang, C.K., "Intermediate Structural Analysis", McGraw Hill	1987
2.	Hibbeler, R.C., "Structural Analysis", Pearson Press	2007
3.	Reddy, C.S., "Basic Structural Analysis", Tata McGraw Hill	2000
4.	Weaver, W. Jr. and Gere, J.M., "Matrix Analysis of Framed Structures", CBS Publishers	2000

Appendix-L

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. **Subject Code:** CEN-206 **Course Title:** Structural Analysis - II
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 2/2
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 2
4. **Relative Weightage: CWS:** 15-30 **PRS:** 20 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring **7. Subject Area:** PCC
8. **Pre-requisite:** CEN-207
9. **Objective:** To introduce the concepts of influence line diagram for various structural elements, response of structures under dynamic conditions and advanced techniques to solve structural mechanics problems.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Influence Lines:** Analysis for different types of moving loads, use of influence line diagrams, application to determinate structures	6
2.	Muller-Breslau principle with application to determinate and indeterminate structures. Qualitative ILD for continuous beams frames and arches.	6
3.	**Members Subjected to Combined Loads:** Short struts subjected to eccentric loads, shafts subjected to combined bending, torsion and axial thrust, Unsymmetrical bending, Shear centre.	5
4.	**Elastic Stability of Columns:** Euler's theory of initially straight columns, critical loads for different end condition of columns, eccentric loading, columns with small initial curvature, empirical formulae.	3
5.	**Failure and Collapse:** Failure theories for solids: Tresca, Von Mises, Mohr-Coulomb Collapse analysis of structures: Upper bound and lower bound theorems, collapse mechanisms, collapse of beam and frame through plastic hinge formation, collapse of slab—yield line theory.	7
6.	**Structures under dynamic excitation—ground acceleration:** Idealization of framed structures as finite degrees of freedom system, un-damped forced vibration of single DOF system, dynamic amplification, response spectra, equations of motion of multi DOF system, modal decomposition, response spectra and mode superposition.	8
7.	**Introduction to finite element method:** Numerical technique to solve boundary value problem; Approximate solution, weighted residual and Galerkin's form; discretization, elements, and shape functions; Matrix form and boundary condition imposition; Examples on Bar problem, Beam problem and Planar frame problem.	7
	Total	**42**

List of Practicals:

(a) To determine the influence line for bending moment at the fixed end of a beam, the other end being pinned.
(b) Analysis of two hinged Arch.
(c) Analysis of three Hinged Arch.
(d) Introduction to finite element software package

- Analysis of indeterminate beams, frames and arches

(e) Generation of Seismic Response spectra using computer programming/software package

11. Suggested Books:

- Relevant additional study materials will be provided as required.

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	Timoshenko, S.P. and Young D. H., "Theory of structures", McGraw Hill	1965
2.	Wong, M. B., Plastic analysis and design of steel structures, Butterworth- Heinemann	2011
3.	Wang, C.K., "Intermediate Structural Analysis", McGraw Hill	1987
4.	Chopra, A. K., "Dynamics of structures", Pearson Publishers (Fourth edition)	2011
5.	Hibbeler, R.C., "Structural Analysis", Pearson Press	2007
6.	Cook, R. D., Malkus, D. S., Plesha, M. E., Witt, R. J., Concepts and Applications of Finite Element Analysis, Wiley India (Fourth Edition)	2007

Appendix-M

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. **Subject code: CEN-101** **Course Title:** Introduction to Civil Engineering
2. **Contact Hours:** **L: 2** **T: 0** **P: 0**
3. **Examination Duration (Hrs):** **Theory: 2** **Practical:** 0
4. **Relative Weightage: CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 2 **6. Semester:** Autumn **7. Subject Area:** PCC
8. **Pre-requisite:** Nil
9. **Objective:** To introduce the Civil Engineering profession and the ethical responsibilities of engineering practice.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Structural Engineering:** Introduction to various aspects associated with analysis and design of various structural systems, Buildings, Bridges and other infrastructure projects.	8
2.	**Hydraulics/Water Resources Engineering:** Hydrological cycle, Flows in pipes and channels, Reservoirs/Dams, Hydro-power	5
3.	**Geotechnical Engineering:** Soil as construction material, Problems in plain and hilly areas, Earth retaining structures, Foundations for different types of structures, Embankments/ levees/earth and rockfill dams, Ground improvement techniques, Underground structures like tunnels, Shafts and caverns, Slopes engineering	3
4.	**Transportation Engineering:** Fields of Transportation Engineering, Transportation Systems – Their suitability and utility, Transportation problems and roles of traffic engineers and transportation planners; Types of pavements, Pavement materials – conventional and new materials, Structure of a pavement, Airfield pavement.	4
5.	**Environmental Engineering:** Infrastructure required for water and wastewater engineering	4
6.	**Geomatics Engineering:** Surveying, Importance of surveying in civil engineering, Types of maps, Aerial photographs and satellite images, GPS survey, LiDAR and UAV surveys, GIS applications in civil engineering projects	4
	Total	**28**

