INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-503 **Course Title:** Water Resources Planning and Management
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** PCC
8. **Pre-requisite:** Nil
9. **Objective:** To provide detailed knowledge of the design, construction, and management of water sources for domestic and agricultural use.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction to Water Resources Systems**: Need for water; Availability of water; Technology for meeting water needs; Water resources planning, development and management; Water resources systems–the concept of system; System analysis techniques; Characteristics of water resources systems; Issues in system approach; Advantages and limitations of systems approach; Challenges in the water sector; Case study of water resources system - Sabarmati system	4
2.	**Acquisition and Processing of Water resources data**: Types of water resources data; Design of the hydro-mereological network; Data validation; Acquisition and processing of precipitation data; Meteorological data and streamflow data; Water quality data; Groundwater data; Reservoir and lake data; Spatial data; Socio-economic and agriculture data; Water use and demand data; Data gathered during system operation; Water resources information system- data transmission; Data storage and retrieval; Data dissemination	4
3.	**Engineering Economics in Water Resources Systems**: Basics of Engineering Economics-General Principles; Discount factors; Amortization; Comparison of Alternative plans; Economic analysis– Market demand and supply; Aggregation of demand; Conditions of project optimality–Water resources as a production process; Conditions of optimality, Benefit-Cost analysis–Benefits and Costs; Cost and benefit curves; Benefit and Cost estimation	10
4.	**Groundwater**: Aquifer properties (transmissivity, storage coefficient, significance); Recharge and groundwater movement including flow lines and equipotential lines; Natural flow; Flow to wells; Conduct and analysis of pumping tests including limitations and assumptions	9
5.	**Exploration and investigation techniques available for groundwater studies**: Mud rotary; Cable percussion and manual drilling techniques including record-keeping (logging); Post-drilling activities - borehole development; Test pumping; Water quality sampling, and testing	6
6.	**Integrated water resources management (IWRM)**: Methods, tools and regulation for WRM; Methods and approaches towards participation in WRM plans; Principles of urban drainage systems; Approaches to sustainable urban drainage systems; Aspects of IWRM; Water resources governance and management frameworks used in India and other countries	9
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Murthy, V.V.N., "Land and Water Management Engineering", Kalayani Publishers.	2020
2.	Fetter, C.W., "Applied Hydrogeology", Waveland Press.	2018
3.	Loucks, D. P., Beek, E., V., Stedinger, J. R., & Haith, D. A. "Water resource systems planning and analysis", Prentice-Hall.	2016
4.	Vedula, S., and Majumdar, P.P., "Water Resources Systems – Modelling Techniques and Analysis", Tata McGraw Hill.	2010
5.	Jain, S. K. and Singh, V. P., "Water Resources Systems Planning and Management", Elsevier.	2006
6.	Todd, D. K. and Mays L.W., "Groundwater Hydrology", John Wiley.	2005
7.	Bear J., "Hydraulics of Groundwater" McGraw Hill.	1979

