

**POSTGRADUATE PROGRAMMES IN ENVIRONMENTAL AND WATER
ENGINEERING**



**MASTER OF THE SCIENCE OF ENGINEERING IN
ENVIRONMENTAL AND WATER ENGINEERING**

**Department of Civil Engineering
Faculty of Engineering
University of Peradeniya**

Course Structure

Course code	Title	Compulsory/ Optional	Credits
CE 6101	Research Methods in Civil Engineering	Optional	2
CE 6201	Environmental Hydraulics	Compulsory	3
CE 6202	Advanced Hydrology	Compulsory	3
CE 6203	Software Application in Water and Environmental Engineering	Compulsory	3
CE 6204	Wastewater Treatment and Reuse	Compulsory	2
CE 6205	Water Resources Project Planning	Compulsory	3
CE 6206	Water Supply Engineering	Compulsory	2
CE 6207	Climate Change Impacts and Adaptation in Water Sector	Optional	2
CE 6208	Coastal Engineering and Coastal Zone Management	Optional	2
CE 6209	Environmental Technology	Compulsory	2
CE 6210	Geographic Information Systems and Remote Sensing in Water Resources	Optional	2
CE 6211	Groundwater Hydrology	Optional	2
CE 6212	Hydraulic Structures	Optional	2
CE 6213	Industrial Waste Management	Optional	2
CE 6214	Integrated Water Resources Management	Optional	2
CE 6215	Irrigation and Drainage Engineering	Optional	2
CE 6216	Public Health Engineering	Optional	2
CE 6217	Solid Waste Management	Optional	2
CE 6104	Advanced Research Study	Compulsory	30

Number of credits from compulsory courses: 18

Number of credits from optional courses: 12

Number of credits from advanced research study: 30

Total number of credits: 60

Course Code	: CE 6101	
Course Title	: Research Methods in Civil Engineering	
No. of Credits	: 2	
Pre-requisites	: -	
Compulsory/Optional	: Optional	
Aim(s): To give the skills needed to plan and conduct a research study in order to create new knowledge in the field of Civil Engineering and related disciplines.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to;		
<ol style="list-style-type: none"> 1. Describe the scientific research methods and how this applies to graduate research studies 2. Prepare a literature review on a topic relevant to their area of concentration by critically reviewing published papers 3. Analyse the collected data and identify the appropriate methods for displaying the data. 4. Prepare an extended abstract and present the research findings in an oral/poster format. 		
Time Allocation (Hours)	Lectures: 18	Tutorials: 02 Practicals: Assignments: 20 Independent learning: 60 (Notional hours=100)
Course Content/Course Description:		
Fundamentals of Research: Definition and Objectives of Research; Qualitative vs Quantitative Research; The Scientific Research Process; Identification, selection, and formulation of research problems; Characteristics of good research problems; Review of literature		
Data Collection, Analysis and Presentation: Methods and techniques of data collection; Design of Experiments; Sampling and sampling designs; Statistical modelling and analysis including introduction to statistical package; Probability Distributions; Multivariate methods; Concepts of correlation and regression, error analysis; Effective presentation of information using Tables, illustrations, graphs, etc.		
Scientific writing and presentation: Essential components of abstract, introduction, literature review, materials and methods, results, discussion, and conclusions; Formatting of contents; Methods of referencing and the use of referencing tools, Preparing and presenting a technical presentation.		
Recommended Texts Fellows R.F., Liu A.M.M., (2015). "Research Methods for Construction", 4 th edition, Wiley Blackwell. Thiel D.V, (2014). "Research Methods for Engineers", 1 st edition, Cambridge university press. Wayne C., Booth G.G.C., Joseph M.W., (2008). "The Craft of Research", 3 rd Edition University of Chicago Press. Willie T., (2017). Research Methods: A Practical Guide for Students and Researchers, World Scientific.		
Assessment		Percentage Marks
In-Course	Assignments/Course work	100
End of Semester Examinations		-

Course Code	: CE 6201	
Course Title	: Environmental Hydraulics	
No. of Credits	: 3	
Pre-requisites	: None	
Compulsory/Optional	: Compulsory	
Aim(s): To impart basic knowledge for analyzing pollution transport to assess, protect and manage surface water environments.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to,		
<ol style="list-style-type: none"> 1. Quantitatively analyze transport and mixing of pollutants in surface water bodies by using concepts of fluid mechanics, hydraulics, and transport and mixing processes. 2. Apply suitable computational models to analyse the impacts of environmental pollution. 3. Select safe wastewater disposal techniques for disposal of wastewater into natural water bodies considering their pollutant assimilative capacities by application of water quality modelling tool. 		
Time Allocation (Hours)	Lectures:30 Tutorials:03 Practical: 20 Assignments:04 Independent learning: 93 (Notional hours = 150)	
Course content/Course Description:		
Fluid mechanics for environmental hydraulics: Governing equations of fluid flow, Applications to pipe flows and free surface flows		
Transport and mixing in fluids: Mixing and transport processes, Fate & transport of pollutants, Wastewater disposal systems		
Environmental modelling: Hydrodynamic modelling, Pollutant transport and water quality modelling, Multi-dimensional and spatially averaged modelling, Modelling of aquatic systems, Application of water quality models		
Recommended Texts		
Ioannis Tsanis Jian Wu Huihua Shen Caterina Valeo, (2006), "Environmental Hydraulics-Hydrodynamic and Pollutant Transport Models of Lakes and Coastal Waters", ISBN: 9780444527127, Elsevier Science.		
Chanson H., (2017). "Environmental Hydraulics for Open Channel Flows", ISBN: 978-0-7506-6165-2., Elsevier B.V.		
Chapra S.C., (1997). "Surface Water Quality Modeling", McGraw-Hill, NY.		
Chow V.T., Maidment D.R., Mays L.W., (1998). "Applied Hydrology", McGraw- Hill, NY.		
Singh V.P., Hager W.H., (1996). "Environmental Hydraulics", Kluwer academic publishers, The Netherlands.		
Tchobanoglous G., Schroeder E.D., (1984). "Water Quality: Characteristics, Modeling, Modification", Addison-Wesley, Massachusetts.		
Assessment		Percentage Marks
In-course	Assignment/ Course work	50
	Mid Semester Examination	-
End of Semester Examinations		50