11. Suggested Books:

S.No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	Penn M. R. and Parker P. J. "Introduction to Infrastructure: An Introduction to Civil and Environmental Engineering" John Wiley & Sons	2011
2.	Mckay W. B. " Building Construction" Orient Longman	2003
3.	Schodek D. L. "Structures" Prentice Hall of India Pvt. Ltd.	2002
4.	Garg, P.K. Theory and Principles of Geoinformatics, Khanna Book Publishing Co. Delhi	2019
5.	Ghosh, J.K. Elementary Engineering Surveying, Studium Press, New Delhi.	2010
6.	Ghosh, J.K. A Text Book on GPS Surveying, CRC Press, US.	2016
7.	Ghosh and Da Silva (Eds). Applications of Geomatics in Civil Engineering Springer, (ISBN: 978-981-13-7066-3).	2020
8.	Ghilani, C.D., Elementary Surveying: An introduction to Geomatics, Prentice Hall, Pearson. 15th Ed.	2018

Appendix-N

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. **Subject Code:** CEN-106 **Course Title:** Geomatics Engineering – I
2. **Contact Hours:** **L:** 3 **T:** 0 **P:** 2
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage: CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits:** 4 **6.** Semester: **Spring** **7.** Subject Area : **PCC**
8. **Pre-requisite:** NIL
9. **Objective:** To impart knowledge about basic principles of field surveying procedures and practices for civil engineering applications.
10. **Details of Course :**

S.No.	Contents	Contact Hours
1.	Geomatics Engineering - definition, Importance and its relevance to engineering projects, basic principles. Classification of surveys based on instruments and survey work.	2
2.	Types of maps, scales and uses, plotting accuracy, map sheet numbering, coordinates and map projections.	4
3.	Surveying equipment, Levels, Digital levels, Compass, Theodolites, Tapes, Tachometer, EDM, Total Stations, GPS, Smart Stations, and Laser based instruments. Adjustment in equipment.	6
4.	Measurement of angles, directions and distances.	6
5.	Determination of elevation, spirit leveling, trigonometrical leveling, and tachometric surveying, Contouring, DEM, DEM derivatives, Cut and fill computations. Accuracy	9
6.	Methods of control establishment, traversing, triangulation, trilateration, adjustment of survey measurements, computation of coordinates. Adjustment in traversing and triangulation.	6
7.	GPS surveying – principles and methods, applications, DGPS, error in observations and corrections.	5
8.	Layout – curve, bridges, buildings	4
	Total	**42**

List of Practicals

S.No.	Objectives
1	Demonstration and study of different types of maps, atlases, conventional symbols and SOI map numbering system.
2	Determine elevations of at least five points from a given BM/TBM using IOP level.
3	(i) Carry out fly leveling to transfer R.L. from a given BM/TBM using Auto Levels

	(ii) Carry out leveling work using Digital levels.
4	Study the different parts of a Vernier Theodolite and measure of horizontal angles between two lines by method of repetition.
5	Using a Vernier Theodolite, measure of horizontal angles between two lines by among four given lines by method of reiteration and vertical angle to find out the height of a building.
6	Demonstration and hands-on-experience of Total Station for collection, download and reduction of sample data.
7	Demonstration of different types of GPS receivers for collection, download and processing of sample data.
8	Establish Control points using single frequency GPS receiver. Carry out post-processing using GNSS solutions software. Plot these points.
9.	Demonstration of Digital Level and Smart Station.
10.	Layout a traverse of five/six sides using Total Station. Carry out detail computations and adjust the traverse using Gale's Table. Plot the traverse at suitable scale for mapping the area.
11 &12.	Prepare a map using data collected by Total Station using methods of radiation, intersection and resection. Use SOI standard symbols and colors to depict the features.

11. Suggested Books

S.No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1	Garg, P.K., Theory and Principles of Geoinformatics, Khanna Book Publishing Co., Delhi 2019	2019
2	Ghosh, J.K. Elementary Engineering Surveying, Studium Press, New Delhi	2010
3	Ghosh, J.K. A Text Book on GPS Surveying, CRC Press, US.	2016
4	Anderson, J.M. and Mikhail, E.M., "Surveying: Theory and Practice", McGraw Hill.	1998
5	Arora, K.R., "Surveying", Vol. I, II and III, Standard Book House.	1995
6.	Chandra, A.M., "Surveying", New Age Publishers.	2002
7.	Schofield, W. and Breach M., "Engineering Surveying", 6th Ed., Butterworth-Heineman.	2007
8.	Sateesh, Gopi, Sathikumar, R. and Madhu, N., Advanced Surveying: Total Station, GPS, GIS & Remote Sensing, Pearson.	2017