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-507 **Course Title:** Drinking-Water and Sanitation Sustainability
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** PCC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on the interlinking of the societal development and sustainable environment in relation with drinking water and sanitation.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction:** Development of society and water resources; Integrated approaches to environmental management; Environmental health; Environmental pollution; Human health risk; Sustainable Development Goals (SDG6); Govt. policies, laws, acts and codal provisions related to drinking water and sanitation.	8
2.	**Water Sanitization and Hygiene:** WASH and Societal Development; Rural WASH service delivery: Financing, Management and Governance; Social research: paradigms, methods and design; Information, Education and Communication (IEC) and Behavioral Change Communication (BCC).	6
3.	**Water Sources Sustainability:** Environmental and ecosystem services; Environmental assessment for rural WASH Services; Environmental, economic, and social sustainability of drinking water sources; Source protection; Balancing diverse needs for water	6
4.	**Land and River Management**: Rainfall and surface water management; Environmental impact assessment and mitigation; Livelihoods and water use; Catchment interventions, Poverty and gender equality	6
5.	**Need Assessment and Governance:** Assessing demand and supply across urban, Peri-Urban, and rural contexts; Urban and peri-urban WASH Service delivery: financing, management, and governance; Framework for a water sensitive city.	8
6.	**Project Management for Development:** Scope for a detailed project report for drinking water and sanitation; Understanding trade-offs; Water pricing and privatization; Participatory approach; Implementation and monitoring	8
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	United Nations Children's Fund (UNICEF). "Global framework for urban water, sanitation and hygiene". UNICEF.	2019
2.	Huston, A., and Moriarty, P., "Understanding the WASH system and its building blocks. Working paper series building strong WASH systems for the SDGs". IRC, The Hague.	2018
3.	United Nations Children's Fund (UNICEF), "Strengthening Enabling Environment for Water, sanitation and hygiene (wash)" UNICEF.	2016
4.	United Nations Children's Fund (UNICEF), "Strategy for Water, Sanitation and Hygiene 2016-2030".UNICEF.	2016
5.	Carter R. C., "Water, Sanitation and Hygiene in Humanitarian Contexts: Reflections on current practice", Practical Action Publishing, UK.	2015
6.	Vries, F. W. T. P., Acquay, H., Molden, D., Scherr, S., Valentin, C., & Cofie, O." Integrated land and water management for food and environmental security". IWMI: Colombo, Sri Lanka.	2003
7.	Alley, W. M., Reilly, T. E., & Franke, O. L. "Sustainability of ground-water resources". US Department of the Interior, US Geological Survey.	1999
8.	Helmer, R., & Hespanhol, I., "Water pollution control: a guide to the use of water quality management principles". CRC Press.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-509 **Course Title:** Water Sanitation, Hygiene and Infrastructural Management
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** PCC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on Water, Sanitation, Hygiene, and infrastructure management.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Water Sanitation and Hygiene:** Pathogen Exposure and Disease, Environmental Classification of Diseases, Excreta and Water-related Diseases, Water Quality & Public Health, Drinking Water, Chemicals & Health, Relationship between Water, Sanitation and related Diseases; Risk Behaviors in Relation to Water and Excreta-Related Disease; Hygiene Evaluation and Promotion, WASH behavior Change, Menstrual Health and Hygiene.	8
2.	**Urban Sanitation:** Conventional and Low-cost Sewerage, Container-based Sanitation, Urban Water Infrastructure for Healthy Cities, Managing Water System and Services	4
3.	**Faecal Sludge Management:** Water Treatment Principles and Challenges, Appropriate Technology Selection, Water Safety Plans, On-site Excreta Disposal Systems, Pour-flush Latrines, Pit Latrines, Ventilated Improved Pit (VIPs), Composting Latrines, Septic Tanks, Soakage Systems, Ecological Sanitation and Benefits.	6
4.	**Water Supply and Monitoring:** Water Source Development; Simple Mechanical Lifting Devices; Household Water Treatment; Indicators, Monitoring Frameworks and their Relationship, International Targets	8
5.	**Poverty and Developmental Policies:** WASH Linkages to Nutrition and Disability, Benefits, Progress and Plans for Improved WASH; Stakeholders in WASH; Governance, Accountability and the Enabling Environment; Institutions, Capacity Development and Institutional Change; Service Delivery Approaches; Project Planning and Management; Basic Economic/ Financial Aspects of WASH services.	8
6.	**Waste Management:** Introduction to Solid and Liquid Waste Management; Solid Waste Storage and Primary Collection; Solid Waste Transfer and Secondary Storage; Waste Disposal Options; Case Study on Vehicle Selection, Sanitary Landfill, Sanitation Value Chain, Project Cycle and Results Framework/Theory of Change; Cast Studies on Successful WASH Projects.	8
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Kullmann, C. P., Andres, L. A., Srivastava, V., Skoufias, E., Li, S., Loughnan, E. C., & Rana, S., "Reducing Inequalities in Water Supply, Sanitation, and Hygiene in the Era of the Sustainable Development Goals". The World Bank.	2017
2.	Central Public Health, & Environmental Engineering Organisation. "Manual on municipal solid waste management". Report of Central Public Health and Environmental Engineering Orgnisation, Ministry of Urban Development, Government of India.	2016
3.	Howe, K. J., Hand, D. W., Crittenden, J. C., Trussell, R. R., & Tchobanoglous, G., "Principles of water treatment". John Wiley & Sons.	2012
4.	Crittenden, J. C., Trussell, R. R., Hand, D. W., Howe, K. J., & Tchobanoglous, G. "MWH's water treatment: principles and design". John Wiley & Sons.	2012
5.	Hoornweg, D., & Bhada-Tata, P., "What a waste: a global review of solid waste management." The World Bank.	2012
6.	Grigg, N. S., "Water, Wastewater and Stormwater Infrastructure Management", CRC Press.	2012
7.	World Health Organization and United Nations Human Settlements Programme. "Hidden Cities: Unmasking and Overcoming Health Inequities in Urban Settings." World Health Organization.	2010
8.	Howard, G., & Bogh, C., "Healthy villages: a guide for communities and community health workers". World health organization.	2007
9.	Bartram, J., Fewtrell, L., & Stenström, T. A., "Harmonised assessment of risk and risk management for water-related infectious disease: an overview". IWA Publishing, London.	2001
10.	Wright, A. M., "Toward a strategic sanitation approach: improving the sustainability of urban sanitation in developing countries". The World Bank.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-516 **Course Title:** Rural and Urban Water Supply
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** PCC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge for planning, design, operation, and maintenance of water supply schemes for rural and urban areas.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction:** Planning and preparation of water supply schemes for rural and urban areas; Issues in water supply for hilly and coastal regions; Regional and national perspective; Water pricing	6
2.	**Water Demand:** Population forecasting; Assessment of domestic, fire, industrial and public demands; Demand management	4
3.	**Water Supply Sources:** Surface and sub-surface sources; Selection, protection, contamination and protection zone; Estimating potential yield and sustainability; Design of wells	8
4.	**Water Quality:** Drinking water quality parameters; Comparison of International and National codes; Physical and chemical treatment processes; Disinfection and appropriate technologies for water treatment; Water quality index	9
5.	**Components of Intake Works:** Sizing water mains; Pumps for water supply; Pumping station; Pipe appurtenances; Pipe materials; Laying of pipes; Design of water distribution network and allied works	6
6.	**Water Distribution Networks:** Flow through pipes; Equivalent pipes; Solving pipe network flow problems; Use of computer software for network analysis	9
Total		**42**

11. **Suggested Books:**

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Bhave, P.R., and Gupta, R., "Analysis of water distribution networks" Narosa Publishing House.	2019
2.	Garg, S. K., "Water Supply Engineering", Khanna Publishers. 33rd ed.	2019
3.	Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., "Environmental Engineering", McGraw Hill.	2017

4.	Hammer, M. J., and Hammer, M. J. (Jr.), "Water and waste water technology", PHI.	2014
5.	Mays, L.W., "Urban Water Supply Handbook", McGraw Hill.	2002
6.	Qasim, S. R., Motley, E. M., and Zhu, G., "Water works engineering -Planning, design, and operation", PHI.	2000
7.	Ministry of Urban Development, "Manual on Water Supply and Treatment", CPHEEO.	1999
8.	Jeppson, R., "Analysis of Flow in Pipe Networks", Ann Arbor Science, An Arbor, Mich.	1976

