INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./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 Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits**:** **4** 6. Semester**: Spring** 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.	**Non linear 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.	Jain, S. K. and Singh, V. P., "Water Resources Planning and Management", Elsevier.	2003
2.	Loucks, D.P., Stedinger, J.R. and Haith, D.A., "Water Resources Systems Planning and Analysis", Prentice Hall.	1981
3.	Ravindran, A., Philips, D.T. and Solberg, J.J., "Operation Research- Principles and Practice", Second Edition, John Wiley.	2000
4.	Rao, S.S. "Optimization - Theory and Applications", Wiley Eastern.	1984
5.	Sharma, J.K., "Operations Research", Macmillan.	1997
6.	Taha, H.A., "Operation Research - An Introduction", PHI.	2002
7.	Wurbs, R.A. and James, W.P., "Water Resources Engineering", PHI .	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN- 502** Course Title: **Design of Water Resources Structures**

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

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

4. Relative Weight **: CWS 25 PRS 0** **25** **50** **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge about the design of various water resources structures.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Design of hydraulic structures on permeable foundation including weir and barrage; determination of afflux and discharge intensity; waterway and looseness factor; stilling basin level and length; uplift pressures and exit gradient; floor thickness and protection works.	6
2.	Gravity dams- general features; forces acting on gravity dam; galleries and their functions; stability analysis; roller compacted RCC dams.	6
3.	Earth dams- homogeneous and zoned sections; filter design and stability analysis.	6
4.	Spillways-layout and design of various types of spillways; design of energy dissipaters.	5
5.	Intake Structures-trash racks and their cleaning and handling devices; stoplog arrangements; intake entrance; aeration vent; gate control.	4
6.	Tunnels-classification; rock cover; hydraulic design and supporting systems; concrete lining; portals and plugs; underground cavities.	4
7.	Gates- various types of gates for barrages; spillways; intakes; sluices; structural design considerations for vertical lift and radial gates.	5
8.	Hydro power-function; classification and main components (penstocks, surge tanks, hydro turbines, etc.) of hydro power stations.	6
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Book/Publisher	Year of Publication/Reprint
1.	Bickel, J .O., Kuesel, T.R. and King,, E.H., "Tunnel Engineering Handbook", CBS Publishers and Distributors.	2002
2.	Mosoyni, E., "Water Power Development", Nem Chand and Bros.	2009
3.	Singh, B. and Varshney, R.S., "Embankment Dam Engineering", Nem Chand and Bros.	2004
4.	Varshney, R. S., "Hydro Power Structures", N.C. Jain.	2001
5.	Varshney, R. S**.,** "Gates and Valves ", Nem Chand and Bros.	2002
6.	Varshney, R.S., Gupta, S. C. and Gupta, R. L. "Theory and Design of Irrigation Structures", Nem Chand and Bros.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./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 Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge of planning and managing surface water resources at project and regional levels.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Objectives of water resource development; needs and opportunities; societal goals.	3
2.	Spatial and temporal characteristics of water resources; constraints for its development like non-reversibility; planning region and horizon.	4
3.	Financial analysis of water resources projects; allocation of cost of multipurpose projects; repayment of cost.	8
4.	Demand for drinking water; irrigation, hydropower; navigational; planning for flood control.	6
5.	Characteristics and functions of reservoir; reservoir sedimentation; conservation storage; conflict among uses, Reservoir operation studies - effect on river regime; long term simulation; reliability; resiliency and vulnerability assessment.	8
6.	Ground water evaluation; conjunctive use of surface and ground water.	2
7.	Discounting techniques; benefit cost parameters; estimation of benefits and costs; appraisal criteria; social benefit cost analysis.	4
8.	Basin planning; inter-basin transfer of water.	3
9.	Environmental impacts assessment guidelines and case studies.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	James, L .D., and Lee, R. R., "Economics of Water Resources Planning", Mc Graw Hill.	1971
2.	Modi, P.N., 'Irrigation, Water Resources and Water Power Engineering', Standard Book Pub., Delhi.	1995
3.	"Guidelines for Preparation of Detail Project Reports of Irrigation and Multipurpose Projects", Ministry of Irrigation, Govt. of India.	2002
4.	Garg, S.K., "Irrigation Engineering and Hydraulic Structure", Khanna Publishers.	2004
5.	Subramanya, K., "Engineering Hydrology", Tata McGraw Hill Publishing Company.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-504** Course Title: **Applied Hydrology**

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

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

4. Relative Weight **: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on hydrologic aspects of investigations, planning, design and operations of river valley projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Hydrologic design requirements, hydrologic cycle, classification of processes and models	**4**
2.	**Hydrologic Data:** Observation and collection; Processing - supplementing, consistency checking, corrections and presentation	**7**
3.	**Frequency Analysis:** Probability distributions, statistical analysis, return period of flood and storm, outliers, regional flood frequency, confidence interval and goodness of fit	**8**
4.	**Rainfall runoff models:** Empirical, conceptual and physical; Unit hydrograph; Decisions with inadequate hydrologic data	**8**
5.	**Hydrologic Design:** Design criteria, dependable yield, design storm, design flood estimation, reservoir and channel routing	**8**
6.	**Flood Forecasting:** Travel time, correlation, telemetry, gage and discharge forecasting	**4**
7.	**Elements of Groundwater Hydrology:** Ground water recharge, ground water balance, aquifer properties	**3**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Chow, V.T., Maidment, D. R. and Mays, L. W., "Applied Hydrology", Tata McGraw Hill.	1988
2.	Mishra, S.K. and Singh, V.P., "Soil Conservation Service-Curve Number Methodology", Kluwer Publication.	2003
3.	Mutreja, K. N., "Applied Hydrology" Tata McGraw Hill.	1986
4.	Subramanya, K., "Engineering Hydrology", Tata McGraw Hill.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-511** Course Title: **Geotechnical Engineering**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge on theory and analysis of soil mechanics for design of water resources structures, compaction and consolidation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Composition and classification of soil:** Importance of soil mechanics in water resources applications; Textural properties and their determination; Identification and classification of soils	**4**
2.	**Seepage analysis:** Flow net; Theory of seepage and analysis; Quick-sand phenomenon and seepage forces	**5**
3.	**Compressibility and consolidation:** Compressibility of soil; Terzaghi's theory of consolidation; Secondary consolidation	**6**
4.	**Shear strength of soils:** Friction; Mohr's circle; Strength theories for soils; Pore pressure parameters; Shearing characteristics of sand and clay	**5**
5.	**Stability of earth slopes:** Earth pressures; Stability of retaining walls; Bearing capacity; settlement analysis	**4**
6.	**Foundation–** Types of shallow foundation, foundation on nonuniform soils; Deep foundation; Design and construction of pile foundation	**6**
7.	**Engineering geology:** Classifications and properties of rocks, folds, faults, joints; Unconformities and their bearing on engineering structures; Geophysical and geological explorations for various engineering projects	**6**
8.	**Rock mechanics:** Theories of failure and strength of rock masses; Geological investigations of dams, reservoirs and tunnels; Design of rock anchors and cables for slopes, dam abutments and foundation	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Krynine, M. G. and Judd, W. R., "Principles of Engineering Geology and Geotechnics", McGraw Hills.	1957
2.	Obert, L. and DuvalI, W.I., "Rock Mechanics and Design of Structure in Rock", John Wiley.	1967
3.	Punmia, B.C., "Soil Mechanics and Foundation", Standard Book House.	1981
4.	Terzagi, K., "Theoretical Soil Mechanics", John Wiley.	1943
5.	Venkatramaiah, C., "Geotechnical Engineering", New Age International	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-512** Course Title: **Hydropower and Appurtenant Works**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on various types of hydroelectric power stations and other related appurtenant works.

