Centre for Pollution Control and Environmental Engineering
MTech Environmental Engineering and Management

Semester I

Hard core courses			*Credits*
CPET	611	Theory to Environmental sampling and analysis	4
CPET	612	Ecology and Environmental Biotechnology	4
CPET	613	Physico-chemical treatment of water and wastewater	4
CPET	614	Air and noise pollution and control	4
CPET	615	Solid and hazardous waste management	4
Soft core courses			
CPET	616	Environmental analysis laboratory	2
			Total 22

Semester II

Hard core courses			*Credits*
CPET	621	Biological treatment of wastewater	4
CPET	622	Environmental impact assessment and management	4
Soft core courses (atleast three to be taken)			
CPET	623	Environmental Toxicology and Risk Assessment	4
CPET	624	Air and surface water quality modeling	4
CPET	625	Industrial waste management	4
CPET	626	Transport of water and wastewater	4
			Total 20

CPET	711	Summer Training	3

Semester III

CPET	712	State-of-the-art review and seminars		3
CPET	714	Project work : preparatory and consolidation phase		8
			Total:	**14**

Semester IV

CPET	721	Project work: advanced phase – thesis and viva voce		16
			Total:	**16**
		Total credits:		**72**

Hard core

CPET 611 Theory to Environmental Sampling and Analysis

4 credits

Unit 1: General considerations (12contact hours)

Qualitative and quantitative analysis; accuracy and precision, errors, repeatability and reproducibility. Significant figures. Different expressions of concentration and their equivalence. Primary and secondary standards, and the do's and don'ts associated with their use. Measuring glassware and Clean/Good laboratory practice.

Unit 2: Sampling techniques (12contact hours)

Techniques for the collection of grab/pooled samples of water, air soil, and solid waste; sampling of micro and macro flora and fauna; preservation and storage of samples; maximum holding time; chain of custody of records

Unit 3: Characterization of water and wastewater (10contact hours)

pH, EC, acidity, alkalinity, hardness, sulphate, iron, DO, BOD and COD, solids, MPN

Unit 4: Characterization of air, soil, and solid wastes (12contact hours)

SPM, NOx, SOx, CO, dioxin, and other air pollutants; noise pollution monitoring; analysis of TS, VS, and major/minor elements in soil and solid waste.

Unit 5: Analytical instruments (14 contact hours)

Principle and functioning of Conductivity meter, pH meter, spectrophotometer – Beer Lambert's Law, molecular and atomic spectroscopy; absorption, emission and fluorescence spectrophotometers; Chromatography: types, chromatogram, resolution, column chromatography: types of column, Gas Chromatography – principle, functioning, types of detectors.

Recommended reading:

- *Standard Methods for the Examination of Water and Wastewater, American Public Health Association,* *Water Works Association, Water Environment Federation, 2012.*
- *Sampling and Analysis of Environmental Chemical Pollutants, E. Popek, 2nd Edition, A Complete Guide, Elsevier, 2017*
- *Fundamentals of Environmental Sampling and Analysis,* Z. Chunlong, Wiley Interscience, Germany 2011.
- *Environmental Chemistry, Stanley E.Manahan, Eighth Edition, CRC Press, London, 2005.*

Hard core

CPET 612 Ecology and Environmental Biotechnology

4 credits

Unit 1: Ecology (12 contact hours)

Biotic and abiotic components in the environment and their interaction. Definition, characteristics, and functions of a typical ecosystem. Types of ecosystems. Energy flow and material cycling. Trophic structure, food chain, food web ecological pyramids. Energy flow and material cycling, Biogeochemical cycling of carbon, nitrogen, phosphorous, and sulphur. Ecological succession. Ecological efficiency. Concepts of ecological engineering.Principles pertaining to limiting factors: Liebig's law of the minimum, Shelford's law of tolerance.

Unit 2: Systematics, cell structure and function (10 Contact hours)

Classifications of living organisms and their basis. Prokaryotic and eukaryotic cells: cell structure and function, cell cycle and cell division; mitosis and meiosis.