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-506 **Course Title:** Mini project on Drinking Water and Sanitation
2. **Contact Hours:** **L:** 0 **T:** 0 **P:** 4
3. **Examination Duration (Hrs.):** **Theory:** 0 **Practical:** 3
4. **Relative Weightage:** **CWS:** 0 **PRS:** 50 **MTE:** 0 **ETE:** 0 **PRE:** 50
5. **Credits:** 2 **6. Semester:** Spring **7. Subject Area:** PCC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on the collection, testing, analysis, and reporting of water and wastewater samples.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	Determination of pH, Color, Turbidity, Hardness, and Alkalinity of water and wastewater sample.	3
2.	Determination of Chlorides, Sulphate, and nitrates of water and wastewater samples.	3
3.	Determination of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) of water and wastewater samples.	3
4.	Assessment of Microbiological water quality – MPN, Plate count, and membrane filtration techniques	3
5.	Assessment of heavy metals and micropollutants in water and wastewater samples.	6
6.	Analysis of Total Organic Carbon (TOC), Mixed Liquor Suspended Solids (MLSS), and Mixed Liquor Volatile Suspended Solids (MVLSS)	3
7.	Mini Project on Drinking Water and Sanitation- Water Sample collection, testing, analysis, and survey to address the water quality and sanitation issues in rural and urban areas	Half semester (21)
Total		**42**

11. **Suggested Books:**

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Indian Standard-Drinking Water — Specification, BIS, New Delhi	2015
2.	Guide Manual: Water and Wastewater Analysis. Central Pollution Control Board (CPCB), New Delhi	2015
3.	American Public Health Association (APHA). Standard methods for the examination of water and wastewater. Standard methods for the examination of water & wastewater. Washington, DC: American Public Health Association.	2005
4.	Sawyer, C.N., McCarty, P.L., and Parkin, G.F. Chemistry for Environmental Engineering 4th Edition. Tata McGraw-Hill Publishing Company Limited.	2000
5.	Helmer, R., & Hespanhol, I., “Water pollution control: a guide to the use of water quality management principles”. CRC Press.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-501 **Course Title:** System Design Techniques
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on the system design techniques and applications to water resources systems analysis, design and management.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**System Concepts:** Boundary, Environment, Input, Output and constraints; Open and Closed Systems; System Modeling; Water Resources Systems; Issues in System Application; Operation Research Approach to System Analysis	4
2.	**Linear Programming:** Model Formulation; Graphical method; Simplex procedure- Two Phase, Big-M, Dual Simplex, Primal-Dual Simplex; Modified Simplex Procedures; Upper bounded solutions, Sensitivity analysis	8
3.	**Transportation Problems:** Basic feasible solution techniques; Testing for optimal solution; Integer and mixed-integer problems; Assignment problems; Applications for efficient water resources management	8
4.	**Nonlinear Programming (NLP):** Separable and convex programming problems; Quadratic Programming; Unconstrained and constrained NLP Problems; Chance constrained programming; Method of calculus; Search techniques	6
5.	**Dynamic Programming:** Optimality principle; Deterministic and stochastic Dynamic programming; Application to water resources problems	8
6.	**Decision Making:** Value and utility concepts, Goal programming, Decision theory and decision trees, Decision making under risk and uncertainty, Theory of games; Multi criteria decision making- Distance based and compromise techniques	8
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Sharma, J.K., "Operations Research", Macmillan, 5th Edition	2012
2.	Rao, S.S. "Optimization - Theory and Applications", Wiley Eastern, 4th Edition.	2009
3.	Taha, H.A., "Operation Research - An Introduction", PHI, 8th Edition.	2007
4.	Jain, S. K., & Singh, V. P., "Water Resources Planning and Management", Elsevier.	2003
5.	Wurbs, R.A. & James, W.P., "Water Resources Engineering", PHI.	2002
6.	Ravindran, A., Philips, D.T. & Solberg, J.J., "Operation Research-Principles and Practice", Second Edition, John Wiley.	2000
7.	Loucks, D.P., Stedinger, J.R. & Haith, D.A., "Water Resources Systems Planning and Analysis", Prentice Hall.	1981

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-580 **Course Title:** Renewable Energy System Technology
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on renewable energy harnessing technologies.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Renewable energy:** Current state-of-the-art; Future use and penetration of renewable energy technologies; Types of renewable energy sources - Solar, Tidal, Waves, Hydro, and Geothermal; Government policies related to renewable energy generation.	3
2.	**Solar thermal energy conversion technologies:** Nature of solar radiation; Insolation; Measurements and estimation; Physical principles of conversion of solar radiation into heat; Flat plate collectors; Energy balance equation and collector efficiency; Concentrating collectors and flat plate collectors; Solar thermal electric power generation	6
3.	**Solar photo voltaic systems:** System components and configurations; Cells, modules, and arrays; Converters; System sizing; Mechanical integration, Electrical integration; Utility interconnection	3
4.	**Wind energy:** Wind characteristics; Data analysis and resource estimation; Wind turbine energy prediction; Measurement of wind velocity and direction; Wind turbine configurations- drag and lift types; Magnus effect in wind turbines; Vortex wind machines; Electric generators for wind turbine application; Power converter, auxiliary equipment; Wind turbine control; Wind turbine sitting considerations; System economics; Environmental aspects and impacts	5
5.	**Small Hydropower:** Small hydropower generation using synchronous and induction generators– characteristic, standalone and grid connected operations; Voltage and frequency control; Power electronic converters; River turbines	6
6.	**Bio mass energy:** Biomass conversion technologies, Generation; Bio- digestion; Classification of biogas plants– floating drum type and fixed dome type; Thermal gasification of biomass; Biomass gasifiers; Gasification process; Application of gasifiers for electricity generation; Pyrolysis and alcohol fuels	6
7.	**Other renewable energy sources:** Wave energy and ocean thermal energy conversion technologies; Geothermal energy sources; Geothermal exploitation; Prime-movers for geothermal energy conversion system; Material selection for geothermal power plants; Flashed steam and total flow concept	6