Course Code	: CE 6202	
Course Title	: Advanced Hydrology	
No. of Credits	: 3	
Pre-requisites	: None	
Compulsory/Optional	: Compulsory	
Aim(s): To equip the students with essential theoretical and design concepts in advance engineering hydrology.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to,		
<ol style="list-style-type: none"> 1. Describe hydrologic processes and their importance in civil engineering applications. 2. Perform quality control of data, analyse and classify types of hydrological time series. 3. Perform frequency analysis of extreme values of precipitation and stream flows. 4. Compute design flows and hydrological extremes to carryout related designs. 		
Time Allocation (Hours)	Lectures: 34 Tutorials: 05 Practical: Assignments:12 Independent learning: 99 (Notional hours = 150)	
Course content/Course Description:		
Hydrological processes: Physical principles governing hydrological processes, rainfall-runoff relationship (Conceptual and Physics-based types), Instantaneous Unit Hydrograph (IUH), Synthetic Unit Hydrograph (Clark Method, SCS Method), Impact of Climate Change and Land-use Changes, Depth-Area-Duration relationship		
Hydrologic statistics: Probability concepts, Probability density functions and Cumulative distribution functions, Hydrologic data handling, Fitting probability distributions Testing the goodness of fit		
Frequency analysis: Extreme value distributions and probability plotting, Frequency factors, Confidence limits, IDF Relationships		
Hydrologic designs: Risk, Design criteria, Derivation of design storms and design flows, Storm sewer design, Drainage design		
Recommended Texts Chow V.T., Maidment D.R., Mays L.W., (1988). "Applied Hydrology", McGraw-Hill. Hann, C.T., (2002). "Statistical Methods in Hydrology", 2 nd Edition, Wiley-Blackwell. Linsley Jr.R.K. Kohler M.A., Paulhus J.L., (1975). "Applied Hydrology", McGraw-Hill, New York.		
Assessment		Percentage Marks
In-course	Assignment/ Course work Mid Semester Examination	40 -
End of Semester Examinations		60

Course Code	: CE 6203		
Course Title	: Software Applications in Water and Environmental Engineering		
No. of Credits	: 3		
Pre-requisites	: None		
Compulsory/Optional	: Compulsory		
Aim(s): To equip students with knowledge and skills to use software related to water and environmental engineering.			
Intended Learning Outcomes:			
On successful completion of the course, the student should be able to;			
<ol style="list-style-type: none"> 1. Simulate basin hydrologic processes. 2. Simulate steady and unsteady river flows and conduct water quality modelling in surface water bodies. 3. Use computational tools to water resource project planning. 4. Design and simulate water supply, storm water and sewer network systems. 5. Simulate wastewater treatment unit processes. 			
Time Allocation (Hours)	Lectures:09	Tutorials: 32	Assignments:40
	Independent learning: 69 (Notional hours=150)		
Course content/Course Description:			
Software packages related to:			
Hydrology (eg.HEC-HMS); Hydraulics (eg.HEC-RAS/ FLO2D); Irrigation engineering (eg. Cropwat /WEAP);Water supply and sewer networks (eg. WaterCAD/ SewerGems); Storm water drainage (eg.SWMM); Wastewater treatment plant design (eg.STOAT); Water quality modelling (eg.WASP)			
Recommended Texts			
Chadwick A., Morfett J., Borthwick M., (2013). "Hydraulics in Civil and Environmental Engineering", CRC press, 5 th Edition.			
McCuen R.H., (2016). "Hydrologic Analysis and Design", Pearson Education, 4 th Edition.			
Stephenson D., (2000). "Pipeline Design for Water Engineers", Volume 6, Elsevier Science, 1 st Edition.			
The catalogues of relevant software.			
Assessment			Percentage Marks
In-course	Assignment/ Course work		100
End of Semester Examinations			-