Unit 3: Microbiology of biological treatment processes (12contact hours)

Microbial diversity, microbial growth. Aerobic and anaerobic microorganisms; attached and suspended growth processes, microorganisms in water and wastewater; indicator organisms and their quantification. Algae in water supplies: problems and control.

Unit 4:Biotechnological pollution control methods (12contact hours)

Desulphurization of coal and oil, Biosubstitution, Composting: mechanism, operation, monitoring, and control of composting process.Animal-based solid-waste treatment systems: vermicomposting and termigradation. Genetic manipulation for developing pollution monitoring and control systems, Macrophyte-based wastewater treatment systems. Algal effluent treatment systems and their limitations.

Unit 5: Biodegradation and bioremediation technologies (14contact hours)

Principles of biodegradation, requirements of biodegradation; nutritional factors, chemical structure – environmental and biological factors, effect of pollutant chemical structure on biodegradation
Bioremediation –contamination availability, microbial catabolism of organic pollutants – catabolic enzymes, properties, detoxification reactions
Phytoremediation: phytoextraction, rhizofiltration, phytostabilisation, phytodegradation and phytovolatilisation. Phytomining.

Recommended reading:

- *Environmental Pollution Control Microbiology, Ross E.McKinney, Marcel Dekker, USA, 2004.*
- *Environmental Biotechnology theory and application, G. M. Evan, J. C. Furlong, John Wiley & Sons, Ltd, 2003*
- *Fundamentals of Ecology,* P. Odum and G. W. Barrett, Brooks/Cole, UK, 2011
- *Environmental Biology for Engineers and Scientists, David A. Vaccari, Peter F.Strom, James E.Alleman, John Wiley & Sons, Inc., Hoboken, New Jersey, 2006.*

Hard Core

CPET 613 Physico-chemical treatment of water and wastewater

4 credits

Unit 1: Introduction

Overview of unit operations and unit processes associated with water and wastewater treatment. Schematic flow diagrams.Treatment requirements and standards.

Unit 2: Sedimentation and floatation

Sedimentation: types of settling (Types 1-4), computation of settling velocities, performance of sedimentation tanks. Design of sedimentation tanks.Dissolved air floatation.

Unit 3: Surface and depth filtration

Screening: types of screens, estimation of head loss due to flow-through screens. Sand filtration: rapid sand and slow sand filters, filter operation, Carmen-Kozeny equation-computation of head loss, backwash hydraulics. Membrane filtration: membrane process classification, membrane operation, recovery rate, membrane area calculation.

Unit 4: Aeration and adsorption

Aeration: two film theory, oxygen transfer rates, factors affecting transfer rates, application of correction factors, aerator performance. Adsorption: adsorbents used in water and wastewater treatment, adsorption isotherms.

Unit 5: Coagulation, flocculation, precipitation and disinfection

Coagulation: destabilization of colloids, types of coagulants. Flocculation.Mixing devices for coagulation and flocculation: types, velocity gradients and power requirement. Precipitation: solubility product and nucleation. Disinfection: characteristics of an ideal disinfectant, types of chemical disinfectants, factors influencing disinfection. Disinfection with chlorine: breakpoint chlorination.

Recommended reading:

- *Wastewater Engineering – Treatment and Reuse,* Metcalf & Eddy, Inc., Revised by G. Tchobanoglous, F. L. Burton, and H. D. Stensel, 4th edition. Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
- *Unit Operations and Processes in Environmental Engineering,* T. D. Reynolds, P. Richards, 2nd edition. PWS Series in Engineering, Boston, 1996.
- *Water and Wastewater Engineering***,** M. L. Davis, McGraw-Hill Education, 2010.
- *Physical–Chemical Treatment Of Water And Wastewater,A. P. Sincero and G. A. Sincero.* IWA Publishing, Boca Raton:CRC Press, 2003.
- *Fair, Geyer, and Okun's, Water and Wastewater Engineering: Water Supply and Wastewater Removal,* N. K. Shammas,L. K. Wang.John Wiley & Sons, 3rd Edition, 2010.