8.	**Applications**: Application to micro-irrigation; Rural water supply; Water and waste water treatment, Special conditions of preference – off-grid and remote areas; Cost-effectiveness, Use of software, Solar Energy based desalination systems and Low-Temperature Thermal Desalination (LTTD); Studies on use of solar energy system on canal/reservoir; Fuel cell applications.	7
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Da Rosa, A. V., & Ordonez, J. C., "Fundamentals of renewable energy processes. Academic Press.	2021
2.	Rai, G.D., "Non-conventional Energy Sources," Khanna Publishers, 6th Edition.	2017
3.	Chapman S. J., "Electric Machinery Fundamentals", Tata McGraw – Hill Publication	2010
4.	Peuser, F. A., Remmers, Karl-Heinz & Schnauss, M., "Solar Thermal Systems: Successful Planning and Construction", Beuth Verlag Publisher, Zurich	2009
5.	Messenger, R.A. & Ventre, J., "Photovoltaic System Engineering," CRC Press.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-581 **Course Title:** Water Quality Monitoring and Modeling
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on water quality modelling and monitoring of water bodies.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Water quality parameters:** Physical, chemical and biological parameters of natural water bodies like lake, river and estuary; Water quality standards, Eutrophication; Sources of pollution, mass bathing impacts, waste load allocation; Water Quality Indices	8
2.	**Water quality monitoring:** Physical, chemical and biological monitoring of rivers; Guidelines for sample size and location of monitoring stations; Sample analysis; Water quality testing including the availability of low-cost test-kit and test procedures	8
3.	**Water pollution:** Sources of surface and ground water pollution; Water contaminants; Heavy minerals; Organic contaminants; PCBs and other Halogens materials; PAH; Pesticides; Waterborne Pathogens; Destiny of Contaminant transmission and transformation; Dissolved Oxygen and natural purification; Eutrophication of water resources; Point source Protection; Water Legislations and Standards	8
4.	**Water purification:** Overview of engineered systems for water and waste water systems; Treatment Processes- Aeration and stripping; Sedimentation and flotation; Coagulation & flocculation; Sand filtration; Membrane filtration; Biological treatment; Oxidation & disinfection; Softening and hardening; Tertiary treatment; Adsorption and ion exchange; Response of streams to biodegradable organic waste	10
5.	**Water quality Modelling:** Characteristics of point and non-point sources of pollution; Solution of diffusion and dispersion problems; Water quality models; Surface & Ground water interaction; Case studies	8
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Zhen, G. J., "Hydrodynamics and Water Quality- Modelling Rivers, Lakes and Estuaries", John Wiley.	2017
2.	Loucks, D. P., Beek, E., V., Stedinger, J. R., & Haith, D. A. "Water resource systems planning and analysis", Prentice-Hall.	2016
3.	Chapra, S. C., "Surface Water Quality Modeling", Waveland Press.	2008
4.	Chin, D.A., "Water Quality Engineering in Natural Systems", Wiley Interscience.	2006
5.	Thomn, R. V., & Mueller, J. A., "Principles of Surface Water Quality Modelling", Harper and Row Publishers.	1997
6.	Orlob, G. T., "Mathematical Modelling of Water Quality- Streams, Lakes, and Reservoirs", John Wiley.	1983
7.	Biswas, A. K., "Models for Water Quality Management", McGraw Hill.	1981

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-586 **Course Title:** Groundwater Development and Management
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on groundwater development and management.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction:** Use of groundwater for water supply; Hydrologic properties of water-bearing formation; Occurrence, storage, and distribution of groundwater; Use of groundwater zone maps; Groundwater resource assessment and budget; Organizational aspects of groundwater development and management	8
2.	**Groundwater hydraulics**: Surface investigations of groundwater; Well hydraulics- steady and unsteady flows; Water wells- test holes and well logs; Design, construction and development of shallow and deep wells; Design of screen and gravel packs	8
3.	**Wells and Pumps**: Pumps and their selection; Installation, and testing of pumps; Monitoring and maintenance of wells; Causes of failure	6
4.	**Groundwater and surface water conservation**: Groundwater conservation and artificial recharge; Sustained yield; Water balance equation; Ground-water and surface-water interaction, Interference of wells; Watershed conservation measures in irrigation Commands; Salt water intrusion	8
5.	**Groundwater quantity**: Groundwater flow parameter estimation; Groundwater simulation and conjunctive use models; Comparative analysis for management of conjunctive use system	6
6.	**Groundwater quality**: Sources of pollution; Causes and monitoring; Technical, socio-economic and organizational aspects of groundwater management; Participatory approach to groundwater management	6
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Sikdar, P. K., "Groundwater Development and Management: Problems and Challenges for Groundwater Management in South Asia". Springer.	2018
2.	Rastogi, A.K., "Numerical Groundwater Hydrology", Penram International.	2012
3.	Sterrett, R.J., "Groundwater and Wells", Smyth Companies.	2008
4.	Raghunath, H.M., "Groundwater", New Age International.	2007
5.	Todd, D. K., and Mays, L.W., "Groundwater Hydrology", John Wiley.	2005
6.	Karanth, K. R., "Groundwater Assessment, Development and Management", Tata McGraw Hill.	1987
7.	Bear, J., "Hydraulics of Groundwater", McGraw Hill.	1979
8.	Sharma, H.D., & Chawla, A.S., "Manual on Ground Water and Tube Wells", Central Board of Irrigation and Power.	1977