Course Code	: CE 6204	
Course Title	: Wastewater Treatment and Reuse	
No. of Credits	: 2	
Pre-requisites	: None	
Compulsory/Optional	: Compulsory	
Aim(s): To provide detailed knowledge of the current practices in wastewater treatment, with specific reference to reuse technologies, emerging wastewater treatment processes and environmental sustainability.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to;		
<ol style="list-style-type: none"> 1. Select and use wastewater treatment processes leading to rational design of overall systems. 2. Define the quality parameters typically used to characterize wastewater and review treatment requirement of wastewater and reuse. 3. Design advanced processes in aerobic treatment, anaerobic treatment and nutrient removal. 4. Compare and apply emerging technologies for advanced wastewater treatment and reuse. 5. Design sludge treatment and disposal systems. 		
Time Allocation (Hours)	Lectures: 21	Tutorials:01 Practical: Assignments: 16 Independent learning: 62 (Notional hours=100)
Course Content/Course Description:		
Introduction to wastewater treatment: Quantity and quality, Characterization, Status, Trends and Needs for wastewater treatment and Reuse		
Wastewater management systems : Decentralized Vs centralized systems, Collection and transport		
Wastewater treatment plant planning and design: Volume, Design period, Demand calculation, Biological systems, (Conventional, on-site and high-efficiency/high rate), Introduction to Chemical processes (coagulation, oxidation etc), Residuals management		
Wastewater reuse options: Standards, Treatment options and application, Tertiary treatment options		
Recommended Texts Crittenden J.C., Trussell R.R., Hand D.W., Howe K.J., (2012).“MWH's Water Treatment: Principles and Design”,George Tchobanoglous Publisher: Wiley, 3rd Edition. Eddy M., Asano T., Burton F.L., Leverenz H.L., Tsuchihashi R., Tchobanoglous G., (2006). “Water Reuse: Issues, Technologies, and Applications”, McGraw-Hill-New York. Eddy M., Tchobanoglous G., Stensel H.D., Tsuchihashi R., (2013).“Wastewater Engineering: Treatment and Resource Recovery”, Franklin Burton Publisher: McGraw-Hill Education, 5th Edition.		
Assessment		Percentage Marks
In-Course	Assignment/ Course work	40
End of Semester Examinations		60

Course Code	: CE 6205	
Course Title	: Water Resources Project Planning	
No. of Credits	: 3	
Pre-requisites	: None	
Compulsory/Optional	: Compulsory	
Aim(s): To provide detailed knowledge for management and planning of water resources development projects.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to;		
<ol style="list-style-type: none"> 1. Carryout feasibility studies for complex water resources projects. 2. Use system analysis and economic analysis techniques in planning and management of water resources development projects. 3. Prepare schedules for the implementation of water resource projects. 4. Appraise water law and policy, and discuss how it influences regional and national decision making on water resource use. 		
Time Allocation (Hours)	Lectures: 34 Tutorials:03 Practical: Assignments:16 Independent learning: 97 (Notional hours=150)	
Course content/Course Description:		
Water resources systems analysis and modelling: General concepts of systems analysis, planning, designing and operation of water resources systems, Application of simulation, optimization and multi-criteria decision analysis models		
Multipurpose river basin planning: Inter-basin and inter-provincial water resources planning and management, Shared water resources and conflict management		
Water policy and governance: Water law and policy, Water rights, Institutional aspects, Water allocation laws		
Economic analysis and project financing: Economic and financial evaluations, Financial models, benefit cost analysis, risk and uncertainty, multipurpose development and cost allocations		
Project planning: Feasibility studies, Planning techniques and project scheduling, Environmental and social aspects, Environmental audit, Project monitoring and post project evaluation, Commissioning and follow-up action.		
Recommended Texts		
Katko T., Juuti P.S., Schwartz K., (2013). "Water Services Management and Governance, Governance and Management for Sustainable Water Systems Series", IWA publishing, London.		
Loucks D.P.,Beek E.V.,(2005)."Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications", UNESCO, Paris.		
Taylor J., (2007)."Project Scheduling and Cost Control: Planning, Monitoring and Controlling - Planning Monitoring and Controlling the Baseline", J. Ross Publishing.		
Vedula S., Mujumdar P.P., (2005). "Water Resources Systems Modelling Techniques and Analysis", Tata-McGraw Hill, New Delhi.		
Assessment		Percentage Marks
In-course	Assignment/ Course work	40
	Mid Semester Examination	-
End of Semester Examinations		60

Course Code	: CE 6206	
Course Title	: Water Supply Engineering	
No. of Credits	: 2	
Pre-requisites	: None	
Compulsory/Optional	: Compulsory	
Aim(s): To provide in-depth knowledge and skills for design and manage drinking water supply schemes.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to;		
<ol style="list-style-type: none"> 1. Identify the importance of water quality and standards in drinking water supply. 2. Design a conventional drinking water treatment plant associated with distribution network. 3. Analyse and propose appropriate advanced water treatment methods to treat source water from non-conventional sources and under special scenarios. 4. Appraise and solve major operational issues arise at a drinking water treatment plant. 		
Time Allocation (Hours)	Lectures: 24	Tutorials: 01 Practical: Assignments: 10 Independent learning: 65 (Notional hours=100)
Course content/Course Description:		
Water quality parameters and standards: Source water quality and safety, Drinking water standards		
Conventional drinking water treatment : Unit processes, Treatment mechanisms, Troubleshooting at the drinking water treatment plant		
Design of water treatment unit processes: Design of the conventional unit processes, Design of the advanced unit processes (plate/tube settlers, filter under drain systems etc.), Selection of pumps and internal plumbing systems, Wash water collection systems		
Distribution networks: Design of pipe networks (Storage reservoirs, Break pressure tanks, Pipes and Valves), Online measuring techniques, Non-revenue water (NRW) management systems.		
Advanced water treatment processes: Membrane technology, Desalination, Water softening, Precipitation methods, Adsorption, Ion exchange, UV irradiation		
Recommended Texts		
American Water Works Association, American Society of Civil Engineers, (2012). "Water Treatment Plant Design", McGraw-Hill.		
Punmia B.C., Jain A., Jain A., (1995). "Water Supply Engineering", Laxmi Publications, New Delhi.		
Twort A.C., Ratnayaka D.D., Brandt M.J., (2000). "Water Supply", 5 th Edition, IWA publishing, London.		
Assessment		Percentage Marks
In-course	Assignment/ Course work	40
End of Semester Examinations		60