110. Details of Course:

S. No.	Contents	Contact Hours
1.	**Surface hydro power stations**: Basic functional features and typical general arrangements; Classification of surface power houses, vertical sub-divisions, type of super structures; Overall layout, preliminary dimensions of various components, main floor levels	6
2.	**Arrangement at various floors:** Details of auxiliary equipment, arrangement at various floors, joints, collection of data, design and indexing of loads	6
3.	**Stability analysis of powerhouse:** Stability of substructures, intermediate structures and superstructures	6
2.	**Underground power stations**: Number and size of cavities, their location and alignment, auxillary equipments and their arrangement, supporting arrangements for roof and sides, design considerations, design of gantary girder column	6
3.	**Tunnels and shafts:** High head pressure tunnels and shafts, design considerations, design of concrete lining and steel liner, pre- stressed concrete lining, grouting and drainage	6
4.	**Surge tanks**: Characteristics and suitability of various types of surge tanks like simple, restricted orifice and differential types, criteria for design and stability, hydraulic design	4

5.	**Penstocks:** Water hammer phenomenon, velocity and pressure waves, estimation of over-pressures by arithmetic integration and by use of charts and curves, effects of over pressure on governing of turbines; Forces acting on penstock pipe lines and preliminary design of steel penstocks, fabrication and testing of penstocks; Design of anchors, piers and saddles	6
6.	**Switchyard**: Equipments in the switchyard and their layout, design of foundation	2
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Book /Publisher**	**Year of Publication/Reprints**
1.	Brown, Gutherie, "Hydroelectric Engineering Practice", Blackie and Sons.	1958
2.	Mosoyni, E., "Eater Power Development", Nem Chand and Brothers.	2009
3.	Nigam, P.S., "Handbook of Hydroelectric Engineering", Nem Chand and Brothers.	1979
4.	Varshney, R. S., "Hydro Power Structures", Nem Chand and Brothers.	2001
5.	Varshney, R. S., "Water Power Systems", Planning and Economics" , Nem Chand and Brothers.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-513** Course Title: **Earth and Rock Fill Dam**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on design and analysis of earth and rock fill dams.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Materials properties of soils:** Pore pressure parameters; Hilf Bishop method; Shear strength of soils; Mohr Coulomb failure criterion; Factors contributing to slope failure	4
2.	**Design criteria:** Types of earth dams; Design considerations- Freeboard calculations, dam section, upstream slope protection; Design considerations in earthquake regions; Filter design; Causes of damage and failure, typical case studies.	6
3.	**Seepage control:** Control of seepage through earth dam on pervious soil foundation and on impervious base; Cutoff trench; Sheet pile; Alluvial grouting; Slurry trench; Horizontal upstream blanket; Relief wells; Loading berm; Treatment of rock foundations and grouting	8
4	**Stability analysis:** Total and effective stress methods of analysis; Standard method of slices, Simplified Bishop method; Wedge method; Stability conditions during construction, full reservoir and reservoir drawdown	8
5	**Analysis of dam:** Introduction to finite element method (FEM); FEM analysis of dams; Nonlinearity in soils	4
6	**Rockfill dam:** Considerations favouring choice of a rockfill dam; Principles of design; Selection of materials; Stability analysis by wedge method, Different types of impervious cores and their locations; Different types of face members; Settlement in rock fill dams; Procedure for placement and compaction of rock fill	5
7	**Instrumentation in earth dams:** Measurements of deformations, pore pressures; Quality control; Foundation preparation and treatment; Quality control of materials and control of moisture, laying and compaction; Tests for quality control; Diversion during construction	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1	Abramson, L.W., Lee, T.S., Sharma, S. and Boyce, G.M., "Slope Stability and Stabilization Method", John Wiley.	1996
2	Creager, W. P., Justin J.D. and Hinds, "Engineering for dams", Wiley Eastern.	1968
3	Hirschfeld, R.C. and Poulos, S.J., "Embankment Dam Engineering - Casagrande Volume" , John Wiley.	1973
4	Sherard, J.L., Woodward, R.J., Gizienski, S.F. and Clevenger, W.A., "Earth and Earth-Rock Dams", John Wiley.	1963
5	Singh, B. and Sharma, H.D., "Earth and Rock Fill Dams", Sarita Prakashan.	1976
6	Singh, B. and Varshney, R.S., "Embankment Dam Engineering", Nem Chand and Brothers.	2004
7	Department of Interior, "Design of Small Dams", United States Bureau of Reclamation.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-514** Course Title: **Masonry and Concrete Dams**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: Nil**

9. Objective: To impart knowledge on design and analysis of masonry and concrete dams.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Selection of site for different types of dams, selection of materials, layout of works; Properties of concrete as related to dams	4
2.	**Gravity Dams:** Forces acting on a dam including uplift and wave forces; Design criteria for stability; Determination of dam profile; Computation of stresses by gravity analysis; Elastic analysis by finite element method and structural modelling techniques; Seismic design and analysis; Determination of internal stresses	8
3.	**Foundation treatment:** Preparation of foundation including consolidation; Curtain grouting and treatment of faults and weak zones; Foundation cutoffs and drainage arrangements; Layout and location of spillway; Powerhouse and other appurtenances	5
4.	**Stressed and their management:** Stresses around openings; Design of galleries in dams; Temperature stresses and methods of temperature control; Joints and seals	7
5.	**Instrumentation and maintenance aspects:** Instrumentation and analysis of data; Deterioration of concrete in dams and remedial measures	6
6.	**Hollow and buttress dams:** Principles of hollow gravity dams; Stability criteria and determination of internal stresses	6
7.	**Arch dams:** Classification, principles of layout and factors affecting layout; Theories for arch dam analysis	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Creager, W. P., Justin J.D. and Hinds, "Engineering for Dams", Wiley Eastern.	1968
2.	Golze, A.R., "Handbook of Dam Engineering", Van Nostrand Reinhold.	1977
3	Sharma, H.D., "Concrete Dams", CBIP Publication.	1998
4	Department of Interior, "Design of Gravity Dams", United States Bureau of Reclamation.	1976
5	Department of Interior, "Design of Arch Dams", United States Bureau of Reclamation.	1977
6	Varshney, R.S., "Concrete Dams", Oxford and IBH Publishing.	1977