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-587 **Course Title:** Watershed Development and Management
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge of watershed components, processes, and management for soil and water conservation.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction**: Components of watershed and need of watershed management; Principal factors influencing watershed operations; Delineation of watersheds; Engineering surveys; Data requirement, watershed policy and guidelines; Water budgeting in a watershed	6
2.	**Watershed hydrology**: Water resources assessment in a watershed; Hydrological cycle; Surface water assessment; Rainfall-runoff analysis; Infiltration and its measurement	8
3.	**Watershed Behavior**: Physical elements of watershed; Effects of land-use changes on hydrological cycle components; Watershed experiments; Land capability classification; Erosion process- factors affecting erosion; Types of erosion; Soil erosion models	8
4.	**Engineering measures for soil and water conservation**: Contour bunding, graded bunding, bench terracing, land leveling and grading; Small storage structures- Types and design data requirement; Loose boulder dams; Gabions; Check dams and their design criteria	8
5.	**Rainwater harvesting**: Direct and indirect methods; Filter-planning and design; Layout and execution; Impact assessment; Operation and maintenance issues	6
6.	**Watershed management plan**: Methodology of planning a watershed; Identification of watershed problems; Water-food-energy nexus; Socio-economic issues including application of Remote sensing and GIS in watershed management	6
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Suresh, R., "Soil and Water Conservation Engineering", Standard Publishers.	2020
2.	Bedient, P.B., Huber, C.W., & Vieux, E.B., "Hydrology and Floodplain Analysis", Pearson Education (US).	2019
3.	Mal, B. C. & Pandey, A., Introductory Soil and Water Conservation Engineering. Kalyani Publishers, Delhi	2018
4	Das, G., "Hydrology and Soil Conservation Engineering", Prentice Hall.	2009
5.	Tideman, E.M., "Watershed Management", Omega Scientific Publisher.	2007
6.	Debarry, P. A., "Watershed: Processes, Assessment and Management", John Wiley.	2004
7.	Lyon, J. G., "GIS for Water Resources and Watershed Management", Taylor and Francis.	2003
8.	Schwab, G.O., Fangmeier, D.D., Elliot, W. J., Frevert, R. K., "Soil and Water Conservation Engineering", John Wiley.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-588 **Course Title:** Remote Sensing and GIS Applications in Water Systems
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on applications of remote sensing and GIS techniques in water systems.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Physics of Remote Sensing:** Introduction; Sources of Energy; Active and Passive radiation; Electromagnetic spectrum; Principles of remote sensing and data analysis; Atmospheric effects; Energy interaction with earth surface features; Basic interaction mechanism of soil, vegetation and water	8
2.	**Sensors & Platforms:** Various types of Sensors; Platforms, and their characteristics; Data acquisition systems (Optical, Thermal, and Microwave); Resolutions-spatial, spectral, radiometric, and temporal; Satellite data products; Sources of remote sensing data (Global and Indian)	6
3.	**Image interpretation**: Image interpretation- virtual and digital; Image rectification; Image enhancement; Image classification and accuracy assessment; Use of image processing software	8
4.	**Geographical information system (GIS):** Definition; Digital maps, projections and coordinate systems; Essential components of Geospatial data structure- raster and vector; Spatial and non-spatial relationship; Geographic database concepts and analysis; GIS packages and salient features	8
5.	**Applications of remote sensing and GIS in water resources**: Estimation of surface and groundwater potential; Erosion hazard assessment; Water quality assessment; Flood inundation mapping and modeling; Drought monitoring; Irrigation Management; Water body siltation; Selection of a site for artificial recharge	8
6.	**Case studies**: Water resources project planning using remote sensing and GIS	4
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Lillesand, T.M., & Kiefer, R. W., "Remote Sensing and Image Interpretation", Seventh Edition, John Wiley.	2017
2.	Burrough, P.A., "Principles of Geographic Information System", Oxford University Press.	2016
3.	Jensen, J.R., "Remote Sensing of the Environment an Earth Resources Perspective", Pearson Education.	2013
4.	Chandra, A.M., & Ghosh, S.K., "Remote Sensing and Geographic Information System", Narosa Publishers.	2007
5.	Curan, P.J., "Principles of Remote Sensing", English Language Book Society, Longman.	1985

