

Department of Civil & Environmental Engineering

The department of Civil & Environmental Engineering offers the following programmes during the academic year 2020-21.

- Master of Technology (M.Tech.) in Civil Engineering with specialization in Structural Engineering, Construction Engineering & Management and Environmental Engineering
- Bachelor of Technology (B.Tech.) in Civil Engineering with Specialization option in Infrastructure Development and Smart Cities.

M.Tech. in civil engineering programme will impart advanced knowledge in the selected disciplines of civil engineering and prepare the students for bright career in industries, research and academic institutions within India and abroad. The programme will be of 2 years duration with 4 semesters for full time and 3 years with 6 semesters for part time. The programme has total credits of 56. The curriculum is designed in such a way that there are specialization options in structural engineering, Construction engineering and Management, and Environmental engineering. Students can opt for any one of these specializations by taking the relevant programme electives, seminar, minor project and major project in those specializations.

The curriculum of B.Tech. Civil engineering will prepare the graduates for suitable employment in civil engineering and related disciplines and prepare graduates with basic competence required to pursue advanced study and research in civil engineering and related disciplines. While framing the curriculum, not only the technology development in civil engineering but also the technology development in information technology, biotechnology, satellite communications, computers and materials have been taken into account. The programme has total credits of 168. Along with a B.Tech. degree in Civil Engineering students will also have an option of taking up a specialization in Infrastructure Development and Smart Cities. Out of the total courses run, specific courses on soft skills development and value added courses on technical skills have been added to improve the employability skills required in Industry.

M.Tech. in Civil Engineering (2020-21)

(with specialization in Structural Engineering / Construction Engineering and Management/ Environmental Engineering)

Semester	Course Name						Lecture Courses	L	T	P	Contact hours per week	Credits
I	CEL501 Sustainable Built Environment 2-0-2 (3)	CEL502 EI&RA 2-0-2 (3)	CEL503 Safety and Reliability Analysis 2-0-2 (3)	CEL504 Advanced Concrete Technology 2-0-2(3)	CEL505 Optimization techniques in Civil Engineering 2-0-2(3)	CEC501 Seminar 0-0-2(1)	5	10	0	12	22	16
II	OE-I 2-0-2(3) MOOC*	PE-1 2-0-2(3)	PE-2 2-0-2(3)	PE-3 2-0-2 (3)	PE-4 2-0-2 (3)	MAL616 Introduction to Research Methodology 2-1-0 (3)	6	12	1	10	23	18
III	OE-II 2-0-2(3) MOOC*	PE-5 2-0-2 (3)	CED601 Dissertation Part-I 0-0-8(4)				2	4	0	12	16	10
IV	CED602 Dissertation Part-II 0-0-24(12)						0	0	0	24	24	12
						Total						56

Scheme of Studies (M.Tech)

Category	PC	PE	OE	Total
Credits	35	15	6	56

Programme Core (PC)

S.No.	Course Code	Title	L-T-P	Credits
1.	CEL501	Sustainable Built Environment	2-0-2	3
2.	CEL502	Environmental Impact and Risk Assessment	2-0-2	3
3.	CEL503	Safety and Reliability Analysis	2-0-2	3
4.	CEL504	Advanced Concrete Technology	2-0-2	3
5.	CEL505	Optimization Techniques in Civil Engineering	2-0-2	3
6.	MAL616	Introduction to Research Methodology	2-1-0	3
7.	CEC501	Seminar & General proficiency	0-0-2	1
8.	CED601	Dissertation Phase – I	0-0-8	4
9.	CED602	Dissertation Phase – II	0-0-24	12
Total Credits				35

Programme Elective (PE)