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-515** Course Title: **Irrigation Structures**

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

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

4. Relative Weight **: CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on the design of various irrigation structures.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Site selection and investigations for diversion works; Hydraulics of flow over weirs/under sluices; Hydraulic jump, seepage theory, Khosla theory, scour depth estimation, critical exit gradient	8
2.	Design flood estimation; Types and design of energy dissipaters; protection works, transitions	6
3.	Components of barrage- waterway, undersluice/weir, glacis, stilling basin and appurtenance works, cutoff, u/s and d/s protection works; Hydraulic design of barrage; Head regulator; Cross regulator	8
4.	Types of cross drainage works; Design aspects of aqueducts, siphon aqueducts, super-passage, siphon	6
5.	Concept of sediment removal, fall velocity, difference between sediment exclusion and ejection devices, design aspects of sediment excluder and sediment ejector	6
6.	Types of loads and their combinations; Structural design of raft foundation, piers, abutments, and retaining walls	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Singh, B., "Fundamentals of Irrigation Engineering", Nem Chand and Brothers.	2005
2.	Varshney, R.S., Gupta, S.C. and Gupta, R.L., "Theory and Design of Irrigation Structures", Nem Chand and Brothers.	2005
3.	Asawa, G.L., "Irrigation and Water Resources Engineering", New Age International.	2005
4.	Arora, K.R., "Irrigation, Water Power and Water Resources Engineering", Standard Publishers Distributers.	2007
5.	Garg, S.K. "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./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 Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

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, selection, protection, contamination 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	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/Reprints
1.	Garg, S. K, "Water Supply Engineering", Khanna Publishers.	2008
2.	Jeppson, R., "Analysis of Flow in Pipe Networks", Ann Arbor Science.	1976
3.	Mays, L.W., "Urban Water Supply Handbook", McGraw Hill.	2002
4.	Ministry of Urban Development, "Manual on Water Supply and Treatment", CPHEEO, Government of India.	1999
5.	Peavy, H.S. and Rowe, D.R. and Tchobanoglous, G., "Environmental Engineering", McGraw Hill.	1985
6.	Qasim, S. R., Motley, E. M. and Zhu, G., "Water works engineering -Planning, design, and operation", PHI.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-517** Course Title: **River Engineering**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: Nil**

9. Objective: The impart knowledge of river mechanics and various river management techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Sediment Transport Processes:** Incipient motion of sediment particles; Regimes of flow; Resistance to flow and velocity distribution in alluvial streams; transport of bed, suspended and total load	8
2.	**River Morphology:** Plan form variations and river channel pattern; Meandering and braided stream characteristics; River equilibrium, river dynamics and adjustments to stream power	8
3.	**River Training Techniques:** Principles of stabilisation and rectification of rivers, river bank stability analysis, spur / groyne, stream bank armouring, guide banks, submerged vanes, porcupine and jack jetty systems, gabions; Bandalling, surface and bottom panels	8
4.	**Inland Navigation Channel Development:** Fairway dimensions and maintenance, canalization, navigation locks and terminals	5
5.	**River Models:** Mathematical modelling - types, mathematical formulation, numerical procedures, calibration and validation; Scale modelling – types, principles of similitude and dimensional analysis, model verification, limitations	8
6.	**Flood Management and Remote Sensing Applications:** Flood control planning, flood plain zoning and other non – structural measures, use of satellite imageries and topo sheets for DEM generation for flood plain zone mapping	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/ Reprints
1.	Blazejewski, R., Pilarczyk, K.W, and Przedwojski, B., "River Training Techniques: Fundamentals, Techniques and Applications", A. A. Balkema, Rotterdam.	1995
2.	Cunge, J. A., et. al., "Practical Aspects of Computational River Hydraulics", Pitman Advance Pub. Program.	1980
3.	Garde, R. J. and Rangaraju, K. G., "Mechanics of Sediment Transportation and Alluvial Stream Problems", New Age International (P) Ltd. Revised Reprint 3rd Edition.	2006
4.	Jansen, P. P., et. al., "Principles of River Engineering"; Pitman Publishing Co.	1979
5.	Julien, Pierre, Y., "River Mechanics", Cambridge University Press.	2002
6.	Peterson, Margaret, S., "River Engineering"; Prentice Hall.	1986
7.	Shen, H. W., "Modeling of Rivers", John Wiley and Sons.	1979

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-518** Course Title: **Finite Element Methods**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: Nil**

9. Objective: To impart knowledge of fundamentals and applications of finite element method and its application to engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Finite difference method (FDM), finite element method (FEM), advantages of FEM over FDM and matrix algebra.	4
2.	**Basics of FEM:** Steps, formulation of element equations, shape functions for triangular elements, load and strain displacements, stress strain relations, variational principles	6
3.	**Weighted Residual Methods:** Collocation, sub-domain, Galerkin's and least square	4
4	**Shape Functions:** Linear elements, element equations, iso-parametric elements, Hermite polynomial, Jacobian matrix, numerical integration, two dimensional, Lagrangian, triangular and trapezoidal elements	8
5	**Solution Techniques:** Axisymetric problems - element equations, stiffness matrix, boundary conditions; Direct and Iterative methods, band solver and frontal solution techniques	8
6	**Applications of FEM:** Heat flow problems in one, two and three dimensions; Beams and trusses; Dams and seepage problems	8
7	**Software Applications:** Case studies, data preparation, processing and result reporting for field problems	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1	Desai, C. S., and Abel, J.E., "Introduction to Finite Element Method" , Van Nostrand Reinhold Company.	1972
2	Desai, C.S., and Christian, J.T., "Numerical Methods in Geotechnical Engineering", Mc Graw Hill.	1977
3	Hinton , E. and Owen, D.R. J., "Finite Element Programming", Academic Press.	1977
4	Norrie, D.H.; De Vries, G., "Introduction to Finite Element Analysis", Academic Press.	1978
5	Segerlind, L.J., "Applied Finite Element Analysis", John Wiley and Sons.	1976
6	Tirupathi, R. Chandrupatla and Belegundu, Ashok D. "Introduction to Finite Elements in Engineering", Pearson Education.	2002
7	Zienkiewicz, O.C., "The Finite Element Method", McGraw Hill.	1973