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-589 **Course Title:** Drinking-Water for Low-Income Societies
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on the design, construction, operation and maintenance of water supplies for low-income economies.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Water Supply and Surveillance**: Water supply design criteria; Water collection, delivery and storage; Water safety plans (WSPs); Operation and maintenance of rural water supplies; Water quality control; Infectious diseases and water quality surveillance; Service quality indicators used in surveillance; Surveillance programme development; Waste water reuse	7
2.	**Water storage and Management**: Traditional/low-cost methods of water treatment and practices; Stormwater and sullage disposal; Rain water harvesting and uses; Design and construction of rainwater collection schemes- various types, site suitability; Ecosystem impact; Community participation; Operation and management strategy	8
3.	**Sources and Treatment**: Hand-dug wells; Hand-drilled boreholes; Protected springs and simple water treatment and distribution systems; Community pumps; Household water treatment	6
4.	**O&M and SWEs:** Types and use of hand-pumps and motorized pumps; Operation and maintenance of small water supplies; Small Water Enterprises (SWEs); Importance of SWEs for the urban poor; Constraints and opportunities for SWEs	7
5.	**Case Studies:** Case studies on drinking water system development; Large scale sea-water RO plants and associated case studies; Rainwater harvesting systems; Springs & Spring shed mapping, and their interaction with ground and surface water; Studies for a comprehensive plan for their sustainable development; Community based water resources management, SWEs in African countries (i.e. Tanzania, Kenya, Sudan, Ghana)	8
6.	**Field Visits:** Hand-dug wells; Rainwater harvesting systems in North India; Springs in Himalayan regions; Interaction with implementing agencies of water & sanitation missions	6
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	IS 17482: "Drinking Water Supply Management System-Requirements for Piped Drinking Water Supply Service", Bureau of Indian Standards, New Delhi.	2020
2.	Ministry of Jal Shakti, "Operational guidelines for the implementation of Jal Jeevan Mission", Department of Drinking Water and Sanitation (National Jal Jeevan Mission)	2019
3.	CPCB, "Rainwater Harvesting in India- An appraisal" ENVIS Centre, CPCB.	2016
4.	Danert, K., Armstrong, T., Adekile, D., Duffau, B., Ouedraogo, I. & Kwei, C. "Code of Practice for Cost-effective Boreholes" RWSN, St Gallen, Switzerland.	2010
5.	Kinkade-Levario, H. "Design for water: Rainwater harvesting, stormwater catchment and alternate water reuse". New Society Publishers.	2007
6.	Carter, R. C. "Ten-step Guide Towards Cost-effective Boreholes. Case study of drilling costs in Ethiopia", WSP, RWSN, Nairobi, Kenya/St Gallen, Switzerland.	2006
7.	MacDonald, A., Davies, J., Calow, R., & Chilton, J. "Developing groundwater: a guide for rural water supply. ITDG publishing.	2005
8.	CGWB, "Rain water Harvesting Techniques to Augment Ground Water" Central Ground Water Board, India.	2003
9.	Smet, J., & Van Wijk, C. "Small Community Water Supplies: Technology, People and Partnership ", IRC, International Water and Sanitation Centre.	2002
10.	Driscoll, F. G., "Groundwater and wells 2nd Edition", Johnson Filtration Systems. Inc.	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-590 **Course Title:** Wastewater and Fecal Sludge Management
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on wastewater treatment and wastewater reuse in low-income countries, small communities, and peri-urban areas.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Wastewater treatment systems**: Introduction to Natural Wastewater Treatment (NWT) systems; Wastewater quality, flows and loads; Overview of Waste Stabilization Ponds (WSP); Anaerobic ponds; UASBs and high-rate anaerobic WSPs; Facultative ponds; Maturation ponds; Physical design and O&M of WSPs; Rock filters; Constructed wetlands; Various types of treatment plants and their applications	10
2.	**Wastewater reuse and recycling**: Introduction to wastewater reuse and discharge; Guidelines for wastewater reuse in drinking water; Quantitative microbial risk analysis (QMRA); Decentralized wastewater treatment (DEWATS); Condominium sewerage; Suitable NWT technologies to meet effluent quality standards in drinking water	10
3.	**Wastewater management:** Effect of Long-term utilization of treated water for irrigation, aquaculture etc., and resulting consequences on soil; Life of aquatic animal environment; Studies on the quality utilization of industrial effluents from different types of industries; Assessment and suggestion for preventive measures.	10
4.	**Low-cost fecal sludge management:** Introduction of faecal sludge, main characteristics; on-site sanitation; Faecal sludge collection and disposal systems; Challenges of solid-liquid separation; Major technologies for solid-liquid separation and fecal sludge treatment; Composting and digestion; Methods for nutrient and energy recovery; Cost appraisal of selected treatment options; Economy of scale- centralization or decentralization; Comparison of various treatment options and their feasibility.	8
5.	**Socio-economic measures for Fecal sludge management:** Advocacy; Capacity building; Institutional and regulatory measures; Financial/economic measures.	4
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Ulrich A., Reuter A., & Gutterer., "Decentralised Wastewater Treatment Systems (DEWATS) and Sanitation in Developing Countries: A Practical Guide" WEDC, Loughborough University, UK.	2009
2.	Arceivala S. J., & Asolekar S. R., "Wastewater Treatment for Pollution Control and Reuse", Third Edition, McGraw Hill Education (India) Private Limited, New Delhi.	2007
3.	Alley E. R., "Water Quality Control Handbook" McGraw-Hill Inc, New York.	2007
4.	Liu D. H. F., & Liptak B. G., "Environmental Engineers' Handbook", CRC Press LLC, Florida, USA.	1999
5.	Letterman R. D., "Water Quality and Treatment: A Handbook of community water supplies" McGraw-Hill Inc, New York.	1999
6.	USDA-NRCS., "A Handbook of Constructed Wetlands – A guide to creating wetlands for agricultural wastewater, domestic wastewater, coal mine drainage, storm water in the mid-Atlantic region", U.S. Government Printing Office.	1995
7.	Hammer D. A., "Constructed Wetlands for Wastewater Treatment: Municipal, Industrial and Agricultural", CRC Press LLC, Florida, USA.	1989
8.	BIS "Indian Standard- Guidelines for the quality of irrigation water (IS 11624: 1986)", Bureau of Indian Standards, New Delhi.	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-591 **Course Title:** Resilience, Shocks and Emergencies
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on water resources services management in adverse conditions like disasters.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction**: Global challenges and future trends for water and wastewater management; Resilience: conceptual underpinning and current understandings and applications in water and wastewater sectors	6
2.	**Water and Wastewater services**: The future of water and wastewater services in a changing world, including innovative treatment and sanitation technologies and alternative water sources; Introduction to integrated planning frameworks for water and wastewater services; Water sensitive design; Involving citizens in water management	8
3.	**Nature & type of shocks:** Natural and man-made disasters; Rapid- and slow-onset; Complex emergencies, and phases of emergencies (acute, post-acute, transition to development/normality); Climate change & its impacts	6
4.	**Disaster/emergency response:** Sheltering displaced people; Protecting public health (water supply and sanitation); Coordination with other sectors and between stakeholders (humanitarian, public authorities)	9
5.	**Global response frameworks:** Introduction to frameworks for humanitarian response and relief (e.g., SPHERE and Common Humanitarian Standards); Developing methods for collective responses; Questionnaire survey; Secondary data management	6
6.	**Case studies:** Hydrological extremes including the floods in Southern India, and Bihar; Earthquake in Nepal; Refugee Camps in Middle eastern countries; Population migration crises in Bangladesh.	7
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Fu, G., Meng, F., Rivas Casado, M., & Kalawsky, R. S. "Towards integrated flood risk and resilience management". Water, 12(6), 1789.	2021
2.	Melesse, A. M., Abtew, W., & Senay, G. (Eds.). "Extreme Hydrology and Climate Variability: Monitoring, Modelling, Adaptation and Mitigation". Elsevier.	2019
3.	Juuti, P., Mattila, H., Rajala, R., Schwartz, K., & Staddon, C. (Eds.). (2019). "Resilient Water Services and Systems: The Foundation of Well-Being". IWA Publishing.	2019
4.	Sphere Project, "Humanitarian Charter and Minimum Standards in Humanitarian Response" Practical Action Publishing, 4th Edition.	2018
5.	Pahl-Wostl, C. "Water governance in the face of global change". 10, 978-3Springer International Publishing: Switzerland.	2015
6.	Blaikie, P., Cannon, T., Davis, I., & Wisner, B. "At risk: natural hazards, people's vulnerability and disasters" Routledge.	2014
7.	Turnbull, M., Sterrett, C., & Hilleboe, A. (2013). Toward resilience: A guide to disaster risk reduction and climate change adaptation. Practical Action Publishing.	2013
8.	House, S.J. & Reed, R.A., "Emergency Water Sources: Guidelines for selection and treatment" WEDC, Loughborough, 3rd edition.	2004
9.	Harvey, P.A., Baghri, S. & Reed, R.A. "Emergency Sanitation: Assessment and programme design" WEDC, Loughborough University, UK.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-592 **Course Title:** Management and Operation of Water Utilities