Hard core

CPET 614 Air and Noise Pollution and Control

4 credits

Unit 1: Air pollution and its effects (8 contact hours)

Air Pollutants: sources, classification, effect on animal health, vegetation, materials, and atmosphere. Chemical and photochemical reactions in the atmosphere and their effects: smoke, smog, acid rain and ozone layer depletion. Green house gases, global warming and its implications.Global atmospheric and climate change, Heat island effects. Air pollution legislation and standards.Issues of indoor air quality.

Unit 2: Air pollution dispersion and modeling (16 contact hours)

Meteorology and air pollution: atmospheric stability and inversions, behavior of air pollutant plumes as effected by nature of source, meteorology, obstacles and terrain; maximum mixing depth. Effluent dispersion theories: models for point and line sources based on Gaussian plume dispersion and their limitations: Box model for area sources. Prediction of effective stack height: Holland's and Briggs equations.

Unit 3: Particulate emission and its controls (16 contact hours)

Reduction in the generation of particulate matter by process modification, good house keeping, and other means. Control of SPM: concepts and the design elements of gravitational settlers, centrifugal collectors, wet collectors, electrostatic precipitators, fabric filters, condensers.

Unit 4: Gaseous emissions and its control (16 contact hours)

Sources of air pollution from fossil fuels and industrial processes.Prevention and reduction of emissions, cleaner production. Carbon sequestration techniques, Air pollution control by absorption, adsorption, condensation, incineration, bioscrubbers, biofilters, etc. Design and performance equations, case studies.

Unit 5: Noise pollution and its control (8 contact hours)

Generation and propagation of sound; sound power, sound intensity and sound pressure levels; plane, sources; outdoor and indoor noise propagation; psycho-acoustics and noise criteria. Noise problem analysis- OSHA regulations, Annoyance rating schemes; noise standards and limit values. Effects of noise on health.Noise pollution measuring instrumentation and monitoring procedure.Noisepollution prevention and control.

Recommended reading:

- *Introduction to Environmental Engineering and Science*, G. M. Masters, Prentice-Hall of India, New Delhi, 2003.
- *Air Pollution Control Engineering,* N. de Nevers, 2nd Edition. McGraw Hill, Singapore, 2000.
- *Environmental Noise Pollution*, P. E. Cunniff, McGraw Hill, New York, 1987.
- Air pollution control equipments, Louis Theodore, Wiley Publication. Year
- *Fundamentals of Air pollution,* R. W. Boubel, D. L. Fox, and A. C. Stern, AcademicPress, NY, 1994.

Hard core

CPET 615 Solid and Hazardous Waste Management

4 credits

Unit 1: Introduction (6 contact hours)

Solid and hazardous wastes- definition, types, sources, and impact on environmental health. Elements of integrated waste management- Legislations on management and handling of solid wastes, construction waste ,biomedical wastes, E-waste ,Plastic waste, and other hazardous wastes.Swatch bharat Mission.

Unit 2: Characterization and Source reduction ,(14 contact hours)

Waste generation rates- characteristics- physical, chemical, biological properties, hazardous characteristics-TCLP test- Concepts of waste reduction, recycling and reuse-Markets and product for recycled material - Public participation and the role of NGOs-Waste exchange programmes – Extended Producer Responsibility- Case studies on awareness programmes related to 3Rs .

Unit 3: Storage, collection and transport (20 contact hours)

Handling and segregation of waste at source - Storage and collection of municipal solid wastes- Analysis of collection systems- Needs for transfer and transport- Development and implementation of material recovery facility- Storage, Labelling, handling and transport of hazardous waste- Case studies on storage, collection and transportofurban and rural systems.

Unit 4: Waste treatment methods (20 contact hours)

Material separation and processing technologies – Biological and chemical conversion methods - Composting- system- Thermodynamic and biological fundamentals- Kinetics-Feed conditioning-Product stability-Odour management. vermicomposting, termigradation, - waste to energy recovery options- incineration- solidification and stabilization of hazardous wastes- treatment of biomedical wastes- Health and environmental considerations of operation facilities.