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-519** Course Title: **Water Resources System Reliability**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on the risk and reliability estimation of water resources systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Concepts of perceived and statistical risk, role of risk assessment in modern technological, social, and environmental context	4
2.	**Risk Assessment:** Techniques, application of probabilistic and Markov models, uncertainty in risk assessment, decision-making under uncertainty and risk	8
3.	**Fuzzy Theory:** Introduction, applications in risk analysis	6
4.	**Reliability concepts:** Bath tub curve, hazard rate, failure density functions, repairable and non-repairable systems, mean time to failure (MTTF), mean time between failures (MTBF), mean time to repair (MTTR)	6
5.	**Reliability Estimation:** Useful life of components, reliability estimation under extreme value distributions	4
6.	**Water Resources Systems Reliability:** Series, parallel and non-series-parallel systems reliability, fault tree analysis (FTA)	8
7.	**Performance Evaluation:** Reliability, resiliency, and vulnerability assessment; Case studies	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Billinton, R., and Allan, R., "Reliability Evaluation of Engineering Systems : Concept and Techniques" Pitman Books	1983
2.	Henley, E.J., and H. Humamoto., "Reliability Engineering and Risk Assessment", Prentice Hall.	1981
3.	Mays, L W., and Tung. K., "Hydrosystems Engineering and Management", McGraw Hill.	1992
4.	Mishra, K. B., "Reliability Analysis and Prediction – A Methodology Oriented Treatment", Elsevier.	1992
5.	Singh, V. P., Jain, S. K, and Tyagi, A., "Risk and Reliability Analysis – A Handbook for Civil Engineers", ASCE, Reston.	2007
6.	Shooman, M. L., "Probabilistic Reliability: An Engineering Approach", McGraw Hill.	1968
7.	Zimmermann, H J., "Fuzzy Set Theory and its Applications", Allied Publisher.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-520** Course Title: **Environmental Impact Assessment of Water Resources Projects**

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

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

4. Relative Weight **: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00**

5. Credits**: 04** 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on environmental aspects of river valley projects and methods for impact assessment and management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Human concern; Need for environmental impact assessment (EIA); Requirements and levels of EIA; Potential impacts of water resource development projects	**6**
2.	**EIA Procedure:** Screening, baseline data, scoping, terms of reference (TOR)	**4**
3.	**Environmental Clearance:** Guidelines, acts and legislations, codes and country practices	**4**
4.	**Environmental flow:** River as habitat, downstream direct and indirect uses, criteria and methods of assessment	**4**
5.	**Soil and Water Quality Management:** Effect of project development on soil and water quality, water logging, soil salinity, and contamination, remedial measures	**5**
6.	**Rehabilitation:** Submergence effects, rehabilitation guidelines, planning, and procedures	**4**
7.	**Monitoring:** Parameters to be monitored, frequency of monitoring, reporting procedures	**4**
8.	**Remote Sensing and GIS Applications:** Monitoring of land use changes, digital elevation model (DEM), assessment of land degradation, catchment area treatment plan	**6**
9.	**Simulation Exercises and Case Studies**	**5**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Book /Publisher	Year of Publication/ Reprints
1.	Govt. of India, "Environmental Impact Assessment of Development Projects", Ministry of Environment and Forests.	1989
2.	Canter, L. W., "Environmental Impact Assessment", McGraw Hill.	1996
3.	Govt. of India, "EIA Notification 2006", Ministry of Environment and Forest.	2006
4.	Bureau of Indian Standards, "Parameters for EIA of Water resources Project", IS 5442:2004.	2004
5.	Burrough, P. A., "Principles of Geographic Information System for Land Resources Assessment" Clarendom Press.	1998
6.	Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographic Information System". Narosa Publishers	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-521** Course Title: **Groundwater Hydrology**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: PEC**
8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge on groundwater behavior, characteristics and its hydrology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Occurrence of groundwater sources; Groundwater bearing formations; Classification of aquifers; Flow and storage characteristics of aquifer; Hydrologic budget	**4**
2.	**Groundwater movement:** Darcy's law; Hydraulic conductivity and its determination; Anisotropy and heterogeneity; Groundwater flow rates and directions, governing equations for groundwater flow; Analytical solutions, general flow equation; Unsteady flow	**6**
3.	**Well hydraulics:** Steady unidirectional and radial flow; Unsteady radial flow in confined and unconfined aquifers; Leaky aquifer; Determination of aquifer parameters; Pumping tests and analysis; Well flow near different boundaries; Multiple well systems; Interference of wells	**6**
4.	**Groundwater wells:** Types and features of each type of wells; Well development, yield test	**4**
5.	**Groundwater quality:** Indian and international standards; Pollution of groundwater and possible sources; Remedial and preventive measures	**4**
6.	**Groundwater flow modeling:** Need of groundwater flow models; numerical modeling, 2D and 3D groundwater flow models; MODLFOW and its application	**6**
7.	**Conjunctive use planning:** Planning of groundwater development; Conjunctive use models, constraints, application in water resources management	**6**

8.	**Groundwater conservation:** Regional groundwater budget; Resource assessment; Estimation of recharge; Artificial recharge; Rainwater harvesting	**6**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Book /Publisher**	**Year of Publication/Reprints**
1.	Bear J., "Hydraulics of Groundwater" McGraw Hill.	**1979**
2.	Delleur, J.W., "The Handbook of Groundwater Engineering", Springer Verlag	**1998**
3.	Rastogi, A.K., "Numerical Groundwater Hydrology", Penram International	**2007**
4.	Todd, D. K. and Mays L.W., "Groundwater Hydrology", John Wiley.	**2005**
5.	Walton, W.C. "Groundwater Resources Evaluation" McGraw Hill.	**1970**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-522** Course Title: **Climate Change and Water Resources**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge on the concepts of climate change and impact assessment of climate change on water resources.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to atmospheric science; Earth, its atmospheric cycle and its relation with climate; Green house gas and climate change; Earth and green house effect; Past climate change; Lessons from history; Present and future climate changes	**7**
2.	Ecological effect on freshwater systems- surface water, ground water and glaciers; Agriculture; Marine environment; Causes, human dimension- impact of human settlement and infrastructure, environmental quality	**8**
3.	Analysis for climatic change assessment, statistical analysis of long-term meteorological and hydrological data; Trend analysis	**8**
4.	Available climatic models such as GCM; Hydrologic models such as SWAT and Mike11; Downscaling of GCM to regional/local scales	**8**
5.	Mitigation- capture of sequester carbon emissions, reducing global warming, renewable energy technologies, efficient use of energy	**6**
6.	Policy, laws, economics, benefits and costs of mitigating climate change, international cooperation	**5**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Dowden, M., "Climate Change and Sustainable Development-Law, Policy and Practice", EG-Books.	2008
2.	Hardy, J.T., "Climate Change-Causes, Effect and Solutions", John Wiley.	2003
3.	Las, D.S., "Climatology", Sharda Pustak Bhawan.	2005
4.	Mirza, M.M.Q. and Ahmed, Q.K., "Climate Change and Water Resources in South Asia", A.A. Balkema Publishers, Taylor and Francis Group.	2005
5.	Rohil, V.R. and Vega, A.J., "Climatology", Jones and Bartlett.	2008
6.	Schubert, R., Hammerschmidt, G. and Scheu, H., "Climate Change as a Security Risk", Earthscan.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-531** Course Title: **Hydro Generating Equipment**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on design, construction, acceptance testing and operation of hydro-turbines and generators.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Characteristics and specification of hydro-generators; constructional details- bearings and bearing location; brakes and jacks for hydro-generators.	8
2.	Cooling and ventilation- insulation and temperature limits; fire protection; electrical and mechanical tests; operating limits of hydro generators.	8
3.	Unit transformer and bus duct- excitation system and voltage regulators; excitation requirement; sources; drives; automatic excitation control equipment; typical schemes.	6
4.	Different types of turbines with their constructional details including reversible pump turbines, tubular, bulb and straflow turbines their characteristics and selection.	10
5.	Cavitation and Turbine setting; testing of water turbines at manufacturer's works and at site, model tests.	6
6.	Mechanical governors, electro hydraulic governors, digital governors, pressurized oil system for hydro-turbines.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Brown,G. J., "Hydroelectric Engineering Practice", CBS Publishers.	1984
2.	Kimbark, E.W., "Power system stability- Synhronous Machines" Wiley Interscience, John Wiley and Sons.	1995
3.	Krivchenko, G.I., "Hydraulic Machines, Turbines and Pumps", MIR Publishers.	1986
3.	Raabe, J., "Hydro Power", VDI-Verlag GmBH.	1985
4.	Walker, J.H., " Large A.C. Machines", Bharat Heavy Electricals Ltd.	1979
5.	Mosoyni, E., "Water Power Development", Nem Chand and Brothers.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-532** Course Title: **Hydropower System Planning**