Appendix-O

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. **Subject Code:** CEN-192 **Course Title:** Geomatics Techniques for Architects
2. **Contact Hours:** **L:** 2 **T:** 0 **P:** 2
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits: 3** **6. Semester: Spring** **7. Subject Area: ESC**
8. **Pre-requisite: NIL**
9. **Objective:** To impart knowledge about the basic principles of geomatics engineering techniques for data collection and mapping for planning infrastructural facilities, including various architectural applications.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	Importance of geomatics engineering techniques to architecture and planning	2
2.	Surveying: Definition of surveying, Basic principles, types of maps, their scales and uses, mapsheet numbering	2
3.	Surveying measurements & techniques - Distance, Height, Angles and Directions. Compass Surveying: Bearings and Azimuths. Levelling: Balancing of sights, Differential levelling, profile and cross-section levelling, Reducing the levels, Trigonometric levelling. Contouring	4
4.	Methods of control establishment: Traversing, Tacheometric Surveying, Triangulation. Theodolite and Total Station.	4
5.	LiDAR and UAV survey: components, data types, data collection, data analysis and software, applications in Architecture and Planning	3
6.	Introduction to GPS, principles and components, GPS data collection methods, applications for mapping	2
7.	Aerial photogrammetry, types of photographs, flying height and scale, relief (height) displacement, stereoscopy, height determination	3
8.	Basic concepts of remote sensing, electromagnetic spectrum, Platforms and Sensors, Remote sensing data products, Introduction to visual and digital image interpretation techniques	4
9.	Introduction to GIS, Creation of database (spatial and non-spatial), Spatial analysis, Digital Elevation Model (DEM), Utility of High resolution data and point cloud data for infrastructure planning, 3D visualisation, Applications in Architecture and Planning	4
	Total	**28**

List of Practicals

1. Study of various maps, Indian Map Numbering Systems, and Conventional symbols.
2. Profile levelling and cross-sectioning using Auto level.
3. (i) Determination of magnetic bearings of a closed traverse.
   (ii) Determination of length and gradient of a line using Tacheometric surveying.
4. Use of Total Station for measuring angles, distances, elevations and coordinates.
5. Demostration of survey and mapping using UAV and LiDAR.
6. Use of GPS for taking field measurements.
7. Determination of scale and flying height of an aerial photograph.
8. Creation of 3-D model and use of parallax scale to find height of points using aerial photographs.
9. Use of remote sensing images for Landuse and Landcover classification.
10. Practice on Image Processing System to use high-resolution remote sensing images for planning applications.
11. Practice on GIS for various thematic layers creation.

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Schofield, W. and Breach, M., "Engineering Surveying", 6th Ed., Butterworth-Heinemam.	2007
2.	Chandra, A. M., "Surveying", New Age Publishers.	2002
3.	Chandra, A.M and Ghosh S.K., "Remote Sensing and Geographical Information Systems", Alpha Science.	2005
4.	Ghosh, J.K., A Text Book on GPS Surveying, CRC Press, US.	2016
5.	Garg, P.K., Theory and Principles of Geoinformatics, Khanna Book Publishing Co., Delhi	2019
6.	Ghilani, C.D., Elementary Surveying: An introduction to Geomatics, Prentice Hall, Pearson. 15th Ed.	2018
7.	Vosselman, George and Maas, Hans-Gerd, Airborne and Terrestrial Laser Scanning, Whittles Publishing.	2010
8.	Valavanis, K. and Vachtsevanos, G.J. (Eds) Handbook of UAV, Springer	2018
9.	Lillesand, T.L., Kieffer, R. W. and Chipman, J., "Remote Sensing and Image Interpretation", John Wiley and Sons, 6th Ed.	2007
10.	Gopi, S., "Global Positioning System: Principles and Applications", Tata McGraw Hill Ltd.	2005
11.	Sateesh, Gopi, Sathikumar, R. and Madhu, N., Advanced Surveying: Total Station, GPS, GIS & Remote Sensing, Pearson.	2017
12.	Valavanis, K and Vachtsevanos, G.J. (Eds) Handbook of UAV, Springer	2018
13.	Paul Fashlstrom and Thomas Gleason, Introduction to UAV Systems, John Wiley & Sons	2018
14.	Ghosh and Da Silva (Eds). Applications of Geomatics in Civil Engineering Springer, (ISBN: 978-981-13-7066-3).	2020

Appendix-P

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Civil Engineering

1. Subject Code: CEN-203 **Course Title:** Geomatics Engineering II

2. Contact Hours: **L:** 3 **T:** 0 **P:** 2

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weight: CWS: 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0

5. Credits: 5 **6. Semester:** Autumn **7. Subject Area:** PCC

8. Pre-requisite: Nil

9. Objective: To impart knowledge on advanced surveying, photogrammetry, remote sensing, and Geographic Information Systems (GIS).

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction of Geomatics Engineering and its applications in Civil engineering	1
2.	**Photogrammetry:** aerial and terrestrial, types and geometry of aerial photograph, scale and flying height, relief (elevation) displacement, parallax, stereopair and stereovision, stereoscopes, 3D mapping, height determination, digital photogrammetry, photogrammetric mapping, applications of photogrammetry.	8
3.	**Remote Sensing:** Basic/ Ideal remote sensing, interaction mechanism with atmospheric and earth surface, atmospheric windows, multi concept of remote sensing, spectral signatures, various platforms and sensors	6
4.	**Data Products:** Various remote sensing data products, optical, thermal, microwave and hyperspectral images, visual data interpretation	6
5.	**LiDAR**: Basic principles, terrestrial and airborne LiDAR, data collection techniques, point cloud generation, analysis of data, 3D mapping.	3
6.	**UAV:** Introduction, components, data collection, data types, data analysis software, applications in civil engineering	3
7.	**Digital Image Processing:** Digital image, introduction to digital image processing, preprocessing, enhancement, transformation, indies, image classification for mapping, ~~soft classification techniques~~, accuracy assessment.	7
8.	**GIS:** Introduction of geographic information system, vector and raster data, database creation, digital elevation model (DEM), buffering and overlay analysis, spatial analysis in GIS, applications.	6
9.	**Applications:** Applications of Geomatics Engineering tools in various Civil Engineering projects.	2
	***Survey Camp of 2 weeks duration with 15 marks**	
Total		**42**