Course Code	: CE 6207	
Course Title	: Climate Change Impacts and Adaptation in Water Sector	
No. of Credits	: 2	
Pre-requisites	: None	
Compulsory/Optional	: Optional	
Aim(s): To provide knowledge on climate change impacts and adaptation techniques in water sector.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to;		
<ol style="list-style-type: none"> 1. Explain climate change referred to science of climate system and drivers. 2. Describe the techniques available for downscaling of GCM predictions for basin scales. 3. Explain the anticipated impacts and propose climate change adaptation techniques with special reference to water resources management. 		
Time Allocation (Hours)	Lectures: 25	Tutorials: 02 Practical: Assignments:06 Independent learning: 67 (Notional hours=100)
Course content/Course Description:		
Science of climate change: Climate system, Drivers of climate change, Climate modelling and climate change projections, GCMs		
Impacts of climate change: Impacts on hydrologic cycle, Impacts on regional climate and water resources, Impacts on water infrastructure, agriculture, food security, health and other sectors		
Adaptation for resilience: Exposure, vulnerability and risk of climate change, Regional and local adaptations in water sector, Resilience and traditional systems, Governance and policy framework		
Climate projection downscaling: Statistical downscaling, Dynamic downscaling, Applications in designs of hydraulic structures and water management		
Recommended Texts		
Fung C.F., Lopez A., New M., (2016). "Modelling the Impact of Climate Change on Water Resources", Wiley-Blackwell.		
Shrestha S., Babel M.S., Pandey V.P., (2014). "Climate Change and Water Resource", CRC Press.		
Turrall H., Burke J., Faurès J.M., (2011). "Climate Change, Water and Food Security", Food and Agriculture Organization of the United Nations, Italy.		
Assessment		Percentage Marks
In-course	Assignment/ Course work	40
	Mid Semester Examination	-
End of Semester Examinations		60

Course Code	: CE 6208		
Course Title	: Coastal Engineering and Coastal Zone Management		
No. of Credits	: 2		
Pre-requisites	: None		
Compulsory/Optional	: Optional		
Aim(s): To provide an in-depth analysis of the nearshore wave, hydrodynamic and morphodynamic processes and to address problems and issues in the coastal zone including the environmental effects of coastal interventions.			
Intended Learning Outcomes: On successful completion of the course, the student should be able to;			
<ol style="list-style-type: none"> 1. Analyse wave measurements and apply higher-order wave theories. 2. Analyse nearshore hydrodynamic and morphodynamic processes. 3. Develop a basic mathematical model related to coastal morphodynamics. 4. Plan and devise appropriate actions and responses in managing the problems and issues in the coastal zone. 			
Time Allocation (Hours)	Lectures: 26	Tutorials:02	Practical: Assignments:04 Independent learning: 68 (Notional hours=100)
Course content/Course Description:			
Wave Mechanics: Wave measurements, Analysis and non-linear wave theories			
Coastal Processes: Nearshore wave, Hydrodynamic and sediment transport processes; Physical modeling of coastal processes, Mathematical modeling			
Coastal Zone Management: Coastal environment and landforms. Problems and issues in the coastal zone, Coastal interventions- hard and soft structures, Coastal hazards, Integrated Coastal Zone Management with particular reference to Sri Lanka.			
Recommended Texts			
Dean R.G.,Dalrymple R.A., (2004). "Coastal Processes with Engineering Applications", 1 st edition, UK: Cambridge University Press.			
French P.W., (2002). "Coastal Defences: Processes, Problems and Solutions", 1 st edition, UK: Routledge.			
Kamphuis J.W., (2010). "Introduction to Coastal Engineering and Management", 1 st edition, Singapore: World Scientific.			
Sorensen R.M., (2006). "Basic Coastal Engineering", 3 rd edition, USA: Springer US.			
Wijetunge J.J., (2013). "An Introduction to Coastal Engineering: Processes, Theory, Hazards and Design Practice", 1 st edition, Colombo: Godage Publishers.			
		Assessment	Percentage Marks
In-course	Assignment/ Course work		40
	Mid Semester Examination		-
End of Semester Examinations			60