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

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

4. Relative Weight **: CWS 25 PRS 0** **25** **50** **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge about the planning of hydropower development in a river basin.

110. Details of Course:

S. No.	Contents	Contact Hours
1.	Sources of energy and status of hydropower-global power scenario; hydropower policies of various countries; principles of hydropower development; components of a hydropower scheme, types of hydro power plants – run-of-river; valley dam; diversion canal plants; high head plants; pumped storage schemes, etc.; power house planning for surface and sub-surface hydropower plants.	10
2.	Rainfall–runoff relationships, flow measurement in rivers and streams, hydrograph analysis, design flood estimation, flow and power duration curves, power potential estimation, prediction of firm and secondary power, load curve, load, capacity, utilization and diversity factors, determination of installed capacity.	10
3.	Diversion structures, different types of dams and their suitability, site selection, intakes, spillways, and energy dissipaters.	6
4.	Water conveyance through penstocks-design criteria and economic diameter of penstock; conduit valves; water hammer.	6
5.	Economics and financial analysis of hydropower projects -time value of money; discount rate; single payment interest factors; uniform series factors; capital recovery factor;effect of inflation; depreciation; return on investment, Benefit cost analysis- Internal rate of return; levllisation; generation cost; energy pricing and tariff principles.	10
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Brown, G.J., "Hydroelectric Engineering Practice", Blackie and Sons.	1958
2.	James, L. D. and Lee, R. R., "Economics of Water Resources Planning", Mc Graw Hill.	1971
3.	Mosoyni, E., "Water Power Development", Nem Chand and Brothers.	2009
4.	Nigam, P.S., "Handbook of Hydroelectric Engineering", Nem Chand and Brothers.	1979
5.	Thuesen, G. J. and Fabrycky, W. J., "Engineering Economy", Prentice Hall.	2008
6.	Varshney, R. S., "Water Power Systems: Planning and Economics", Nem Chand and Brothers.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-533** Course Title: **Power System Protection Applications**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weight **: CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on power system protection applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Principles of power system protection application	2
2.	Current and voltage transformers– characteristics and application	6
3.	Electro-mechanical, static and microprocessor-based relays	6
4.	Electrical protection of generators and generator transformers	6
5.	Protection of transformers for electrical and incipient faults	4
6.	Different types of electrical protection applicable to bus zones	4
7.	Protection of transmission lines by over current, pilot-wire, distance and with carrier application	8
8.	Protection of single phase and three phase motors- induction and synchronous types; Protection of reactors, capacitor banks and industrial power systems	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	GEC Measurements, "Protective Relays - Application Guide"', General Electric.	1987
2.	Patra, S.P., Basu, S.K. and Choudhuri, S., "Power System Protection", Oxford and IBH Publishing.	1983
3.	Rao, T.S.M., "Power System Protection– Static Relays", McGraw Hill.	1981
4.	Mason, C.R., "The Art and Science of Protective Relaying", Wiley Eastern.	1984
5.	Blackburn, J.L., Domin, T.J., "Protective Relaying Principles and Applications", CRC Press.	2007
6.	Anderson, P.M., "Power System Protection", McGraw Hill.	1999
7.	Hewitson, L., Brown, M. and Ramesh, B., "Practical Power Systems Protection", Newnes.	2005
8.	Singh, R.P., "Digital Power System Protection", Prentice-Hall.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-534** Course Title: **Substation and Transmission Line Design**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on planning and design of EHV lines, substation, their equipment characteristics and specifications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Transmission system planning including selection of voltage, AC and DC transmission systems, number of circuits	4
2.	Travelling waves, lightning phenomenon, lightning and switching surges, surge wave shapes over voltages in power systems- types lightning, switching and temporary control of over voltage, statistical characteristics of over voltage; Flashover characteristics of rods gaps and insulators	8
3.	Characteristics of lightning arresters and protective devices, selection of lightning arresters, insulation coordination, location of protective devices, direct stroke protection, protection of transformers, surge protection of generators	6
4.	Electrical design of overhead lines, choice of conductor, voltage regulation, losses, charging KVA requirements; Surge impedance loading; Stability considerations; Corona and radio interference characteristics	6
5.	Survey of transmission lines, plotting of profiles, planning and locating line supports; Inductive coordination between power and communication lines; Series and shunt compensation	6
6.	Design of various HV and EHV substations, switching and busbar schemes, typical layouts, oil and compressed air systems	4
7.	Power transformers- specification, types, rating electrical characteristic, insulation temperature rise	4
8.	Circuit breakers- types, ratings, electrical characteristics	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Begamudre, R.D., "EHV AC Transmission Engineering", New Age International.	2006
2.	Edison Electric Institute, "EHV Transmission Line Reference Book", General Electric.	1968
3.	EPRI., "Transmission Line Reference Book : 345 KV and Above", Wiley Eastern.	1990
4.	Gupta, P.V. and Satnam, P.S., "Substation Design and Equipment", Dhanpat Rai.	1983
5.	Pabla, A.S., "Electric Power Distribution", Tata McGraw-Hill	2004
6.	Bayliss, C.R., and Hardy, B.J., "Transmission and Distribution Electrical Engineering", Elsevier India.	2009
7.	McDonald, J.D., (Ed), "Electric Power Substation Engineering", CRC Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-535** Course Title: **Installation, Maintenance and Testing of Hydro Generating Equipment**