List of Practicals:

1. Familiarization with different types of data products, such as maps, aerial photographs, Mosaics, satellite imagery. Study the information content and suitability of these data products in Civil Engineering applications.
2. Study the difference between a topographic map and aerial photograph of an area. Determine the average scale of the photograph. Also compute the flying height of the aircraft taking observations on minimum 10 points.
3. Study and test of stereovision using the Stereo Test Cards and Pocket Stereoscope. Demonstration of Mirror Stereoscopes to create 3D Model.
4. Base lining of a pair of stereo photograph and creation of 3D Model. Study and use of Parallax Bar.
5. Determination of elevation of minimum 10 points on a stereo pair using Parallax Bar measurements. Determination of corrected elevation by drawing error Contours.
6. Study of photo-interpretation Keys for extraction of Thematic and Topographic information from Aerial Photographs and Satellite Imagery. Preparation of Thematic map such as land cover, drainage pattern of area.
7. Study the Image Processing Systems. Carry out Digital Image Processing of remote sensing image for:
   a. Initial Statistics Extraction
   b. Image Enhancement
   c. Image Transformation (vegetation indices)
8. Sites for free download of satellite images. Geo referencing of remote sensing image with GCP data. Demonstrate the utility of Geo referenced temporal satellite images.
9. Carry out Supervised Landuse and Land Cover Classification of Remote Sensing data and its accuracy assessment.
10. Practice on GIS software, Data input to GIS from various sources.
11. Creation of Digital database (Spatial and Non-spatial) in GIS.
12. Spatial analysis (including buffer and overlay analysis) in GIS.
13. Demonstration on UAV.

12. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Bossler, J.D., "Manual of Geospatial Science and Technology", Taylor and Francis.	2002
2.	Burrough, P.A. and McDonnell, R.A., "Principles of Geographic Information System", Oxford University Press.	2000
3.	Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographical Information Systems", Alpha Science.	2005
4.	Garg, P.K. Theory and Principles of Geoinformatics, Khanna Book Publishing Co. Delhi	2019
5.	Lillesand, T.L., Kieffer, R. W. and Chipman, J., "Remote Sensing and Image Interpretation", John Wiley and Sons, 6th Ed.	2007
6.	Vosselman, George and Maas, Hans-Gerd, Airborne and Terrestrial Laser Scanning, Whittles Publishing.	2010
7.	Valavanis, K and Vachtsevanos, G.J. (Eds) Handbook of UAV, Springer	2018
8.	Paul Fashlstrom and Thomas Gleason, Introduction to UAV Systems, John Wiley & Sons	2018

9.	Ghosh and Da Silva (Eds). Applications of Geomatics in Civil Engineering Springer, (ISBN: 978-981-13-7066-3).	2020
10.	Ghilani, C.D., Elementary Surveying: An introduction to Geomatics, Prentice Hall, Pearson. 15th Ed.	2018

Appendix-O

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. / CENTRE: Civil Engineering

1. Subject Code: CEN-511 **Course Title:** Surveying Measurements and Adjustments

2. Contact Hours: **L:** 3 **T:** 0 **P:** 2

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weightage: CWS: 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0

5. Credits: 4 **6. Semester:** Autumn **7. Subject Area:** PCC

8. Pre-requisite: Nil

9. Objective of Course: To introduce the various concept of field surveying.

10. Details of Course :

S. No.	Particulars	Contact Hours
1.	Principles of surveying, Various maps and their scales, Symbols and colours, Generalisation of information on maps	3
2.	Surveying measurement equipment & techniques - Distance, Height, Angles and Directions. Compass Surveying: Bearings and Azimuths Adjustment of equipment.	5
3.	Levelling: Balancing of sights, Differential leveling, Profile and cross-section leveling, Reducing the levels- Height of Instrument and Rise & Fall method. Contouring, 3D models	4
4.	Trigonometrical Leveling and Tacheometric surveying	2
5.	Methods of control establishment: Traversing, Traverse computations and adjustments. Triangulation and Trilateration. Adjustment and accuracy	6
6.	Plane table surveys	3
7.	Electronic Total Station, components, measurements and applications	3
8.	LiDAR- Basic principles, Data collection techniques, Point cloud generation, Analysis, 3D models. GPR – Principles and components, Utility mapping and other applications	3
9.	UAV- Introduction, Components, Data collection, Data types, Analysis software, Applications in civil engineering	2
10.	Concept of observations and models, The mathematical model and errors, Precision and accuracy, Random and systematic errors, Adjustments of errors.	5
11.	Least squares adjustment techniques, Adjustment by linear and non-linear functions in the model, Adjustment by observation equation (variation of parameters) and condition equation methods.	6
	TOTAL	**42**

List of Practicals

1. Study of various maps and map numbering system
2. Working of Dumpy and IOP level and determination of elevation of few points