Unit 5: Waste Disposal (12contact hours)

Waste Disposal options- Concepts of waste disposal – NIMBY, NIABY NIMTO, LULU, BANANA. ALARA, YIMBY. Disposal in landfills- Landfill classification- Site selection-design and operation of sanitary landfills, secure landfills and landfill bioreactors-Leachate and landfill gas management-landfill closure and environmental monitoring-rehabilation of open dumps- landfill remediation.

Recommended reading:

- *Handbook of Solid Waste Management,* F. Kreith, G. Tchobanoglous, 2nd edition.
- CPHEEO, *Manual on Municipal Solid waste management,* Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2000.
- *Solid Waste Management with Earthworms,* Abbasi, S. A. and E. V. Ramasamy Discovery Publishing House, New Delhi, 2000.
- *Hazardous Waste Management,* M. D. LaGrega, P. L Buckingham, J. C. Evans, 2nd edition. McGraw-Hill, 2000.
- *The practical handbook of compost engineering , Roger T.Haug, Lewis Publishers,1993*

Hard core

CPET 616 Environmental Analysis Laboratory

2 credits

Determination of pH, EC, acidity, alkalinity, hardness, sulphate, iron, BOD and COD, solids, MPN and metal.

Analysis of soil for pH, EC, C,N,P,K, CEC.

Determination of SPM, NOx, and SOx of ambient air.

Sampling of terrestrial flora and fauna by quadrat and line transect methods. Sampling and identification of plankton in water samples.

Recommended reading:

- *Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Water Works Association, Water Environment Federation, 2012.*
- *Practical Environmental Analysis, M. Radojevic and V.N.Bashkin, RSC Publishing, 2nd Edition, 2006.*
- *Methods in Environmental Analysis: Water Soil and Air,* P. K. Gupta, Agrobios, Jodhpur, 2000.
- *Water Quality, Sampling and Analysis,* S. A. Abbasi, DPH, New Delhi, 1998.

Hard Core
CPET 621 Biological treatment of Wastewater
4 credits

Unit 1: Classification and kinetics

Aerobic and anaerobic fermentation. Suspended and attached growth systems. Rates of substrate utilization and biomass growth in suspended and attached growth systems.Types of reactors.

Unit 2: Aerobic wastewater treatment

Aerobic suspended growth processes: activated sludge process and its variants, sequencing batch reactors.. Modeling and design of activated sludge processes. Aerobic attached growth process: trickling filters, rotating biological contactors. Combined aerobic treatment processes.

Unit 3: Anaerobic wastewater treatment

Anaerobic suspended growth processes: complete mix process, anaerobic contact process, anaerobic sequencing batch reactors. Anaerobic attached growth processes: upflow and downflow attached growth processes, expanded-bed reactor, fluidized bed- reactor. Anaerobic sludge blanket reactors.Facultative ponds and lagoons.

Unit 4: Biological nutrient removal

Biological nitrogen and phosphorous removal: microbiology, stoichiometry, growth kinetics, and environmental factors.

Unit 5: Biological sludge treatment

Sludge thickening: design of gravity thickening beds. Sludge drying beds: bed area and bed layers dimensions. Filter (belt) press. Anaerobic sludge digestion: low and high rate digestion.

Recommended reading:

- *Manual on Sewerage and Sewage Treatment.* CPHEEO, Ministry of Urban Development, GoI, New Delhi, 1993.
- *Wastewater Engineering – Treatment and Reuse,* Metcalf & Eddy, Inc., Revised by G. Tchobanoglous, F. L. Burton, and H. D. Stensel, 4th edition. Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
- *Fair, Geyer, and Okun's, Water and Wastewater Engineering: Water Supply and Wastewater Removal,* N. K. Shammas,L. K. Wang.John Wiley & Sons, 3rd Edition, 2010.

Hard core

CPET 622 Environmental Impact Assessment and management

4 credits

Unit 1: Overview (6 contact hours)

Environmental Impact Statement (EIS), Environmental Risk Assessment (ERA). Legal and Regulatory aspects of EIA in India,.EIA Notifications.Environmental laws.Terms of Reference in EIA.Issues in EIA; national, cross sectoral, social, and cultural.