Sl. No.		Course Code	Title	L-T-P	Credits	Remark
1.	PE-I	CEL506	Prestressed Concrete Structures	2-0-2	3	SE
2.		CEL507	Design of Industrial structures	2-0-2	3	
3.		CEL510	Construction and Contract Management	2-0-2	3	CT&M
4.		CEL511	Infrastructure Development and Management.	2-0-2	3	
5.		CEL513	Water Supply Engineering	2-0-2	3	EE
6.		CEL514	Industrial Waste Management	2-0-2	3	
7.	PE-II	CEL515	Structural Dynamics	2-0-2	3	SE
8.		CEL516	Principles of Bridge Engineering	2-0-2	3	
9.		CEL509	Functional Planning, Building Services and Management	2-0-2	3	CT&M
10.		CEL519	Construction Economics & Finance	2-0-2	3	
11.		CEL521	Geo-Environmental Engineering	2-0-2	3	EE
12.		CEL512	Environmental Chemistry	2-0-2	3	
13.	PE-III	CEL517	Theory of Elasticity and Plasticity	2-0-2	3	SE
14.		CEL524	Matrix Methods of Structural Analysis	2-0-2	3	
15.		CEL527	Quality and Safety in Construction	2-0-2	3	CT&M
16.		CEL528	Strategic Planning and Management	2-0-2	3	
17.		CEL530	Environmental Policy & Legislation	2-0-2	3	EE
18.		CEL523	Waste Water Engineering	2-0-2	3	
19.	PE-IV	CEL603	Finite Element Analysis	2-0-2	3	SE
20.		CEL525	Prefabricated Structures	2-0-2	3	
21.		CEL606	Project Planning and Control	2-0-2	3	CT&M
22.		CEL607	Advanced Methods for management research	2-0-2	3	
23.		CEL610	Environmental Hydraulics and Hydrology	2-0-2	3	EE
24.		CEL609	Solid and Hazardous Waste Management	2-0-2	3	
25.	PE-V	CEL526	Theory of plates and shells	2-0-2	3	SE
26.		CEL604	Design of Tall Structures	2-0-2	3	
27.		CEL520	Shoring, Scaffolding and Formwork	2-0-2	3	CT&M
28.		CEL529	Flexible Systems Management	2-0-2	3	
29.		CEL611	Environmental Modeling and Simulation	2-0-2	3	EE
30.		CEL522	Global Climate Change Adaptation and Mitigation	2-0-2	3	
*Selected Topics of equivalent credits can be offered along with above mentioned elective courses						

Master of Technology in Civil Engineering
Department of Civil and Environmental Engineering

CEL501 Sustainable Built Environment

3 Credits (2-0-2)

Background terms; Smart Growth, smart city and New Urbanism and the Resistance to Change; Green Building Assessment; Green Building Index; Life Cycle Costing; The Setting/Green Roofs, Case Study; Energy and Buildings; Energy And Hydrologic Systems; Materials/Specifications; Interior Environments (lighting, air), GRIHA, LEEDs rating system, BEE Standards and guidelines.

CEL502 Environmental Impact & Risk Assessment

3 Credits (2-0-2)

Planning and Management of Environmental Impact Studies. Impact indentation methodologies: base line studies, screening, scooping, checklist, networks, overlays. Prediction and assessment of impacts on the socio-economic environment. Environmental cost benefit analysis. Decision methods for evaluation of alternatives. Case Studies. Environmental impact assessment at project level, regional level, sectoral level, and policy level. Sustainable development; Environmental policy in planned, mixed and market economies; global environmentalism. Preventive environmentalism. Preventive environmental management

CEL503 Safety and Reliability Analysis

3 credits (2-0-2)

Fundamentals of set theory and probability, probability distribution, regression analysis, hypothesis testing. Stochastic process and its moments and distributions, Concepts of safety factors, Safety, reliability and risk analysis, first order and second order reliability methods, simulation based methods, confidence limits and baysean revision of reliability, reliability based design, examples of reliability analysis of structures.

CEL504 Advanced Concrete Technology

3 Credits (2-0-2)

Concrete Making Materials Aggregates – Classification, IS specifications, Properties, Grading, Methods of combining aggregates, specified grading, Testing of aggregates. Cement Chemical composition, Hydration of cement, structure of hydrated cement, special cements, and water chemical admixtures. Concrete Properties of fresh concrete, Hardened concrete, Strength, Elastic properties, Creep and Shrinkage, Variability of concrete strength. Mix Design Principles of

concrete mix design, Methods of concrete mix design, testing of concrete. Special Concretes Light weight concrete, Fiber reinforced concrete, Polymer concrete, Super plasticized concrete, Properties and applications. Concreting Methods Process of manufacturing of concrete. Methods of Transportation, placing and curing. Extreme weather concreting, special concreting methods.