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

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

4. Relative Weight : **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on erection and commissioning of hydro turbine, generator and transformers in hydropower projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic components of hydro turbines, pre-requisite for erection of hydro turbine, erection of under water parts, concreting of embedded parts, erection of internal parts for Francis, Kaplan, Deriaz and Pelton turbines (vertical type), erection precision	10
2.	Erection of vertical large generator	4
3.	Hydraulic model testing of hydro turbines and on-site testing	4
4.	Pre-commissioning and commissioning tests on generator	6
5.	Erection of large power transformers, commissioning tests and preventive maintenance tests of solid and liquid insulation, reconditioning and reclaiming methods of insulating oil	4
6.	Preventive maintenance testing of generator insulation	4
7.	Routine and preventive maintenance and capital maintenance of hydro turbines and generators	4
8.	Testing of protective relays, over current, impedance and directional relays	4
9.	Preventive maintenance and its scheduling, maintenance of records, record keeping and analysis	2
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Carr, L. H. A., "The Testing of Electrical Machines", The Book Centre.	1963
2.	Walker, J. H., "Large AC Machines – Design, Manufacture, and Operation", BHEL.	1979
3.	Kerszenbaum, I., "Inspection of Large Synchronous Machines", IEEE Press.	1996
4.	Gill, P., "Electrical Power Equipment Maintenance and Testing", CRC Press.	2009
5.	Clemen, D.M., "Hydro Plant Electrical Systems", Penn Well.	1999
6.	Agarwal, K.C., "Electrical Power Engineering Reference and Applications Handbook", Knowledge Books.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **WRN-536** Course Title: **Maintenance Management in Power Plants**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on policies and schedules of maintenance and strategies for power plant equipments.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Importance of maintenance, objectives, functions, maintenance management strategies for hydro power stations and their organization.	4
2.	Maintenance policies and planning- maintenance strategies and their advantages and disadvantages, planned maintenance procedure, advantage of planned maintenance, scientific maintenance, safety in maintenance	8
3.	Maintenance activities- optimal overhaul, repair or replacement policies for equipments subjected to breakdown, budgeting and control, production maintenance integration	8
4.	Replacement decisions- economic models, replacement policy, economics of preventive maintenance	8
5.	Maintainability and availability- economics of maintainability and reliability, maintainability increment, equipment availability	8
6.	Management information systems for maintenance	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Clifton, R.H., "Principle of Planned Maintenance", McGraw Hill.	1983
2.	Cunningham, C.E., "Applied Maintainability Engineering", John Wiley.	1972
3.	Enthory, K., "Maintenance Planning and Control", EWP.	1984
4.	Heintzelman, "The Complete Handbook of Maintenance Management", Prentice Hall.	1976
5.	Morse, P.M., "Queues, Inventories and Maintenance", Wiley.	1958

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-537** Course Title: **Power System Management**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on the organization and management of power utilities.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Management and its goals- management processes, managerial skills and performance, policy and objectives of a power utility; electricity industry and market- main concerns of electric utilities, performance of electric utilities, power sector changes	8
2.	Financial accounting of utility- balance sheet, income statement, accounting for depreciation, interest charges during construction, financial performance analysis	4
3.	Investment proposal- interest and compounding, measure of price- public and private perspective, internal rate of return and pay-back period	4
4.	Cost of generation, levellisation of cost of generation; Tariff for electricity- objectives, traditional approach, long-run marginal costs, general principles of tariff design	6
5.	Dynamic, spot and real time pricing strategy, bidding strategies	4
6.	Concepts and methods of demand side management (DSM)- load control, energy efficiency, load management, DSM planning, design, marketing, customer incentives	4
7.	Fundamentals of deregulation- privatization and deregulation, necessity for restructuring the power industry, necessity of unbundling of generation, transmission and distribution	4
8.	Components of restructured systems, independent system operators, functions and responsibilities, trading arrangements (pool, bilateral and multilateral), open access transmission system	4
9.	Different models of deregulation- Indian model, UK model, California model, Australian and New Zealand models, Japan model, Thailand model	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Bartol, K.M. and Martin, D. C., "Management" McGraw Hill.	1994
2.	Gellings, C.W. and Chamberlain, J.H., "Demand side Management : Concepts and Methods," Fairmont Press.	1988
3.	Lai, L.L., "Power System Restructuring and Deregulation," John Wiley.	2001
4.	Levy, H. and Sarnat, M., "Capital Investment and Financial Decissions," Prentice Hall.	1994
5.	Shahidehpur,M. and Alomoush, M., "Restructured Electrical Power Systems, Operation, Trading and Volatility," Marcel Dekker.	2001
6.	Stickney, C.P. and Weil, R.L., "Financial Accounting", Dryden Press.	1994
7.	Stoft, S., "Power System Economics: Designing Market for Electricity," IEEE Press, Wiley –Interscience.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-538** Course Title: **Electrical Design of Hydro Power Station**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: WH-511**