Unit 2: Components and methods of EIA (20 contact hours)

Components: screening, setting, analysis, prediction of impacts - mitigation. Matrices - Networks - Checklists. Importance assessment techniques - cost benefit analysis - analysis of alternatives - methods for Prediction and assessment of impacts - air - water - soil - noise - biological - cultural - social - economic environments. Standards and guidelines for evaluation. Public Participation in environmental decision making: public hearings.

Unit 3: Quality control, documentation and monitoring of EIA (12 contact hours)

Trends in EIA practice and evaluation criteria - capacity building for quality assurance. Expert System in EIA - use of regulations- Document planning - collection and organization of relevant information - use of visual display materials – team writing - reminder checklists. Preparation of environmental Management Plan.

Unit 4: Environmental management systems and audit (20 contact hours

Introduction to environmental management system (EMS). Principles & elements of successful environmental management; ISO principles; creating an environmental management system in line with ISO: 14000. Benefits of an environmental management system. Principles and elements of successful environmental management: leadership, environmental management planning, implementing an environmental management system, measurement & evaluations required for an environmental management system, environmental management reviews & improvements. Legal and regulatory concerns; Integrating ISO 9000 & ISO 14000.TQM.**)**Concepts of environmental audit, objectives of audit. Management of audits: waste management contractor audits.

Unit 5: Industrial ecology (6 contact hours)

Industrial metabolism –Dematerilization and decarbonization- Eco design- Life cycle planning, design and assessment-Industrial symbiosis- Product stewardship- Product oriented environmental policy- Eco-efficiency.

Recommended reading:

- Environmental Impact Assessment, L. W. Canter, McGraw Hill, New York, 1996.
- Handbook of Environmental Impact Assessment Vol I and II, J. Petts, Blackwell Science, London, 1999.
- The Theory and the Practice of Environmental Impact Assessment, S. A. Abbasi and N. Ramesh, DPH, New Delhi, 2003.
- *Complete Guide to ISO 14000,* R. B. Clements. Simon & Schuster, 1996.
- EIA Notifications, GoI.

Soft core

CPET 623 Environmental Toxicology and Risk Assessment

4 credits

Unit 1: Introduction to ecotoxicology (10 contact hours)

Principles of ecotoxicology, toxicants in the environment types of toxic substances – degradation and non-degradation; factors influencing toxicity;sources, entry routes, cycles and residence time of toxic substances, transport through food chain – bioaccumulation and biomagnification

Unit 2: Evaluation of toxicity (12 contact hours)

Methods used to assess toxicity; concepts of bioassays – types, characteristics, importance and significance; threshold limit values, LC50, LD 50, dosimetry concept, lethal, sublethal and chronic tests; dose response curves; methods of toxicity evaluation at cellular and molecular level by in vitro and in vivo methods

Unit 3: Toxicity indicators (12 contact hours)

Monitoring approaches – indicator populations and indicator species; model ecosystem – microcosms and mesocosms; biomonitoring and bioindicators – concepts and approaches, advantages and disadvantages; molecular markers to toxicants – metabolites as indicators, protein induction, cytochrome P450 enzymes, stress proteins, metalothioneins

Unit 4: Occupational hazards and safety (12 contact hours)

Environmental and occupational safety, occupational exposure, occupational hazards and diseases; control of toxic materials and protection measures; toxicity of biohazard; occupational health and safety policy

Unit 5: Risk assessment (14 contact hours)

Epidemiological diseases due to pollution; health effect of cosmetics and drugs; health risk assessment of toxic chemicals; ecological risk assessment in environmental management; human health risk assessment; detoxification in human body; detoxification mechanisms; organs of detoxification; education and training in health hygiene

Recommended Reading:

- *Environmental determinants of human health: molecular and integrative toxicology., J.M.Pacyna ., E.G. Pacyna (Eds.), Springer International Publishing, Switzerland, 2016.*
- *Ecosystem and human health: toxicology and environmental hazards, Richard B. Philip, third edition, CRC Press, Boca Raton, 2013*
- *A guide to practical toxicology: Evaluation, prediction, and risk, Adam Woolley, Second edition, Informa Healthcare USA, Inc., USA, online publication 2012.*
- *Environmental risk assessment: a toxicological approach, T.Simon, CRC Press, 2016*

Soft Core
CPET 624 Air and surface water quality modeling
4 credits

Unit: I Fundamentals of mass and energy balance

Mass and energy – laws of conservation of mass and energy. Steady state systems, non-steady state systems. Mass balance – mass-balance principle.Advection, diffusion, dispersion.Setting up mass balance equations. Energy balances.