CEL505 Optimizat on Techniques in Civil Engineering

3 Credits (2-0-2)

Optimization Introduction – Formulation of LPP – Geometry of LPP and Graphical Solution of LPP – Solution of LPP: Simplex Method – Big M Method – Two Phase Method – Special cases in simple applications – Introduction to Duality Theory – Dual Simplex Method – Optimization of Transportation Problems – Project Management – Path Analysis

MAL 616 Introduction to Research Methodology

3 credits (2-1-0)

Foundations of Research, Scientific Research, Motivation, Research Objectives, Research Designs, Research Processes, Understanding Feasibility of Objectives and Processes, Qualitative and Quantitative Research Methods, Data Collection Processes, Biases in Data Collection, Data Pre-processing, Sampling Distribution and Confidence Intervals, Hypothesis Testing, Interpretation of Results, Literature Review, Technical Writing, Citations, Reference management software, Plagiarism, Software for Detection of Plagiarism.

CEL 506 Prestressed Concrete Structures

3 credits (2-0-2)

Theory and behavior – basic concept, methods of pre stressing,, loss of pre stress, Analysis of prestress, calculations of deflections , crack width; design concepts – procedures as per codes, stress distributions, limit state design criteria; design of pre stressed concrete, Analysis and design of indeterminate prestress members, tanks, pipes and composites construction and elementary idea of pre stressed concrete bridge.

CEL507 Design of Industrial structures

3 credits (2-0-2)

Elementary Plastic Analysis and Design: Introduction, Scope of plastic analysis, ultimate load carrying capacity of tension members and compression members, flexural members, and simple portal frames and design Industrial Buildings- Loads, general arrangement and stability, design considerations, design of roof trusses, industrial building frames, Design of Water Tanks Stacks and Towers.

CEL509 Functional Planning, Building Services and Management

3 credits (2-0-2)

Building Services- Water supply systems, water services to multistory buildings, building drainage and refuse collection, types of fixtures and fittings, Air Conditioning, Heating & Ventilation, lifts and acoustics, traffic analysis and selection of lifts, selection of acoustical materials, acoustics of auditorium, schools, Functional planning and maintenance of services

CEL510 Construction and Contract Management

3 credits (2-0-2)

Project cost estimation, rate analysis, overhead charges, bidding models and bidding strategies. Qualification of bidders, Owner's and contractor's estimate. Tendering and contractual procedures, Indian Contract Act 1872, Definition of Contract and its applicability, Types of contracts, International contracts, FIDIC, Conditions and specifications of contract. Contract administration, Claims, compensation and disputes, Dispute resolution techniques, Arbitration and Conciliation Act 1996, Arbitration case studies, Professional ethics, Duties and responsibilities of parties. Management Information systems

CEL511 Infrastructure Development and Management.

3 credits (2-0-2)

Infrastructure overview. Private involvement in infrastructure - The Benefits and problems of Infrastructure Privatization. Challenges in Privatization – case study. Challenges to Successful Infrastructure Planning and Implementation- Mapping and Facing the Landscape of Risks in Infrastructure Projects.

Strategies for Successful Infrastructure Project Implementation - Risk Management Framework for Infrastructure Projects, Shaping the Planning Phase of Infrastructure Projects to mitigate risks, Designing Sustainable Contracts, Innovative Design and Maintenance of Infrastructure Facilities, Infrastructure Modelling and Life Cycle Analysis Techniques.