Course Code	: CE 6209	
Course Title	: Environmental Technology	
No. of Credits	: 2	
Pre-requisites	: None	
Compulsory/Optional	: Compulsory	
Aim(s): To familiarize with the basic instrumentations, technologies used in Environmental water quality analysis and improve the knowledge on Environmental issues.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to;		
<ol style="list-style-type: none"> 1. Explain global environmental issues and suggest mitigation and controls. 2. Perform major water quality measuring experiments and explain the working mechanisms of water quality measuring equipment. 3. Describe the behaviors of microorganisms in geochemical cycle. 4. Design systems that used in Environmental Biotechnology in some important industrial processes. 		
Time Allocation (Hours)	Lectures: 16 Tutorials: Practical: 24 Assignments: 04 Independent learning: 56 (Notional hours=100)	
Course Content/Course Description:		
Global Environmental issues and sustainability: Global Warming, Discharges of Hazardous air pollutants, Inhabitability of Modern Urban Habitat (heat Island Effect, Noise pollution, Sick building syndrome etc.), Introduction to sustainability, Sustainable development goal, Material Life Cycle		
Instrumentation: Working mechanism behind water quality measuring instruments, Spectrophotometric techniques, Chromatographic techniques, Potentiometric techniques, Mass spectrometry; Laboratory demonstration of instruments, Field level experiments		
Environmental Biotechnology: Role of microorganisms in geochemical cycles, Application of Environmental Biotechnology in Production of biogas, bioethanol, biodiesel and biohydrogen, Molecular approaches in Environmental Engineering and biotechnology		
Recommended Texts		
Rittmann B.E., McCarty P.L., (2001). "Environmental Biotechnology: Principles and Applications", McGraw-Hill Book Co., New York.		
Sawyer C., McCarty P., Parkin G., (2003). "Chemistry for Environmental Engineering and Science", 5 th Edition, McGraw-Hill Higher Education, New York.		
Baird R.B., Eaton A.D., Rice E.W., (2017). "Standard Methods for the Examination of Water and Wastewater", American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), 23 rd Edition.		
Assessment		Percentage Marks
In-Course	Assignment/ Course work	50
End of Semester Examinations		50

Course Code	: CE 6210	
Course Title	: Geographic Information Systems and Remote Sensing in Water Resources	
No. of Credits	: 2	
Pre-requisites	: None	
Compulsory/Optional	: Optional	
Aim(s): To equip students with knowledge and skills on the applications of geographic information systems (GIS) and Remote Sensing (RS) in water resources management and planning.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to;		
<ol style="list-style-type: none"> 1. Explain the basic principles and procedures in geographic data processing 2. Develop practical skills in GIS data formats, data collection methods, data entry and manipulation, coordinate systems and map projections, methods of spatial and 3D analysis and geovisualization. 3. Explain the physical principles underlying remote sensing and apply digital image processing techniques 4. Describe the operation of available Global Navigation Satellite Systems (GNSS) and the error sources. 		
Time Allocation (Hours)	Lectures: 15 Tutorials: Practical: 15 Assignments: 15 Independent learning: 55 (Notional hours=100)	
Course content/Course Description:		
Introduction to GIS and software: Raster data, Vector data, Data structures, Data manipulation, Exploring the interface and file management system		
Spatial data structures and sources: Map projections/coordinate system, World and National datum and transformations, Web and other spatial data sources		
GIS analysis functions and operations: Creating editing and GIS data, Spatial and overlay analysis , Distance analysis, Application of Hydrology tools		
Layouts, reports, graphs and data interoperability: Preparing and presenting maps and tables and exporting them to different online formats, Exporting and importing data to and from different formats		
Remote Sensed Data and Image processing techniques: Use of Elector Magnetic Spectrum in RS, Active and passive remote sensing, Supervised and unsupervised classification, remote sensing application in water resources		
Introduction to Geographic Positioning Systems: GNSS for GIS data capture, importing and exporting GPS data		
Recommended Texts		
Johnson L.E., (2009). "Geographic Information Systems in Water Resources Engineering", 1 st edition, Taylor & Francis Group.		
Law M., Collins A., (2013). "Getting to Know ArcGIS for Desktop", 3 rd edition, Esri press.		
Assessment		Percentage Marks
In-course	Assignment/ Course work	60
End of Semester Examinations		40

Course Code	: CE 6211	
Course Title	: Groundwater Hydrology	
No. of Credits	: 2	
Pre-requisites	: None	
Compulsory/Optional	: Optional	
Aim(s): To impart knowledge on the essential concepts and computation techniques in groundwater hydrology for engineering applications in environmental and water engineering.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to,		
<ol style="list-style-type: none"> 1. Identify porous medium properties that control groundwater flow and transport. 2. Apply groundwater flow equations to confined and unconfined aquifers. 3. Perform test to determine aquifer properties and analyse subsurface contaminant transport and suggest suitable remediation techniques. 4. Identify suitable groundwater basin management strategies. 5. Assess saline water intrusion scenarios and suggest suitable control technologies. 		
Time Allocation (Hours)	Lectures:24	Tutorials:03 Practical: Assignments:06 Independent learning: 67 (Notional hours = 100)
Course content/Course Description:		
Movement of Groundwater: Steady state and transient groundwater flow in confined and unconfined aquifers		
Well Hydraulics: Steady and unsteady radial flow, Multiple well systems, Wells near aquifer boundaries, Pump tests		
Groundwater contamination and remediation: Groundwater quality, Contamination sources, Mechanisms of contamination, Remediation technologies, Groundwater basin management		
Saline water intrusion: Occurrence of saline water intrusion; Fresh-Saline water interface, Upconing, Control technologies		
Computer-Assisted groundwater flow modeling: Modeling process, Computer models, Model calibration and parameter estimation.		
Hydrogeology: Surface investigation of groundwater, Subsurface investigation of groundwater, Artificial recharge of groundwater.		
Recommended Texts Fits C.R., (2013). "Groundwater Science", 2 nd Edition, Elsevier, USA. Todd D.K., (2003). "Groundwater Hydrology", 2 nd Edition, John Wiley & Sons, New York.		
Assessment		Percentage Marks
In-course	Assignment/ Course work	40
	Mid Semester Examination	-
End of Semester Examinations		60