3. Working of Auto level and Digital level and carrying out differential leveling for a small traverse
4. Profile and Cross-section levelling using Digital Level
5. Working of Prismatic and Surveyor Compass and carrying out traverse survey using compass
6. Measurement of horizontal angles using Vernier theodolite using method of reiteration
7. Measurement of horizontal angles using Vernier theodolite using method of repetition
8. Determination of height of the objects using trigonometric levelling
9. Working of Electronic Total Station and taking observations of few points
10. Traverse survey using Electronic Total Station
11. Plotting of details for the small area using Electronic Total Station
12. Taking observation using UAV/drone
13. Processing the UAV/drone data and generating a high resolution map of the area
14. Taking observation using Terrestrial Laser Scanner and processing the data

11. Suggested Books :

Sl. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Chandra, A.M., "Surveying", New Age Publishers.	2002
2	Arora, K.R. Surveying. Vol. 1, 2 & 3. Standard Book House	2005
3	Sateesh, Gopi, Sathikumar, R. and Madhu, N., Advanced Surveying: Total Station, GPS, GIS & Remote Sensing, Pearson.	2017
4	Vosselman, George and Maas, Hans-Gerd, Airborne and Terrestrial Laser Scanning, Whittles Publishing.	2010
5	Paul, Fashlstrom and Thomas Gleason. Introduction to UAV systems, John Wiley Sons.	2018
6	Ghilani, Charles D., Adjustment Computations: Spatial Data Analysis, John Wiley & Sons, Inc.	2018
7.	Ghilani, C.D., Elementary Surveying: An introduction to Geomatics, Prentice Hall, Pearson. 15th Ed.	2018
8.	Ghosh, J.K. Elementary Engineering Surveying, Studium Press, New Delhi.	2010

Appendix-R

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. / CENTRE: Civil Engineering

1. Subject Code: CEN-652 **Course Title: Geomatics for Civil Engineering**

2. Contact Hours: **L:** 3 **T:** 0 **P:** 2

3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0

4. Relative Weightage: CWS: 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0

5. Credits: 5 **6. Semester:** Spring **7. Subject Area:** PEC

8. Pre-requisite: Basics of Geomatics/Civil Engineering

9. Objective of Course: To impart knowledge on applications of Geomatics Engineering in different domains of Civil Engineering. The subject is being structured for Final Year B.Tech (Civil), M.Tech (Civil) Engineering [for all specialisation] and Ph.D. students having Bachelor degree in Civil Engineering.

10. Details of Course :

S. No.	Particulars	Contact Hours
1.	**Introduction:** Geomatics Engineering – divisions; data types	2
2.	**Terrestrial based data:** Types of Data- spatial, spatio-temporal Geomatics data acquired through instruments like Level, Theodolite, Total Station, GPS Receivers, Laser Scanner, Gravity meter, Spectro-radiometer, Terrestrial Camera-single & stereo, Thermal radiometer and other sensors; Data Quality Analysis and assessment.	6
3.	**Aerial based data :** Spatial, spatio-temporal data/photograoh/imges acquired through UAV and aircraft in different e.m.e bands like Panchromatic, Thermal, Micro-wave bands; SAR data. Data Quality Analysis and assessment.	4
4.	**Satellite-borne data:** Types of Data**,** Multi-spectral and Hyperspectral data in Visible, Thermal, Micro-wave bands Bands; SAR data; geo-physical data; atmospheric data; weather/climate data. Data Quality Analysis and assessment.	8
5.	**Civil Engineering Information Extraction**: Basic Methods - for data acquired based on terrestrial, aerial and space based platforms.	6
6.	**Geomatics Data processing software**: TBC, L-Infinity, ERDAS, AGI-Soft, ArcGIS etc.	4
7.	**Applications of Geomatics Engineering in Civil Engineering:** data, information, case studies for Environmental Engineering, Geotechnical Engineering, Transportation Engineering, Structural Engineering, Water resource Engineering.	12
	TOTAL	**42**

List of Practicals

P1: Demonstration of TOTAL STATION, its working and geomatics data acquisition.
P2: Demonstration of GPS receivers, their working and acquisition of geomatics data.
P3: Demonstration & working of **TBC and** and extraction of information from total station, GPS observations.
P**4:** Demonstration of LASER SCANNER, its working, collection of data, data download and processing of data.
P**5:** Demonstration & working with **L-Infinity**.
P8: Demonstration of GRAVIMETER, its working, collection of data and extraction of information.
P7: Demonstration & working of Spectro radiometer, collection of data, data download and information extraction.
P8: Demonstration of working of **ERDAS** and extraction of information from terrestrial/aerial/ remote sensing data.
P9: Demonstration & working of UAV for geomatics data acquisition.
P10: Demonstration of working and processing of UAV data using **AGI-Soft**.
P11: Demonstration and application ARC-GIS software in Civil Engineering work.