9. Objective: To impart knowledge on the design criteria and principles of electrical system design of hydroelectric stations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Selection of turbine and generating equipment for conventional, small hydro and pumped storage stations	4
2.	Types of pumping schemes- sources of power for pumping, starting of reversible units, pumped storage plant operation in the system, economics, choice of site, choice of plant	4
3.	Design and dimensional parameters of the turbine and generators; Cavitation and turbine setting	6
4.	Planning and layout of electrical equipment in a conventional, small hydro and pumped storage stations- case studies; Turbine governing, speed and pressure regulation, relief valves, frequency control	8
5.	Auxiliary power supply system design and equipment, power and control cables and their ratings	4
6.	Auxiliary system design and equipment for DC system and batteries, lighting system, grounding system, control and annunciation system and internal communication system	8
7.	Auxiliary system design involving air conditioning and ventilation system, lubricating oil system, fire protection system, power house crane and drainage and dewatering systems	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Brown, J. G., "Hydro-electric Engineering Practice, Vols. I - III", CBS Publishers.	1984
2.	Bureau of Indian Standards, Indian Standards Specifications and Guidelines (Relevant) on the equipment and systems.	Latest edition
3.	Prasad, M., Arora, J.K., Mathur, G.N. and Kanjia, V.K.,"Manual on Earthing of AC power Systems," Central Board of Irrigation and Power.	2007
4.	ASME Hydro Power Technical Committee, "The Guide to Hydropower Mechanical Design", Penn Well.	1996
5.	DiLaura, D., Houser, Mistrick, R. and Steffy, G., (Ede.), "The IES Lighting Handbook", IES.	2011
6.	Agarwal, K.C., "Electrical Power Engineering Reference and Applications Handbook", Knowledge Books.	2007
7.	Clemen, D.M., "Hydro Plant Electrical Systems", HCI Publications.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-539** Course Title: **Power System Operation and Control**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on judicious power system operation and control.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Modelling of generator, load, prime-mover, governor and excitation system	6
2.	Modelling of governor and excitation system	4
3.	Probabilistic methods for generation planning	4
4.	Unit commitment- spinning reserve, thermal unit constraint, hydro constraints and solution methods	4
5.	Long-term and short-term hydro-generation scheduling	4
6.	Hydro-thermal scheduling- problem formulation and solution	4
7.	Interchange evaluation- economy, capacity, diversity emergency power, inadvertent power exchange, energy banking	4
8.	Power pools- energy broker system, centralized economic dispatch of a power pool, allocating pool savings	4
9.	Power system security evaluation, factors affecting power system security, contingency analysis	4
10.	Power system state estimation- maximum likelihood weighted least squares estimation, detection and identification of bad data, application of power system state measurement	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Cohn, N., "Control of Generation and Power flow on Interconnected Systems", Wiley.	1966
2.	El-Hawary, M.E. and Christensen, G.S., "Optimal Economic Operation of Electric Power Systems", Academic.	1979
3.	Kirchmeyer, L.K., "Economic Operation of Power Systems", Wiley.	1958
4.	Kothari, D.P, "Power System Engineering", Tata-McGraw Hill.	2008
5.	Sterling, M.J.H., "Power System Control", Peregrinus.	1978
6.	Wood, A.J., Woolenberg, Bruce, F., "Power Generation Operation and Control", John Wiley.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-540** Course Title: **Control and Instrumentation of Hydro Power Plant**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To imparting knowledge on control and instrumentation of hydro power plants.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Essentials of measurement, implementation and scope of instrumentation; Performance characteristics, accuracy, response time, reliability and availability, types of equipment	6
2.	Measurement techniques and instruments for temperature, pressure, level, flow, speed, vibration, electric power and power factor measurement	10
3.	Strip-chart and X-Y recorders of galvanometric and servo types- magnetic recorder; FM recording technique; Indicating and display devices	4
4.	Control room instrumentation- design factors and validation, operator interface and ergonomics, computer based displays	4
5.	DC, AC pulse and digital telemetry, signal transmission media	8
6.	Automation schemes in hydro-electric power plants for start and stop operation	4
7.	Elements and functions of SCADA system, automatic controllers closed loop control; On-off, proportional, PI and PID controllers, pneumatic and electronic controllers, automatic controllers in hydro-electric plant	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Jervis, M.W. (Ed.),"Power Station Instrumentation," Butterworth Hienemann.	1993
2.	Johnson, C.D., "Process Control Instrumentation Technology," John Wiley.	1977

3.	Rangan, C.S., Sarma, G.R. and Mani, V.S.N., "Instrumentation Devices and System", Tata Mc-Graw Hill.	1983
4.	Cegrell,T., "Power System Control Technology", Prentice Hall.	1986
5.	Littler, D.J., Davies, E.J., Johnson, H.E., Kirkhy, F., Myerscough, P.B. and Wright, W., "Modern Power Station Practice (Vol. F)", ASM International.	2008
6.	Bolton, W., "Instrumentation and Control Systems", Newnes	2004
7.	Northrop, R.B., "Introduction to Instrumentation and Measurements", CRC Press.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-541** Course Title: **Power System Analysis**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on power systems analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Complex power in balanced transmission lines, per unit system, constant impedance representation of the loads, three winding transformers, autotransformers, delta-wye and wye - delta transformations	4
2.	Disturbance of normal operating conditions, fault types and their analysis, symmetrical components, sequence networks balanced three phase faults at no load and full load, analysis of unbalanced faults, application of current limiting reactors	4
3.	Load flow analysis, Gauss iterative method, Gauss-Seidel iterative method and its applications; Y_{bus}, application of acceleration factors, application of Gauss-Seidel method Z_{bus}; Newton - Raphson method and its applications in rectangular coordinates and polar coordinates; Decoupled load flow method, fast decoupled load flow method, DC load flow method	10
4.	Linear models of the synchronous machine, steady-state equations and phasor diagrams, initial conditions for a multi-machine system, analog and digital simulation of synchronous machine	10
5.	Excitation systems- control configuration, response, state-space description, computer representation, typical system constants, effect of excitation on generator performance	4
6.	Speed governing, modeling of governing system for hydro turbines	4
7.	Modeling of hydraulic turbine prime movers, conduits, surge tanks and penstocks, hydraulic system equations, hydraulic system transfer function, block diagram for a hydro system	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Anderson, P.M. and Fouad, A.A., "Power System Control and Stability", Wiley Interscience.	2003
2.	Gonen, T., "Modern Power System Analysis", Wiley.	1998
3.	Nagrath, I.J. and Kothari, D.P., "Power System Engineering", Tata McGraw-Hill.	1994
4.	Nagrath, I.J. and Kothari, D.P., "Modern Power System Analysis", Tata McGraw-Hill.	1994
5.	Murty, P.S.R., "Power System Operation and Control", Tata McGraw-Hill.	1984
6.	Kundur, P., "Power System Stability and Control", McGraw Hill.	1994
7.	Das, J.C., "Power System Analysis", Marcel Dekker.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-542** Course Title: **Power System Reliability**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on reliability techniques used for design and planning of power systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic probability theory, binomial distribution, Poisson distribution, normal distribution, adequacy and security evaluation	4
2.	Basic reliability concepts- general reliability function, exponential distribution, mean time to failure, series and parallel systems, Markov and continuous Markov processes, recursive techniques; Other Markov applications- simple series and parallel system models	4
3.	Component reliability- non-repairable components, hazard models, components with preventive maintenance, repairable components, ideal repair, ideal repair and preventive maintenance, repairable components, normal repair and preventive maintenance	4
3.	Static generating capacity reliability evaluation-capacity outage probability tables, the loss of load probability method, load forecast uncertainty, the loss of energy probability method, frequency and duration approach	6
4.	Spinning generating capacity reliability evaluation-spinning capacity evaluation, load forecast uncertainty, derated capacity levels	4
5.	Transmission system reliability evaluation-average interruption rate method, frequency and duration method, stormy and normal weather effects, Markov process approach, system studies	4
6.	Composite system reliability evaluation- service quality criterion, conditional probability approach, simple system application, two-plant single load systems, two-plant two load systems, networked system approach	4
7.	Interconnected system generating capacity reliability evaluation- probability array for two systems, loss of load approach, reliability evaluation in more than two systems, interconnection benefits	4