Course Code	: CE 6212	
Course Title	: Hydraulic Structures	
No. of Credits	: 2	
Pre-requisites	: None	
Compulsory/Optional	: Optional	
Aim(s): To impart knowledge on the planning, application of hydraulic structures in water resources management.		
Intended Learning Outcomes: On successful completion of the course, the student should be able to,		
<ol style="list-style-type: none"> 1. Explain fluid mechanics and hydraulics concepts applied in planning and design of hydraulic structures. 2. Explain the natural behavior of water bodies/flows and approach for water resources management in harmony with natural environments. 3. Analyze and design different hydraulic structures in water resources development (irrigation, water supply), flood mitigation, coastal zone management for sustainable development. 		
Time Allocation (Hours)	Lectures: 25	Tutorials: 03 Practical: Assignments: 04 Independent learning: 68 (Notional hours = 100)
Course content/Course Description:		
River engineering: River hydraulics, River morphology, River training, dredging & bank protection, Physical and mathematical models, Environmental aspects in river management		
Inland hydraulic structures: Water retaining, water conveyance and drainage structures and their designs, Flow regulators, Sediment management, Environmental implications of hydraulic structures		
Coastal structures: Physical features of coasts and near shore processes, Shore protection structures, Land reclamations		
Recommended Texts		
Birdie G.S., Das R.C., (2006). "Irrigation Engineering", DhanpatRai Publishing Company, New Delhi.		
French P.W., (2002). "Coastal Defences: Processes, Problems And Solutions", 1 st edition, UK: Routledge.		
Garg S.K., (2006). "Irrigation Engineering and Hydraulic Structure", Khanna Publishers, New Delhi.		
Novak P., Moffat A., Nalluri C., Narayanan R., (2007). "Hydraulic Structures", Taylor & Francis, London, UK.		
Ljubomir Tanchev, (2014), "Dams and Appurtenant Hydraulic Structures", 2nd edition, CRC Press.		
James C.S., (2020), "Hydraulic Structures", Springer Nature Switzerland AG.		
Assessment		Percentage Marks
In-course	Assignment/ Course work	40
	Mid Semester Examination	-
End of Semester Examinations		60

Course Code	: CE 6213		
Course Title	: Industrial Waste Management		
No. of Credits	: 2		
Pre-requisites	: CE 6204		
Compulsory/Optional	: Optional		
Aim(s): To make students familiarize with industrial processes, associated waste streams, pollution control concepts and techniques by introducing industrial waste management options and legal & policy aspects.			
Intended Learning Outcomes: On successful completion of the course, the student should be able to;			
<ol style="list-style-type: none"> 1. Recognize the need for monitoring, reporting and controlling industrial waste systems in relation to national, regional and international policy and legal aspects. 2. Identify and apply in-plant industrial waste management strategies to develop and design industrial waste management programs giving emphasis to best available and application of environmental management systems. 3. Plan, design and execute industrial waste management programs. 4. Evaluate and design industry specific waste treatment technologies. 5. Discuss air pollution monitoring and control systems. 			
Time Allocation (Hours)	Lectures: 24	Tutorials: 01	Practical: Assignments: 10 Independent learning: 65 (Notional hours=100)
Course Content/Course Description:			
Introduction to industrial waste management : Industrial processes, Industrial waste characterization/ testing, Basic industrial waste management concepts and national, regional and international rules and agreements			
In-plant waste management: Waste Minimization, Life cycle assessment, Cleaner Production, Reclamation and Reuse, Environmental Management Systems and related case studies, ISO standards			
Industrial waste management: Primary, secondary and tertiary wastewater treatment unit processes for industrial wastewater treatment (with special emphasis on physical and chemical unit processes) Industrial solid and sludge management (Control of sludge generation and industrial sludge treatment and reuse)			
Air Pollution Monitoring and Control: Sources of air pollution, Technologies for monitoring and control of air pollution			
Recommended Texts EddyM., Tchobanoglous G., Stense H.D., Tsuchihashi R., Burton F., Burton F.L., (2013). "Wastewater Engineering: Treatment and Reuse", 5 th edition, McGraw-Hill. Kuhre W.L., (1995). "ISO 14001 Certification - Environmental Management Systems: A Practical Guide for Preparing Effective Environmental Management Systems", Prentice Hall International. Ranade V.V., Bhandari V.M., (2014). "Industrial Wastewater Treatment, Recycling and Reuse", 1 st edition, Elsevier. Tchobanoglous G., (2015). "Integrated Solid Waste Management Engineering Principles and Management Issues", McGraw-Hill. Water Environment Federation, (2008). "Industrial Wastewater Management, Treatment, and Disposal -Manual of Practice", 3 rd edition WEF.			
Assessment		Percentage Marks	
In-Course	Assignment/ Course work		40
End of Semester Examinations			60