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication
1.	Ghilani, C.D., Elementary Surveying: An introduction to Geomatics, Prentice Hall, Pearson. 15th Ed.	2018
2.	Ghosh, J.K. Elementary Engineering Surveying, Studium Press, New Delhi	2010
3.	Vosselman, George and Maas, Hans-Gerd, Airborne and Terrestrial Laser Scanning, Whittles Publishing.	2010
4.	Ghosh, J.K. A Text Book on GPS Surveying, CRC Press, US.	2018
5.	Wolf, P.R, Dewitt, B.A., and Wilkinson,B.E. Elements of Photogrammetry with applications in GIS, McGraw Hill	2014
6.	Paul Fashlstrom and Thomas Gleason, Introduction to UAV Systems, John Wiley & Sons	2018
7.	Lilles and, T.L., Kieffer, R. W. and Chipman, J., "Remote Sensing and Image Interpretation", John Wiley and Sons, 6th Ed.	2007
8.	Jensen, J.R. Introductory Digital Image Processing – A Remote sensing Prerspective,Fourth Edition, Pearson	2016
9.	Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographical Information Systems", Alpha Science.	2005
10.	Burrough, P.A. and McDonnell, R.A., "Principles of Geographic Information System", Oxford University Press.	2000
11.	Garg, P.K. Theory and Principles of Geoinformatics, Khanna Book Publishing Co. Delhi	2019
12.	Ghosh and Da Silva (Eds). Applications of Geomatics in Civil Engineering Springer, (ISBN: 978-981-13-7066-3).	2020
13.	Ghosh, S.K.Ghosh. Digital Image processing, Narosa Publishing House.	2009

Appendix-S

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: Civil Engineering

1. **Subject Code:** CEN-307 **Course Title:** Railway Engineering
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage: CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** PCC
8. **Pre-requisite:** Nil
9. **Objective of Course:** To introduce the fundamentals and advances in the area of railway engineering.
10. **Details of Course**

S.No.	Contents	Contact hours
1	**Permanent way and components**: Historical development and set-up of Indian Railways; Rail Gauges; Permanent way – functions, requirements, sections; Electrified tracks; Locomotives, Wheel and Axle arrangement; Coning of wheels; Components – Rail, Sleeper and Ballast, and their functional requirements.	08
2.	**Resistances and Stresses in tracks, Hauling Capacity:** Resistances to traction; Stresses in the track; Hauling capacity and tractive effort.	03
3.	**Joints and Fastenings:** Types of joints; Welded rails – short and long, continuous; Rail to Rail and Rail to Sleeper fastenings, Elastic fastenings; Induced effects – Creep, wear	05
3.	**Track Geometry Turnouts and Crossings:** Track alignment, Horizontal alignment – curves, superevelation, cant, safe speed, transition curves, widening of gauge, track clearances; Vertical alignment – gradients; Points and Crossings – terminologies, types, turnouts, design of turnouts and crossings	06
4.	**Railway Safety:** Signals – Classification, functions; Train operation control systems – Absolute, Automatic Block system, Centralized control system, ATS; Interlocking of tracks – Principle, types; Railway Certification process.	06
5.	**High Speed Rails**: HSR systems in world; Types of HSR technologies; track requirements and speed limitations; HSR development in India.	06
6.	**Rail Transit Systems:** Classification; Urban and medium distance technologies; Technological and Operational Features; Medium performance transit modes, high-performance transit modes; Station and station area development	08
	Total	42

11. Suggested Books:

S.No.	Name of Books / Authors / Publisher	Year of Publication
1	Chandra, Satish and Agarwal, M. M., "Railway Engineering", Oxford University Press, New Delhi	2nd edition 2013
2	Arora, S. P. and Saxena, S. C, "A Textbook on Railway Engineering", Dhanpat Rai Publications (P) Ltd., New Delhi	7th edition, 2006
3.	Mundrey, J. S., "Railway Track Engineering", Tata McGraw-Hill Publishing Company, New Delhi.	2017
4.	M M Agarwal, "Railway Works Engineering", Prabha & Co. Delhi	2007
5.	M M Agarwal, "Indian Railway Track", Prabha & Co. Delhi	2007

BACHELOR OF TECHNOLOGY (CIVIL)

First Year (Autumn Semester)

S.No	Code	Title	Area	Cr	L	T	P	TH	PH	CWS	PRS	MTE	ETE	PRE
1	MAN-001	Mathematics-I	BSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	PHN-001	Mechanics	BSC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
3	CEN-105	Introduction to Environmental Studies	GSC	3	3	0	0	2	0	20-35	-	20-30	40-50	-
4	HSN-001B	Communication Skills (Advance)	HSSC	2	1	0	2	2	-	25	-	25	50	-
5	HSN-001A	Communication Skills (Basic)	HSSC	2	1	0	2	2	0	25	-	25	50	-
6	HSN-002	Ethics and Self Awareness	HSSC	2	1	1	0	2	0	25	-	25	50	-
7	CEN-101	Introduction to Civil Engineering	PCC	2	2	0	0	2	0	20-35	-	20-30	40-50	-
8	CEN-103	Numerical Methods and Computer Programming	ESC	4	3	0	2	3	0	10-25	25	15-25	30-40	-

First Year (Spring Semester)

S.No	Code	Title	Area	Cr	L	T	P	TH	PH	CWS	PRS	MTE	ETE	PRE
1	CYN-008	General Chemistry - III	BSC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
2	MAN-006	Probability and Statistics	BSC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3	CEN-102	Solid Mechanics	ESC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	CEN-104	Engineering Graphics	PCC	4	2	2	0	3	0	20-35	-	20-30	40-50	-
5	CEN-106	Geomatics Engineering – I	PCC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
6	CEN-108	Fluid Mechanics	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-

Second Year (Autumn Semester)