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on design, operation and management of water including the principles of organisational design and management of water utility services.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction:** Components of water utilities; Integrated urban water services management; Strategic approach; Effective storm-water, sanitation and waste management; Effective and interactive institutional arrangements; Smart network monitoring (IoT) and fault detection	8
2.	**Water supply and demand Management (WSDM):** Estimation of supply and various demands; Non-revenue water; Cost recovery and water tariffs; Utility concepts; Demand and willingness to pay; Subsidies, benefits and costs of implementing WSDM; Multi-stakeholder planning for demand management	10
3.	**Water services:** Service to low-income urban community; Customer services; Marketing and satisfaction; Development of human resources; Asset management; Organizational change Management; Public-Private Partnership; Inefficiencies of water utilities; Effective management information systems	9
4.	**Enhancement of utility performance:** Performance Improvement Plans (PIPs); Expansion of services to peri-urban areas; Supply Reduction of Unaccounted-for-Water and its reduction strategies; Capacity building tools i.e. on-the-job training, manuals for utility management; Water user's association; Benchmarking case studies; On-line support; Workshops, and field demonstrations	9
5.	**Case studies:** Examples of water utilities in Afro-Asian countries.	6
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Water, Engineering and Development Centre, and SWITCH. "Water Demand Management in the City of the Future. Selected Tools and Instruments for Practitioners". WEDC, Loughborough University.	2019
2.	Deverill P., Bibby S., Wedgwood A. & Smout I., "Designing water supply and sanitation projects to meet demand in rural and peri-urban communities Book 1: Concept, Principles and Practice" WEDC, Loughborough University.	2019
3.	Botton, Sarah, Alexandra Brailowsky, and Sarah Matthieussent, "The Real Obstacles to Universal Access to Drinking Water in Developing Countries: Thoughts Stemming from How Poor Neighbourhood Populations Living in Port-au-prince (haiti) and Buenos Aires (argentina) Experience Access to Drinking Water". WEDC, Loughborough University.	2019
4.	Sohail, M., Sue Cavill, and Andrew P. Cotton, "Operation, Maintenance and Sustainability of Services for the Urban Poor: Findings, Lessons Learned and Case Studies Summary and Analysis". WEDC, Loughborough University.	2019
5.	Cyrus Njiru, Brian Reed and Darren Saywell, "Improving water utility management and reduction of unaccounted-for water" WEDC, Loughborough University.	2006
6.	Kayaga, S., Njiru, C., Itiko, E. M., & Onyango-Awin, J. "Improving utility management: case study from Kisumu, Kenya" WEDC, Loughborough University.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-593 **Course Title:** Water Works Engineering
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on planning, design and operation of water works.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction to Water Works:** Historical Background; Drinking Water Standards; Components of a Typical Water Works System; Basic Design Considerations	4
2.	**Water Treatment Processes:** Water Quality constituents; Raw Water Intake; Treatment systems; Screening and Aeration; Coagulation, Flocculation and Precipitation; Sedimentation; Filtration; Color, Taste and Odor Control; Disinfection and Fluoridation	10
3.	**Basic Design Consideration:** Regulatory Requirements; Initial Design Years and Staging Periods; Plant Capacity and Service Area; Source, Process; Treatment and Equipment Selection; Energy and Resources Requirement; Plant Economics, Environmental Impact Assessment	8
4.	**Conveyance, Measurement and Pumping:** Water Conveyance Systems; Flow Measurement; Pumps, Design, Operation Maintenance and Troubleshooting	4
5.	**Distribution Systems:** Equipment manufacturing for Clearwell; High Service Pumps and Distribution System; Operation Maintenance and Troubleshooting	6
6.	**Residual Processing and Disposal:** Sources and Characteristics of Residual Streams; Residual Processing; Design, Operation, Maintenance and Troubleshooting	5
7.	**Plant Siting, Layout, Yard Piping, Hydraulic Profile and Process Control:** Plant Siting; Plant Layout Considerations; Yard Piping and Hydraulic Profile and Design; Benefits and Need of Instrumentation and Control Systems; Components, and its design.	5
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	WHO "Guidelines for drinking-water quality (Vol. 1). World health organization, 4th Edition.	2017
2.	USEPA. Drinking Water Treatment Plant Residuals Management Technical Report.	2011
3.	James K Edzwald, "Water quality & Treatment: A Handbook on Drinking Water" American Water Works Association	2011
4.	Qasim, S. R., Motley, E. M. & Zhu, G., "Water works engineering -Planning, design, and operation", PHI.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-594 **Course Title:** Flow Hydraulics and Urban Drainage
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on the hydraulics of pipe flow and design of urban drainage system.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction:** Properties of fluids; Pressure and its measurement; Hydrostatic forces on surfaces; Buoyancy and flotation; Kinematics of flow; Ideal flow; Dynamics of fluid flow	8
2.	**Flow measurements:** Flow through orifices and mouthpieces; Notches and Weirs; Viscous flow; Turbulent flow; Flow through pipes; Forces on submerged bodies; Compressible flow	8
3.	**Flow analysis:** Strom water runoff generation; Frequency analysis; IDF relations; Design storm; Open channel flow in urban watersheds; Estimation of runoff rates from urban watersheds; Flow routing.	8
4.	**Urban drainage design and analysis:** Introduction to urban drainage; Types of urban drainage systems; Hydraulics of urban drainage systems; Sewerage layout and design; Sewer network operation; Hydrological and hydrodynamic modelling; Concept of Integrated Urban Drainage modeling; Developments in 1D, 2D and 1D-2D urban stormwater models; Sensitivity testing; Data collection and processing for urban drainage management; Conducting surveys; Verification and calibration	10
5.	**Management practices:** Need of Integrated water resources management; Urban water resource management; Social aspects of urban water management; Use of modern techniques in urban water management; Storm water and flood management; Water conservation and cycling.	8
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Butler, D. & Davies, J.W, Digman C, Makropoulos C. "Urban Drainage", Spon Press, 4th Edition.	2018
2.	Çengel, Y.A. & Cimbala, J. "Fluid Mechanics: Fundamentals and Applications", McGraw-Hill 4th Edition.	2018
3.	Chen, D.H. "Sustainable Water Management", CRC Press.	2016
4.	Shaw, E.M. "Hydrology in Practice" 4th Edition., Keith J. Beven, Nick A. Chappell & Rob Lamb.	2011
5.	Chow, V. T. "Open channel hydraulics" McGraw-Hill.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-595 **Course Title:** Circular Water Economy
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on planning, design, and operation of water infrastructure towards a circular and resilient approach considering paradigm shift in the water sector.
10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Introduction**: Circular economy; Linear economy; Resource scarcity; Climatic and Non-climatic challenges to cater the linear economy; Techno-economic feasibility; Social acceptance of a circular economy	10
2.	**Circular economy and resilience**: Application of circular economy principles in the water sector; Resilient and inclusiveness of water systems in the circular economy; The 6 R's in the circular water economy	6
3.	**Circular Economy in water Conservation:** Water efficiency; Reducing water wastage; Water utility-led water conservation	6
4.	**Developing the Circular Water Economy:** Reuse and Recycle- Industrial water reuse and recycling; Agricultural reuse; Urban reuse; Sustainable water management and circular economy in water-energy-food nexus	4
5.	**Circular Water Economy in Energy sector:** Recover-Renewable energy generation technologies at wastewater treatment facilities; Traditional renewable energy at water and wastewater treatment facilities; Resource recovery from wastewater	8
6.	**Circular Economy in water resources management**: Restore and Reclaim-Restoration of the water sources like groundwater, river water, water in lakes, artificial recharge; Managed Aquifer Recharge; Rejuvenation of water sources; Constructed Wetland (CW) technology; Repurposing the wastewater from residential buildings, industries or agriculture	8
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Delgado, A., Rodriguez, D. J., Amadei, C. A., & Makino, M., "Water in Circular Economy and Resilience (WICER)." World Bank, Washington, DC.	2021
2.	Brears, R. C., "Developing the circular water economy" Springer International Publishing.	2020
3.	WBCSD (World Business Council for Sustainable Development)., "Business Guide to Circular Water Management: Spotlight on Reduce, Reuse and Recycle", World Business Council for Sustainable Development.	2017
4.	UNIDO (United Nations Industrial Development Organization). "Circular Economy"	2017
5.	IWA. "Water Utility Pathways in a Circular Economy." IWA, London.	2016
6.	Veolia., "Water at the Heart of the Circular Economy.	2014
7.	McKinsey Global Institute. Resource Revolution: Meeting the World's Energy, Materials, Food, and Water Needs. McKinsey Global Institute.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Water Resources Development and Management