Course Code	: CE 6214		
Course Title	: Integrated Water Resources Management		
No. of Credits	: 2		
Pre-requisites	: None		
Compulsory/Optional	: Optional		
Aim(s): To equip the students with the knowledge for improved water resources management through the implementation of applicable and effective integrated management tools and techniques.			
Intended Learning Outcomes: On successful completion of the course, the student should be able to;			
<ol style="list-style-type: none"> 1. Interpret and recommend improved water resources management measures through the implementation of applicable and effective integrated management tools and techniques. 2. Critically analyse the principles of governance, planning, adaptive management and capacity building in local, regional and trans boundary water resources regimes. 3. Assess the concept of integrated water resources management in relation to climate change. 			
Time Allocation (Hours)	Lectures: 25	Tutorials: 03	Practical: Assignments:04 Independent learning: 68 (Notional hours=100)
Course content/Course Description:			
Basic concepts: Components and dimensions of IWRM			
Protection of water resources: Demand and supply management, Catchment management and recycling and reuse.			
Gender in IWRM: Mainstreaming gender and IWRM nexus, Gender differential roles Climate change and impacts on water			
Water governance: Regulations and policy, Management of shared water resources.			
Water and ecosystems: Ensuring water quality, Water supply, Sanitation and health, Pollution control and prevention of waterborne diseases			
Recommended Texts Adamowski J., Zyla C., Cuenca E., Medema W., Clamen M., Reig P., (2013).“Integrated and Adaptive Water Resources Planning, Management, and Governance”, Water Resources Publications LLC, Littleton, Colorado, USA. Grigg N.S., (2016).“Integrated Water Resources Management: An Interdisciplinary Approach”, Palgrave Macmillan, UK.			
Assessment			Percentage Marks
In-course	Assignment/ Course work		40
	Mid Semester Examination		-
End of Semester Examinations			60

Course Code	: CE 6215		
Course Title	: Irrigation and Drainage Engineering		
No. of Credits	: 2		
Pre-requisites	: None		
Compulsory/Optional	: Optional		
Aim(s): To impart knowledge on the essential concepts in the field of irrigation and drainage engineering to design and manage efficient irrigation and drainage systems.			
Intended Learning Outcomes:			
On successful completion of the course, the student should be able to,			
<ol style="list-style-type: none"> 1. Plan, design, manage and operate irrigation systems. 2. Analyse and design surface irrigation systems and sprinkler irrigation systems at field level. 3. Plan and design irrigation structures used for water diversion, regulation and cross drainage purposes. 4. Plan, design and manage land drainage systems in agricultural fields. 			
Time Allocation (Hours)	Lectures: 25	Tutorials: 03	Practical: Assignments: 04 Independent learning: 68 (Notional hours = 100)
Course content/Course Description:			
Irrigation Project Planning:			
Project identification, Water availability, Performance and economic aspects of irrigated agriculture, Performance indicators			
Irrigation Methods and Design:			
Crop water requirement, Irrigation water requirement, Infiltration characteristics of soils for irrigation designs, Design of surface, overhead and drip irrigation systems			
Irrigation Water Management:			
Water delivery systems, Yield response to water, Irrigation scheduling techniques, Deficit irrigation strategy, Modern irrigation systems			
Sustainable Irrigation Systems:			
Ancient irrigation systems, Recycling of irrigation water, Environmental aspects of irrigation projects, Ground water pollution control			
Drainage Requirements and Systems:			
Causes of water logging, Types of drainage systems, Layout and design of drainage systems and their operation and maintenance			
Recommended Texts			
Garg S.K., (1987). "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.			
Sharma R.K., Sharma T.K., (1991). "Irrigation and Drainage Engineering", Oxford & IBH Publishing Co Pvt. Ltd. Michael A.M., (1978). "Irrigation Theory & Practices", Amazing Books International, India.			
A.L. Asawa, (2008), "Irrigation and Water Resources Engineering, New Age International (P) Limited, Publishers.			
Waller, Peter, Yitayew, Muluneh, (2015), Irrigation and Drainage Engineering, Springer.			
Assessment			Percentage Marks
In-course	Assignment/ Course work		40
	Mid Semester Examination		-
End of Semester Examinations			60