S.No	Code	Title	Area	Cr	L	T	P	TH	PH	CWS	PRS	MTE	ETE	PRE
1	EEN-112	Electrical Sciences	ESC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
2	CEN-203	Geomatics Engineering – II	PCC	5	3	0	2	3	0	10-25	25	15-25	30-40	-
3	CEN-205	Channel Hydraulics	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
4	CEN-207	Structural Analysis – I	PCC	4	3	1	2/2	3	2	15-30	20	15-25	30-40	-
5	CEN-209	Water Supply Engineering	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
6	HSN-ELE	HSS Elective Course	HSSMEC	3	3	2	1	0	3	0	15	-	35	50

Second Year (Spring Semester)

S.No	Code	Title	Area	Cr	L	T	P	TH	PH	CWS	PRS	MTE	ETE	PRE
1	MIN-102	Basic Manufacturing Processes	ESC	4	2	0	4	3	0	15	15	30	40	-
2	CEN-202	Waste Water Engineering	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
3	CEN-204	Engineering Hydrology	PCC	4	3	1	-	3	0	20-35	0	20-30	40-50	-
4	CEN-206	Structural Analysis-II	PCC	4	3	1	2/2	3	2	15-30	20	15-25	30-40	-
5	CEN-208	Design of Reinforced Concrete Elements	PCC	4	3	1	2/2	3	2	15-30	20	15-25	30-40	-
6	CEN-210	Highway Engineering	PCC	5	3	1	2	3	0	10-25	25	15-25	30-40	-

Third Year (Autumn Semester)														
S.No.	**Code**	**Title**	**Area**	**Cr**	**L**	**T**	**P**	**TH**	**PH**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	CEN-303	Soil Mechanics	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
2	CEN-305	Design of Steel Elements	PCC	4	3	0	2	3	0	10-25	25	15-25	30-40	-
3	CEN-307	Railway Engineering	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	CEN-ELE1	Department Elective Course – I	PEC	4	-	-	-	-	-	-	-	-	-	-
5	OEC/ BM-ELE	Open Elective Course/ Management Studies Elective Course	OEC/ HSSMEC	3	-	-	-	-	-	-	-	-	-	-
6	CEN-391	Technical Communication	PCC	2	0	2	0	0	0	100	-	-	-	-
Third Year (Spring Semester)														
S.No.	**Code**	**Title**	**Area**	**Cr**	**L**	**T**	**P**	**TH**	**PH**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	CEN-300	Practical Problem	PCC	3	-	-	-	-	-	-	-	-	-	-
2	CEN-306	Foundation Engineering	PCC	4	3	1	2/2	3	0	15-30	20	15-25	30-40	-
3	CEN-308	Design of Structural Systems	PCC	5	3	1	2	3	0	10-25	25	15-25	30-40	-
4	CEN-ELE2	Department Elective Course – II	PEC	4	-	-	-	-	-	-	-	-	-	-
5	MSC1/ DHC1	Minor Specialization Course-I / Department Honours Course – I	MSC/DHC	4	-	-	-	-	-	-	-	-	-	-
6	OEC/ BM-ELE	Open Elective Course/ Management Studies Elective Course	OEC/ HSSMEC	3	-	-	-	-	-	-	-	-	-	-
7	CEN-399	Educational Tour	PCC	0	-	-	-	-	-	-	-	-	-	-
Fourth Year (Autumn Semester)														
S.No.	**Code**	**Title**	**Area**	**Cr**	**L**	**T**	**P**	**TH**	**PH**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	CEN-400A	B. Tech. Project	PCC	4	-	-	-	-	-	-	-	-	-	-
2	CEN-ELE3	Department Elective Course-III	PEC	4	-	-	-	-	-	-	-	-	-	-
3	CEN-ELE4	Department Elective Course-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
4	MSC2/ DHC2	Minor Specialization Course-II / Department Honours Course – II	MSC/DHC	4	-	-	-	-	-	-	-	-	-	-
5	MSC3/ DHC3	Minor Specialization Course-III / Department Honours Course – III	MSC/ DHC	4	-	-	-	-	-	-	-	-	-	-
6	CEN-499	Training Seminar	PCC	2	-	-	-	-	-	-	-	-	-	-
Fourth Year (Spring Semester)														
S.No.	**Code**	**Title**	**Area**	**Cr**	**L**	**T**	**P**	**TH**	**PH**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	CEN-400B	B. Tech. Project (Contd. From Autumn Semester)	PCC	8	-	-	-	-	-	-	-	-	-	-
2	CEN-ELE5	Department Elective Course-V	PEC	4	-	-	-	-	-	-	-	-	-	-
3	CEN-ELE6	Department Elective Course-VI	PEC	4	-	-	-	-	-	-	-	-	-	-
4	MSC4/ DHC4	Minor Specialization Course-IV / Department Honours Course – IV	MSC/DHC	4	-	-	-	-	-	-	-	-	-	-
5	MSC5/ DHC5	Minor Specialization Course-V / Department Honours Course – V	MSC/ DHC	4	-	-	-	-	-	-	-	-	-	-

***All the MTech courses of Civil Engineering Department will be available as electives for the civil engineering UG students.**
CE 431 Advanced highway engg and CEN 434 Traffic Engineering and Management dropped as Electives.