CEL512 Environmental Chemistry

Aquatic Chemistry: Chemical equilibria and kinetics fundamentals; Acids and bases; Titrations; Acidity; Alkalinity; Buffers and buffer intensity; Chemical equilibrium calculations; pC-pH diagram. Precipitation and dissolution; Water softening and water conditioning; Langelier index; Solubility diagram; Coexistence of phases in equilibrium; Complexation of metal ions and organic complexes in natural water. Oxidation and reduction reactions stoichiometry; Redox couples; pE-pH diagrams; Redox control in natural systems; Basic concepts of organic and colloid chemistry. Soil Chemistry : Weathering reactions; Structure and surface reactions of clays and oxides; Forces at soil-water interfaces. Atmospheric Chemistry : Chemical equilibria and kinetics; Photo-dissociation and free radical reactions; Chemistry of precipitation; Acid rain

CEL513 Water Supply Engineering

Review of public water supply requirements. Sources of water-Surface and subsurface water sources Quality of water-I: physico-chemical parameters of water Quality of water-II: Water microbiology and biology Quality of water-III: water quality standards for chemical, physical and microbiological parameters, processes of treatment, Flow measurement devices - Venturi, Orifice meters, weirs, flumes and gates. Pipeline distribution system analysis and design.

CEL514 Industrial Waste Management

General Characteristics of Industrial Effluents, Effects on Environment - ISI tolerance limits for discharging industrial effluents into surface water, into public sewers and onto land for irrigation - Toxic chemicals from industry. Pretreatment of Industrial Wastewater: Necessity of pretreatment - Equalization - Segregation - Process Changes - Salvaging - By product Recovery. Removal by Reverse Osmosis, Ion Exchange, Electrodialysis, Solvent Extraction, Floatation.- Removal of Refractory Organics - Removal of Nitrogen and Phosphorus. Major Industrial Effluents: Sources, Characteristics and Treatment. Food Industries: Sugar, Dairy, Distilleries Chemical Industries: Paper and Pulp, Tanneries, Textiles, Fertilizers, Pharmaceuticals, Cement and Steel.

CEL515 Structural Dynamics

3 credits (2-0-2)

Free and forced vibration of single degree of freedom (SDOF) system, response to harmonic, periodic, impulsive and general dynamic loading, response of SDOF to earthquake, Free vibration of lumped multi-degree of freedom system, Approximate methods for obtaining natural frequencies and mode shapes, Frequency domain analysis of lumped multi-degree of freedom system using normal mode theory, Time domain analysis using numerical integration scheme, Free and forced vibration of continuous systems, Introduction to the dynamics of soil structure interaction problems.

CEL516 Principles of Bridge Engineering

3 credits (2-0-2)

Introduction- Definition, components of bridge, classification of bridges, selection of site, economical span, aesthetics consideration, necessary investigations and essential design data; Standard specifications for roads and railways bridges: Indian Road Congress Bridge Code for specifications and loads,: Various types of R.C.C. bridges (brief description of each type), Design Consideration for R.C.C.Bridges and culverts.: Design of Tee beam bridge, Various types of steel bridges (brief description of each), Design Consideration for Steel Bridges design of plate girder bridges. Hydraulic & Structural Design of piers, abutments, wing wall and approaches: Brief descriptions of bearings, joints, articulation and other details. Bridge foundation-Variety types, necessary investigations and design criteria of well foundation.

CEL 517 Theory of Elasticity and Plasticity

3 credits (2-0-2)

Concept of Elasticity - plane stress and plane strain analysis, two dimensional problems in rectangular coordinates - solution by polynomials - Saint- Venant's principle-determination of displacements-bending of simple beams: application of fourier series for two dimensional problems - gravity loading- Two dimensional problems in polar, analysis of stress and strain in three dimensions - differential equations of equilibrium - principle of super position - uniqueness of solution - the reciprocal theorem, torsion of prismatic bars - bars with elliptical cross sections – other elementary solution - membrane analogy - bending of prismatic bars, theory of plasticity - introduction concepts and assumptions - yield criterions.

CEL519 Construction Economics & Finance

3 credits (2-0-2)

Benefit-cost analysis, Replacement analysis, Break even analysis. Risks and uncertainties and management decision in capital budgeting. Taxation and inflation. Work pricing. Working capital management, financial plan and multiple source of finance. International finance, Budgeting and budgetary control, Practical problems and case studies, Project cash flow, Methods, Practice, Role of Lender's Engineer. Financial Planning, Budget –Budgetary control system.