1. **Subject Code:** WRN-596 **Course Title:** Sustainable Water Resources
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** PEC
8. **Pre-requisite:** Nil
9. **Objective:** To impart knowledge on overall understanding and skill development to manage and protect water resources.

10. **Details of Course:**

S.No.	Contents	Contact Hours
1.	**Humans and Water:** Current and future challenges to water availability; Sustainable development and water; Climate change and water resources; Future of water resources (virtual water, desalination, reclaiming water); Water footprints (green, blue and grey) of products and consumers, sustainable water footprints	8
2.	**Balancing diverse needs for water:** Environment, ecosystem services, and the human right to water; Water budgets, Water balance; Multiple uses of water (classification of uses, water for agriculture); Water demand and supply (surface water and groundwater); Water reuse for agricultural and landscape irrigation; Industrial processes; Toilet flushing, and groundwater replenishing; Conjunctive water use	8
3.	**Identifying water resource protection/management areas:** Use of field methods; Computer models and geographic information systems (GIS); Freshwater Management (lakes and rivers)-values and functions; Coastal waters management- water quality issues; Impacts from watershed development, and coastal management techniques; Groundwater and stormwater management; Wetlands Protection	10
4.	**Assessing water sustainability:** Agricultural water use and relevance of food-water-energy nexus to sustainability; Concepts of water accounting, water quality, and pollution processes; Types and sources of contamination in surface water and groundwater (physical, chemical and biological parameters); Water quality standards; Water quantity and quality- monitoring and assessment; Models to assess the effects of management options, restoration, environmental or climate change; Sustainability Index of water resources – concepts and assessment	10
5.	**Water resources policy and Governance:** Role of local governments in water resources management; Global and local scale water-related problems, water scarcity challenges; Water Crowding; Guiding principles for water management; UN Millennium Goals; Nature based solutions, managed aquifer recharge (MAR) and its impact on ecosystems and quality of groundwater; Water economics	6
Total		**42**

11. Suggested Books

S.No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	United Nations., "Summary Report Global workshop for integrated monitoring of Sustainable Development Goal 6 on water and sanitation", UN-Water	2018
2.	Salam, P. A., Shrestha, S., Pandey, V. P., & Anal, A. K. "Water-energy-food Nexus principles and practices", John Wiley & Sons.	2017
3.	Chen, D.H., "Sustainable water management", Taylor & Francis.	2017
4.	Anderson, M.P., Woessner, W. W., & Hunt, R. J., "Applied groundwater modeling: simulation of flow and advective transport", Academic press.	2015
5.	Chapagain, A.K., & Tickner, D., "Water footprint: help or hindrance?", Water Alternatives, 5(3), 563-581	2012
6.	Mays, L. W., "Ground and Surface Water Hydrology", Wiley.	2012
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