Unit: II Reaction kinetics and reactors

Reactions, reaction rates, reaction rate coefficients.Ideal reactors - ideal flow in complete mix reactors, plug flow reactors, performance equations. Non-ideal reactors - causes for non-ideal flow, tracer studies, modeling non-ideal flows. Process kinetics modeling.

Unit: III Surface water quality modeling

River water quality modelling - The Streeter-Phelps equation and its limitations. Lake water quality modelling.

Unit: IV Air quality modeling

Models for point and line sources based on Gaussian plume dispersion.Area source models.Indoor air quality modeling.

Unit: V Software

Environmental systems modeling with various tools: QUAL, SUTRA, DGADIS, HEGADIS, etc.

Recommended reading

- *Environmental Modeling: A Practical Introduction*, M. J. Barnsley. CRC Press,1st edition, 2007.
- *Surface Water quality modeling,* S. C. Chapra. McGraw-Hill., New York, 1997.
- *Handbook of Environmental and Ecological Modelling*, B. Halling-Sorensen, S. N. Nielsen and S. E. Jorgensen. Lewis Publishers Inc, 1995.
- *Fundamentals of Atmospheric Modelling*, M. Z. Jacobson, Kluwer Academic Press, 2002.
- *Wastewater Engineering - Treatment and Reuse,* Metcalf & Eddy, Inc., Revised by G. Tchobanoglous, F. L. Burton, and H. D. Stensel, 4th edition. Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
- *Introduction to Environmental Engineering and Science,* G. M. Masters, W. P. Ela.Prentice Hall India Learning Private Limited; 3rd edition, 2008.

Soft Core
CPET 625 Industrial Waste Management
4 credits

Unit 1: Overview

Major industries (dairy, distillery, sugar, textile, tannery, pulp & paper, metal finishing, petroleum refining, pharmaceutical and fertilizer, thermal power), their water requirements, and the typical quantities and characteristics of waste generated. Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal. Treatment costs.

Unit 2: Source reduction, recycling, and reuse

Waste minimization with process modification and cleaner production techniques. Benefit-cost optimization with common effluent treatment plants. Recycling, reuse, and recovery strategies. Process optimization for waste minimization. Flowsheet analysis. Energy and resource audits for efficient usage and conservation. Waste audits, emission inventories, and waste management hierarchy. Case studies of re-engineering for waste minimization. Concept of zero liquid discharge.

Unit 3: Industrial wastewater treatment

Effluent mixing, equalization, neutralization. Separation of oil and grease. Removal of pollutants by flotation, screening, flocculation, sedimentation, precipitation, adsorption, membrane filtration, ion exchange. Biosorption and biodegradation techniques.

Unit 4: Industrial sludge management

Sludge management: characterization, thickening, conditioning, digestion, dewatering and disposal.

Unit 5: Case studies on waste treatment from various industries

Case studies of waste generation from various industries and their treatment: dairy, distillery, sugar, textile, tannery, pulp and paper, metal finishing, iron and steel, petroleum refining, pharmaceutical, fertilizer and thermal power generation

Recommended reading:

- *Industrial Water Pollution Control,* W.W. Eckenfelder. Mc-Graw Hill, 1999.
- *Wastewater Treatment for Pollution Control,* S. J. Arceivala, Tata McGraw Hill, 1998.
- *Pollution Prevention and Abatement Handbook – Towards Cleaner Production,* World Bank Group, World Bank and UNEP, Washington D.C, 1998.
- *Waste Treatment in the Process Industries,* edited by L. K. Wang, Y-T Hung, H. H. Lo, C. Yapijakis. CRC Press, Taylor and Francis Group, Boca Raton, 2006.
- *Industrial Waste Treatment: Contemporary Practise and Vision for the Future*, *N. L. Nemerow,* Elsevier Science & Technology Books, 2006.
- *Industrial Wastewater Management, Treatment, and Disposal*, WEF Manual of Practice No. FD-3, Third Edition, 2008.