CEL520 Shoring, Scaffolding and Formwork

3 credits (2-0-2)

Planning of construction work, site equipment required, Calculation of labour constants - Formwork hours - Labour Requirement - Overall programme - Detailed programme – Costing. Materials accessories proprietary products – finish materials, scaffolding material, design of forms – analysis of forces, building and erection of formwork, formwork for domes, tunnels etc.

CEL521 Geo-Environmental Engineering

Sources and effects of subsurface contamination; Physical, chemical and biological characteristics of solid wastes; Soil waste interaction; Contaminant transport; Laboratory and field evaluation of permeability; Factors affecting permeability; Waste disposal on land case study; Landfills and impoundments types; Silting criteria; Waste containment principles; Types of barrier materials; Planning and design aspects relating to waste disposal in landfills; Soil exploration at contaminated site; Vertical cutoff walls; Cover system; Recovery well system; Bioremediation of soil ; In situ Bioremediation of ground water; Soil washing; Monitoring around landfills; Detection, control and remediation of subsurface contamination; Reclamation of old waste dumps; Regulations; Case studies; Engineering properties and geotechnical reuse of waste materials.

CEL522 Global Climate Change Adaptation and Mitigation

Introduction to global climate; Global climatic models; Methods of reconstructing climate; Quaternary climates, sea level changes, glacial/interglacial cycles; Geological records of climate change, sedimentology, stable isotopes, geochemistry; Geochronology – relative and numerical methods; Vegetation dynamics, migration history, response of vegetation to climatic reversals

CEL523 Waste Water Engineering

Wastewater Characteristics, Standards of Disposal, Treatment Objective and, Strategies, Layouts of Primary, Secondary and Advanced Treatment Units. Design Of Preliminary And Primary Treatment Operations, Biological Treatment Processes: Types, Kinetics of Plug Flow and Completely Mixed Systems. Aerobic and Anaerobic Sludge Digestion Processes, Design of Digester Tank, Sludge Dewatering, Ultimate Disposal, Sludge Drying Beds, Other Methods of Sludge Treatment.

CEL524 Matrix Methods of Structural Analysis

3 credits (2-0-2)

General Introduction. A Few Historical Remarks. Matrix Methods of Analysis of Skeletal Structures. Methods of Analysis. Displacement Method: Stiffness Relationships. The Matrix Displacement Approach, Introduction, Stiffness Matrix of a Bar Element subjected to Axial Force. Co-ordinate Transformations. Global Stiffness Matrix. Application to Pin-Jointed Frames. Stiffness Matrix of a Beam Element. Application to Continuous Beams. Matrix Displacement Analysis of Planar Rigid-Jointed Frames. Neglect of Axial Strain in the Analysis of Planar Rigid-Jointed Frames. Other Kinds of Loading & Other Kinds of Frames. Co-ordinate Transformations. Element Stiffness Matrix & its Application. Matrix Displacement Analysis of Three-Dimensional Structures. Co-ordinate Transformations. Application to Space Trusses & Space Frames.

CEL525 Prefabricated Structures

Types of prefabrication, prefabrication systems and structural schemes- Disuniting of structures- Structural behaviour of precast structures. Handling and erection stresses - Application of prestressing of roof members; floor systems two way load bearing slabs, Wall panels, hipped plate and shell structures. Dimensioning and detailing of joints for different structural connections; construction and expansion joints. Production, Transportation & erection- Shuttering and mould design Dimensional tolerances- Erection of R.C. Structures, Total prefabricated buildings. Designing and detailing prefabricated units for 1) industrial structures 2) Multistorey buildings and 3) Water tanks, silos bunkers etc.,4) Application of prestressed concrete in prefabrication

CEL526 Theory of Plates and Shells

3 credits (2-0-2)