DEPARTMENT OF CIVIL ENGINEERING

M. Tech. (Geotechnical Engineering)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1st YEAR										**Semester- I (Autumn)**				
1.	CEN-521	Advanced Numerical Analysis	PCC	4	3	-	2	3	-	10-25	25	15-25	30-40	-
2.	CEN-522	Advanced Soil Mechanics	PCC	4	3	1	2/2	3	-	15-30	20	15-25	30-40	-
3.	CEN-523	Engineering Behaviour of Rocks	PCC	4	3	1	2/2	3	-	15-30	20	15-25	30-40	-
4	CEN-524	Soil Dynamics and Machine Foundations	PCC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
5.	CEN-525	FEM in Geotechnical Engineering	PCC	4	3	0	2	3	-	10-25	25	15-25	30-40	-
		Total		20	15	3	4							
Semester-II (Spring)														
1.	CEN-700	Seminar	SEM	2	0	0	2	-	-	-	-	-	100	-
2.		Programme Elective-I	PEC	4	-	-	-	-	-	-	-	-	-	-
3.		Programme Elective-II	PEC	4	-	-	-	-	-	-	-	-	-	-
4.		Programme Elective-III	PEC	4	-	-	-	-	-	-	-	-	-	-
5.		Programme Elective-IV	PEC	4	-	-	-	-	-	-	-	-	-	-
		Total		18										
2nd YEAR										**Semester- I (Autumn)**				
1.	CEN-701A	Dissertation Stage–I (to be continued next semester)	DIS	12	-	-	-	-	-	-	-	-	100	-
		Total		12										
Note: Students can take 1 or 2 audit courses as advised by the supervisor, if required.														
Semester-II (Spring)														
1.	CEN-701B	Dissertation Stage–II (contd. From III semester)	DIS	18	-	-	-	-	-	-	-	-	100	-
		Total		18										
		Total Credits		**68**										

Program Elective Courses (Geotechnical Engineering)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	CEN-621	Advanced Geotechnical Exploration and Testing	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
2.	CEN-622	Advanced Foundation Engineering	PEC	4	3	1	2/2	3	-	15-30	20	15-25	30-40	-
3.	CEN-623	Stability Analysis of Slopes	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
4.	CEN-624	Design of Under-Ground Excavations	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
5.	CEN-625	Ground Improvement Engineering	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
6.	CEN-626	Foundations on Weak Rocks	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
7.	CEN-627	Landslide Analysis and Control	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
8.	CEN-628	Constitutive Modeling of Geological Materials	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
9.	CEN-629	Earthquake Resistant Design Of Geotechnical Structures	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
10.	CEN-545	Finite Element Method	PEC	4	3	-	2	3	-	10-25	25	15-25	30-40	-
11.	CEN-650	Design of Bridge Sub-structure	PEC	4	3	-	2	3	-	10-25	25	15-25	30-40	-

DEPARTMENT OF CIVIL ENGINEERING

M. Tech. (Environmental Engineering)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1st YEAR										**Semester- I (Autumn)**				
1.	CEN-501	Environmental Modeling and Simulation	PCC	4	3	1	2/2	3	-	15-30	20	15-25	30-40	-
2.	CEN-502	Environmental Separation Processes	PCC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
3.	CEN-503	Wastewater Treatment	PCC	4	3	1		3	-	20-35	-	20-30	40-50	-
4.	CEN-504	Environmental Chemistry	PCC	5	3	1	2	3	-	10-25	25	15-25	30-40	-
5.	CEN-505	Statistics and Instrumentation for Environmental Engineers	PCC	4	3	1	1	3	-	15-30	20	15-25	30-40	-
		Total		21	15	5	3							
Semester-II (Spring)														
1.	CEN-700	Seminar	SEM	2	0	0	2	-	-	-	-	-	100	-
2.		Programme Elective-I	PEC	4										
3.		Programme Elective-II	PEC	4										
4.		Programme Elective-III	PEC	4										
5.		Programme Elective-IV	PEC	4										
		Total		18										
2nd YEAR										**Semester- I (Autumn)**				
1.	CEN-701A	Dissertation Stage–I (to be continued next semester)	DIS	12	-	-	-	-	-	-	-	-	100	-
		Total		12										
Note: Students can take 1 or 2 audit courses as advised by the supervisor, if required.														
Semester-II (Spring)														
1.	CEN-701B	Dissertation Stage–II (contd. From III semester)	DIS	18	-	-	-	-	-	-	-	-	100	-
		Total		18										
		Total Credits		**69**										

Program Elective Courses (Environmental Engg.)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	CEN-601	Air Pollution and Control	PEC	4	3	1	2/2	3	-	15-30	20	15-25	30-40	-
2.	CEN-602	Water Quality Management	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
3.	CEN-603	Industrial and Hazardous Waste Management	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
4.	CEN-604	Environmental Impact and Risk Assessment	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
5.	CEN-605	Solid Waste Management	PEC	4	3	1	2/2	3	-	15-30	20	15-25	30-40	-
6.	CEN-606	Environmental Remediation of Contaminated Sites	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	
7.	CEN-535	Ground Water Engg.	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
8.	CEN-614	Theory and Applications of GIS	PEC	4	3	-	2	3	-	10-25	25	15-25	30-40	-
9.	CEN-633	Systems Engineering	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-
10.	NTN-562	Environmental Nanotechnology	PEC	4	3	1	-	3	-	20-35	-	20-30	40-50	-