Soft core

CPET 626 Transport of Water and Wastewater

4 credits

Unit 1: Fluid flow (14 contact hours)

Fluid flow: continuity, energy and momentum principles ; frictional head losses in free and pressure flow, major and minor head losses and their estimation. Pumping of fluids and selection of pumps. Flow measurement.

Unit 2: Water transmission and distribution (14 contact hours)

Urban and rural water supply, emergency responses, Planning factors. Water transmission main design. Pipe material and economics; water distribution pipe networks, and methods for their analysis and optimisation. Laying and maintenance of pipelines; in situ: lining, appurtenances and corrosion prevention. Application of softwares.

Unit 3: Wastewater collection and conveyance (16 contact hours)

Design of sanitary sewer; partial flow in sewers, economics of sewer design ; sewer appurtenances ; material, construction, inspection and maintenance of sewers ; design of sewer outfalls: mixing conditions; conveyance of corrosive wastewaters.

Unit 4: Storm water drainage and water reservoir management (10 contact hours)

Run-off estimation, rainfall data analysis, storm water drain design. Rainwater harvesting. Planning ,maintenance, design ,storage and restoration techniques of water reservoir, Traditional knowledge on managements of water resources, Role of public and government. Case studies.

Unit 5: Special water supply and sanitary systems (8 contact hours)

Emergency sanitary system, Immediate and short term long term sanitation in emergencies- Basic types of toilets- Low cost toilets- Selections of toilets - Public gathering- gender based toilets in buildings- Source diversion, challenges in transportation systems- Noise reduction in water conveyance systems.

Recommended reading:

- *Manual on water supply and Treatment.* CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1999.
- *Manual on Sewerage and Sewage Development.* CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1993.
- *Practical Hydraulics Hand Book,* B.A. Hauser. Lewis Publishers, New York, 1991.
- *Water and Wastewater Technology,* M.J. Hammer. Regents/Prentice Hall, New Jersey, 1991.
- Textbook of water supply and sanitary Engineering , S.K Hussain (3 edition), oxford &IBH publishers, Jan 1, 2006.

Hard core

CPET 711 **Summer Training**

3 credits

This course, with credit equivalent of 96 hours of experimental/field work will be conducted during the summer vacation and would actually involve a minimum of double of this quantum of work, spanning atleast 25 working days.

During this period the student shall work either in an industry, a relevant governmental institution (eg. a pollution control board, a public health department, an R&D laboratory), a consultancy firm, or one of the sponsored R&D/consultancy projects of this centre. The purpose would be to get hands-on experience of some of the 'live' problems relating to environmental engineering and management.

Hard core

CPET 712 **State-of-the-art Review and Seminars**

3 credits

In this course the student is expected to make a very comprehensive *and critical* review of the state-of-the-art of his/her specialization topic. The objective would be to answer the questions: why this study; in what terms it is a better approach than the ones attempted by others; where exactly it breaks away from the general run; what does it aim to do which is newer and better? The student would comprehensively survey the work done till date, on the basis of reference books, theses/reports, *and* journal publications. He/she would then critically comment on the positive attributes and shortcomings of the past work, and put his/her own plans of work in this perspective.

The preparation of the state-of-the-art report shall also be accompanied by a presentation for both internal and external evaluation.

Hard core

CPET 714 Project work : preparatory and consolidation phase

8 credits

In this course the student is assigned topics for carrying out research. He/she would put forth his/her own plans of work, consolidate the set of objectives, hypothesis and methodology and commence preliminary studies

Hard core

CPET 721 Project work : advanced phase – thesis and viva voce

16 credits

In this course the student continues the research work commenced in the previous semester. Besides continuous assessment made throughout, at the end of the semester, the student submits a dissertation based on the research output which he/she has carried out, followed by extensive Viva-Voce.