Bending theory of flat plates: thin plates, Kirchoff theory - strain displacement relations, stresses and stress resultants, constitutive equations, equilibrium equations, boundary conditions, derivation of theory from principle of virtual work, rectangular plates-solution by double Fourier series, circular plates Classical theory of shells – Membrane theory of shells: equilibrium equations, applications to shells of revolution under axisymmetric loads, applications to cylindrical shells under asymmetric loads, strain-displacement relations , application in calculation of displacements; Bending theory of shells: kinematic assumptions and strain-displacement relations, stress measures and equilibrium

CEL527 Quality and Safety in Construction

3 credits (2-0-2)

Introduction to quality management. Planning and control of quality during design of structures. Quality assurance during construction. Inspection of materials and machinery. Preparation of quality manuals, check-list and inspection report. Establishing quality assurance system. Quality standards/codes in design and construction. Concept and philosophy of total quality management (TQM). Training in quality and quality management systems (ISO-9000). Concept of safety. Factors affecting safety: Site management with regard to safety recommendations. Training for safety awareness and implementation. Formulation of safety manuals. Safety legislation, standards/codes with regard to construction. Quality vs Safety. Case Studies

CEL528 Strategic Planning and Management

3 credits (2-0-2)

Emerging technology-strategy relationship in the large corporation. Global technology comparison. Technology Information. Criticality of technology for growth, core competencies, R&D productivity, Generic competitive technology strategies. Corporate R&D, Strategic technology management process, relationship between technology strategy and corporate strategy. Strategic shifts and resource commitments, technology leadership. SWOT analysis for technology, Matching Business Portfolio and Technology Portfolio, Technology- Market matrix. Innovation and entry strategy.

CEL529 Flexible Systems Management

3 credits (2-0-2)

Emerging management paradigms: Total Quality Management, Business Process Reengineering, Learning Organisation, World Class Organisation, Flexibility in Management. Concept of systemic flexibility. Liberalisation, Globalisation and change. New Organisation forms. Concept and dimensions of Systemic flexibility. Managing paradoxes. Methodology and

tools of flexible systems management. Underlying values, and guiding principles, Case Analysis using SAPLAP framework. SAP-LAP models and linkages

CEL530 Environmental Policy and Legislation

3 credits (2-0-2)

Introduction: Economics and Environmental Policy Theory of externalities: Relevance. Externalities: definitions, significant types, and optimal pricing conditions, formal analysis Uncertainty and choice of policy instruments: price or quantity controls. Market imperfections and the number of participants. Detrimental externalities, and nonconvexities in the production set, optimal pricing of exhaustible resources Introduction to design of Environmental policy. Efficiency without optimality: the charges and standard approaches Marketable emission permits for the protection of the environment. Stochastic influences, direct controls, and taxes. Taxes vs subsidies: a partial analysis. Environment protection and the distribution of income International environmental issues, National and local standards for environmental quality

CED 601 Dissertation Phase - I

4 credits (0-0-8)

Part-I of the dissertation will cover the problem identification followed by literature review, data collections and data generations and identification of the tool of analysis, simulation and modeling and hypothesis for the problem solving, some basic trail studies.

CED 602 Dissertation Phase – II

12 credits (0-0-24)

Part-II of the dissertation will cover the actual detailed experimentation, simulation, modeling, result generation and reaching to the desired goal set in Part-I. Report writing and publication.

CEL603 Finite Element Analysis

3 credits (2-0-2)

Introduction to Finite Element Method. Brief History of the Development. Advantages & Disadvantages of Finite Element Method. Finite Element Method- The Displacement Approach. Foundations of the FEM- Energy Principles. One Dimensional Finite Element. Stiffness Matrix for the basic Bar & Beam Element Representation of Distributed Loading. The Assembly Process within the PMPE Approach. Element Stresses. Shape Functions & Interpolation Polynomials. Refined One Dimensional Element. Finite Elements for Two Dimensional Planar Bodies. Triangular Elements for Plane Stress or Strain Conditions. Higher Order Triangular Elements. Rectangular Elements for Plane Stress or Strain