Course Code	: CE 6216		
Course Title	: Public Health Engineering		
No. of Credits	: 2		
Pre-requisites	: None		
Compulsory/Optional	: Optional		
Aim(s): To provide essential concepts related to water and sanitation, household water treatment, water and sanitation systems for rural and peri-urban areas, water safety plans, sanitation safety plans and quantitative risk assessment.			
Intended Learning Outcomes: On successful completion of the course, the student should be able to;			
<ol style="list-style-type: none"> 1. Describe the importance of WASH - Explain the link between water contamination, good hygiene practices and health, Disease transmission routes and options for breaking transmission routes. 2. Plan and design hygiene promotion, water supply schemes and appropriate sanitation systems. 3. Develop water safety plans and sanitation safety plans and quantitative risk assessment techniques. 			
Time Allocation (Hours)	Lectures: 24	Tutorials: 01	Practical: Assignments: 10 Independent learning: 65 (Notional hours=100)
Course content/Course Description:			
Global sanitation and health : Safe water, sanitation and health consequences in the world, Major water, sanitation and hygiene related diseases, their modes of transmission and appropriate options for breaking the transmission routes			
Good WASH practices : Multi barrier approach for safe water (select and design low cost water supply systems), Safe water storage and handling, Hygiene promotion, Sanitation ladder			
Sanitation safety plans : Principles of excreta management, Fecal sludge management (e.g. pond systems, anaerobic digestion) Introduction to water safety plans and Emergency water supply systems (disasters) Quantitative microbial risk assessment techniques			
Recommended Texts Evans B., Mara D., (2013). "Sanitation and Water Supply in Low Income Countries", 1 st edition, ISBN: 978-87-7681-866. Tilley E., Ulrich L., Lüthi C., Reymond P., Zurbrügg C., (2014). "Compendium of Sanitation Systems and Technologies", IWA, eawag.			
		Assessment	Percentage Marks
In-course	Assignment/ Course work		40
End of Semester Examinations			60

Course Code	: CE 6217		
Course Title	: Solid Waste Management		
No. of Credits	: 2		
Pre-requisites	: None		
Compulsory/Optional	: Optional		
Aim(s): To provide knowledge on technical aspects and the management of solid wastes.			
Intended Learning Outcomes: On successful completion of the course, the student should be able to;			
<ol style="list-style-type: none"> 1. Explain the implications of generation, management and environmental impacts of solid waste management. 2. Describe main features of an integrated solid waste management system and its associated processing techniques that are intended to minimize the adverse effects. 3. Assess the benefits that can be generated from Solid Waste through various management approaches. 4. Perform basic calculations for sanitary landfills, composting and recycling systems. 			
Time Allocation (Hours)	Lectures: 23	Tutorials:01	Practical: Assignments:12 Independent learning: 64 (Notional hours=100)
Course content/Course Description:			
Introduction to Solid Waste Management: Waste quantity and quality, Classification of waste, Waste generation rates, Legislation, regulation and control			
Waste Collection & Transport: Collection of mixed waste or of source separated waste, Collection logistics (root planning etc.), Transfer stations, Case study			
Treatment/disposal Technologies: Dumping, Sanitary landfills, Mechanical-biological treatment, Incineration, Anaerobic digestion, Composting; Reduce , reuse and recycling			
Green House Gas emission: Clean Development Mechanism, Energy recovery, Hazardous waste management			
Recommended Texts Chandrappa R., Das D.B., (2012). "Solid Waste Management: Principles and Practice", Springer. Tchobanoglous G., Kreith F. , (2002). "Handbook of Solid Waste Management", McGraw Hill. Tchobanoglous G., Theisen H., Vigil S.A., (1993). "Integrated Solid Waste Management: Engineering Principles and Management Issues", McGraw-Hill.			
Assessment		Percentage Marks	
In-course	Assignment/ Course work		40
End of Semester Examinations			60

Course Code	: CE 6104
Course Title	: Advanced Research Study
No. of Credits	: 30
Pre-requisites	: None
Compulsory/Optional	: Compulsory
Aim(s): To train the students to carry out an extensive literature review, conduct an advanced research study in depth, analyse data, synthesize research findings, write and present the results, and disseminate findings in a scientific forum.	
Intended Learning Outcomes: On successful completion of the course, the student should be able to;	
<ol style="list-style-type: none"> 1. search for technical literature from various sources and conduct a critical literature review. 2. formulate the research problem and develop appropriate methodology. 3. collect and analyse the data and synthesize research findings. 4. write the thesis and present the research findings in a precise and coherent manner. 5. disseminate the findings in a publication at a scientific forum. 	
Time Allocation (Hours)	Notional hours = 3000
Course Content/Course Description:	
Self-studies: Search of technical literature, summarise literature review, collect data, analyse data, write the thesis, prepare progress/ defence presentations, write a research paper.	
Meetings with supervisor: Conduct progress meetings with the supervisor, discuss the progress, and receive feedback from the supervisor for the presentation, thesis and paper.	
Recommended Texts Wayne C., Booth G.G.C., Joseph M.W. (2008). "The Craft of Research", 3 rd Edition University of Chicago Press. David E., Paul G. (2014). "How to Write a Better Thesis", 2 nd Edition, Springer International Publishing. Geoffrey R.M., David D., David F. (2005). "Essentials of Research Design and Methodology", John Wiley & Sons. Creswell J. W., David J. C. (2017). "Research Design: Qualitative, Quantitative, and Mixed Methods", John SAGE Publications.	
Assessment	
Three progress evaluations: Progress evaluation 1: Oral presentation 1 Progress evaluation 2: Oral presentation 2 Progress evaluation 3: Oral presentation 3	
Detailed Proposal: Detailed Proposal should be defended before continuing to the research study	
Progress report: Progress reports submitted every six months (after defending the detailed proposal)	
Final Evaluation: Final defence and the thesis Acceptance of a paper for publication	