Conditions. Higher Order Rectangular Elements, Lagrange Element Family. Finite Elements for Three Dimensional Analysis. Tetrahedral Elements. Higher-Order Tetrahedral. Rectangular Hexahedral Elements. Higher-Order Rectangular Hexahedra, Lagrange Element Family. Advanced Concepts In The Formulation of Two & Three Dimensional Elasticity Elements. Natural Co-ordinates. Area or Triangular Co-ordinates. Serendipity Rectangles & Hexahedra. The Isoparametric Concept. Properties of Isoparametric Elements. Numerical Integration. Finite Elements For Plate Bending Analysis. A 12-Degree-Of-Freedom Rectangular Element (R1). Triangular Elements

CEL604 Design of Tall Structures

3 credits (2-0-2)

Design philosophy – Loading - Sequential loading, materials. High risk behaviour, Rigid frames, braced frames, infilled frames, shear walls, coupled shear walls, wall – frames, tubulars, cores, futrigger - braced and hybrid mega system. Approximate Analysis, Accurate Analysis and Reduction Techniques - Analysis of building for member forces - drift and twist - Computerised general three-dimensional analysis. Structural elements- design, deflection, cracking, prestressing, shear flow Design for differential movements, creep and shrinkage effects, temperature effects and fire. Overall buckling analysis of frames, wall – frames–second order effects of gravity of loading– simultaneous first order and P-delta analysis Translational - torsional instability, out of plum effects

CEL606 Project Planning and Control

3 credits (2-0-2)

Work study, work break down structure, time estimates, application of CPM/PERT, statical concepts, Man-Material-Machinery-Money optimization, scheduling, monitoring, updating. Cost function, time-cost trade off, resource planning-levelling and allocation. Resources – based network, crashing, master network, interface activities, and dependences, line of balancing techniques, application of digital computer. Material management- purchase management and inventory control, ABC analysis. Human resource management

CEL607 Advanced Methods for management research

3 credits (2-0-2)

Problem conceptualization and definition. Hypothesis formulation. Selection of Research Methods, Flexible Systems Methodology for preparing research design, Scaling, sampling methods, Managing oral evidence, Questionnaire design, validation and pretesting. Interview design, Case study, Field experiments, Quasi experiments. Qualitative research methods. Statistical techniques and implementation of research plan using statistical packages.

CEL609 Solid and Hazardous Waste Management

3 Credits (2-0-2)

Municipal Solid Waste: Generation, Rate Variation, characteristics (Physical, Biological and Chemical); Management Options for Solid Waste, Waste Reduction at the Source, Collection techniques, Materials and Resources Recovery / Recycling. Transport of Municipal Solid Waste, Routing and Scheduling, Treatment, Transformations and Disposal Techniques (Composting, Vermi Composting, Incineration, Refuse Derived fuels, Landfilling). Norms, Rules and Regulations. Economics of the on-site v/s off site waste management options. Integrated waste management.

CEL610 Environmental Hydraulics and Hydrology

3 credits (2-0-2)

Basic concepts of open channel flows, conservation laws, continuity equation, momentum equation, Application of momentum and energy equations Critical flow, its properties and application; location of critical flow and its computation Uniform flow, flow resistance, equations of flow resistance, computation of normal depth, Gradually varied flow, governing equations classification of water surface profiles Rapidly varied flow, application of conservation laws, channel transition, supercritical flow, Hydraulic Jump Hydrologic cycle and its interaction with human activity, Hydrologic processes, Hydrologic analysis, Hydrologic statistics. Transport processes, diffusion phenomena, Fick's 1st and 2nd Laws of diffusion, Advection diffusion equation, Turbulent diffusion and dispersion mixing in rivers Porous medium flow, Approximation of Dupuit, Contaminant transport, Saltwater intrusion into aquifers, Non aqueous phase liquid (NAPL) in groundwater, aspects of numerical modelling

CEL611 Environmental Modeling and Simulation

3 credits (2-0-2)

Sources and effects of water pollutants, introduction to principles of water quality modeling, distribution of water quality in rivers, estuaries and lakes, contaminant transport in groundwater, water quality modeling applications and discussion of case studies. Sources and effects of air pollutants, air quality standards, and emission inventory, meteorological aspects related to air pollution, air quality modeling and its application, trans-boundary air pollution.