8.	Direct current transmission system reliability evaluation- system failure modes, loss of load approach, frequency and duration approach, Spare valve assessment, multiple bridge equivalents	4
9.	Assessment of reliability worth- interruption cost for commercial users, industrial users, residential users and interruption energy assessment rate	4
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Book /Publisher**	**Year of Publication/Reprints**
1.	Billinton, R. and Allan, R.N., "Reliability Assessment of Large Electric Power System", Kluwer Academic.	1988
2.	Billinton, R., Ringlee, R.J. and Wood, A.J., "Power System Reliability Calculations", The MIT Press.	1978
3.	Endrenyi, J., "Reliability Modeling in Electric Power Systems", John Wiley.	1979
4.	Elmakais, D., "New Computational Methods in Power System Reliability", Springer – Verlag.	2008
5.	Billinton, R. and Allon, R.N., "Reliability Evaluation of Power Systems", Springer.	2006
6.	Pansini, A., "Transmission Line Reliability and Security", Marcel Dekker.	2004
7.	Brown, R., "Electric Power Distribution Reliability", Marcel Dekker.	2002
8.	Chawdhury, A.A. and Koval, D.O., "Power Distribution System Reliability – Practical Methods and Applications", John Wiley.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-543** Course Title: **Insulating Systems**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on insulating systems and their characteristics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Electrical conduction of dielectrics, volume resistance, electrical conduction in metals, semi-conductors and dielectric, band theory of solids, ionic and molionic electrical conduction of dielectrics, electrical condition of gases, dependence of resistivity of dielectric on various factors, surface conduction of dielectrics	6
2.	Polarization of dielectrics, relationship between capacitance and resistance of an insulator, polar and non-polar dielectric, polarization, dependence of permittivity on various factors, electric fields in non-homogeneous dielectrics, mechanical forces in dielectric	6
3.	Dielectric losses, basic definitions and equations, dependence of tan delta on various factors, dielectric losses under non-sinusoidal voltage	4
4.	Breakdown of dielectrics, breakdown of gaseous, liquid, solid dielectrics	4
5.	Non-linear dielectrics, ferroelectrics, capacitors with a barrier layer, piezoelectrics; Properties of dielectrics, wetting thermal and radiation properties	4
6.	Insulation of power transformers, construction of the insulation of power transformers, transient processes in transformer windings, internal protection of transformers, testing of transformer insulation	4
7.	Insulation of high voltage rotating machines and its construction, puncture voltages of the insulation of rotating machines, methods of elimination of corona in the insulation of rotating machines, transient phenomena in windings of electrical machines, testing of the insulating systems	4

8.	Insulation of high voltage power cables, types and construction, oil fuel cables, testing of cable insulations, insulation of power condensers, paper impregnated condenser insulation	3
9.	Preventive testing of insulation, measurement of tan delta and capacitance, partial discharges and methods of its detection, preventive testing of bushings, suspension and post insulators, preventive testing of transformer insulation, preventive testing of insulation rotating machines, preventive testing of cables with viscous impregnation	7
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Book /Publisher**	**Year of Publication/Reprints**
1.	Razevig, D.V. and Chourasia, M.P., "High Voltage Engineering", Khanna Publishers.	1978
2.	Tareev, B., "Physics of Dielectric Materials", English Translation, Mir Publishers.	1979
3.	Stone, G.C., Boulter, E.A., Culbert, I. and Dhirani, H., "Electrical Insulation for Rotating Machines", Wiley Interscience.	2004
4.	Malik, N.H., Al-arainy, A.A. and Qureshi, M.I., "Electrical Insulation in Power Systems", Taylor & Francis.	1997
5.	Arora, R. and Mosch, W., "High Voltage and Electrical Insulation Engineering", Wiley.	2011
6.	James, R. and Su, Q., "Condition Assessment of High Voltage Insulation in Power Equipment", The Institution of Engineering & Technology.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-544** Course Title: **Planning and Design of Small Hydro Power Scheme**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on planning and design of small hydro power schemes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Small hydro definition and country status, government policy for renewable energy development including small hydro, basic components of a small hydro scheme	4
2.	Hydrology, regional flow duration models, rainfall-runoff modeling for small catchments, flow duration, considerations for environmental flow	4
3.	Planning and design of diversion, intake, desilting and water conductor system	8
3.	Types of turbines for small hydro, their characteristics, construction and selection of turbine	6
4.	Synchronous and induction generators– characteristic, specification and application	4
5.	Power evacuation system, design, control systems	4
6.	Planning and design of auxiliary systems– cooling water, drainage and dewatering, ventilation and lighting	3
7.	Protection of synchronous and induction generators, protection of transformer and transformer feeder	3
8.	Economic and financial analysis of small hydro projects	3
9.	Case Studies– low, medium and high head small hydro projects	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Masonyi, E., "Water Power Development , Vol.I, and Vol.II, Part A and B", Nem Chand and Brothers.	2009
2.	Nigam, P.S., "Hand Book of Hydro Electric Engineering", Nem Chand and Brothers.	1985
3.	USBR, " Design of Small Dams," SBS.	2006
4.	Fritz, J.J., "Small and Mini Hydropower Systems", McGraw Hill.	1984
5.	Bureau of Indian Standards, Indian Standards Specifications and Guidelines (Relevant) on the Equipment and Systems.	Latest Edition
6.	Singh, A.N., Parasuraman, M.P., Tyagi, S.P., Ghose, D.P. and Ajwani, M.G., "Manual on Planning and Design of Small Hydroelectric Schemes", CBIP.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-545** Course Title: **Power Electronics Controlled Hydro-Electric Systems**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: The course aims to provide the role of power electronics in variable speed hydroelectric systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, Interdisciplinary nature of power electronics, interconnection of renewable energy sources and energy storage, Power semiconductor devices: Diode, Thyristor, Triac, GTO, BJT, Power MOSFET, IGBT, SIT, IGCT, commutation, line commutated diode and thyristor rectifiers: single phase and three phase, practical limitations, application of line commutated rectifiers	10
2.	Gate commutated inverters (DC to AC converter), single phase square wave inverter, single phase PWM inverter, three phase inverters, cycloconverters, AC voltage regulators.	5
3.	Static excitation systems, Variable speed operation of electric generators (synchronous and asynchronous): Equivalent circuit, operation at the power grid, autonomous operation, electrical losses and efficiency, modeling of synchronous and squirrel cage and doubly-fed induction machines in *d-q* frame, static power converters for induction generators, vector control of machine-side and source-side converters.	11
4.	Voltage, active power and reactive power control in variable speed hydro generators, parallel operation of induction generators, static capacitor exciter stand-alone induction generator for pumping applications, power control strategies for pumped storage system: load following and frequency droop control, power factor and displacement factor.	8
5.	Electromagnetic compatibility: analysis of harmonic distortion, acceptable levels of distortion in main supply system, voltage and current in the machine side converters, methods of reducing harmonic voltages, protection of ac converters and generators, installation and commissioning of converters	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Ned Mohan, Undeland T.M., Robbins W.P., "Power Electronics-Converters, John Wiley Publications, Third Edition.	2003
2.	Boldea I., "Variable Speed Generators," Taylor and Francis, CRC Press.	2006
3.	Boldea I., "Synchronous Generators," Taylor and Francis, CRC Press.	2006
4.	Barnes M., "Practical Variable Speed Drives and Power electronics," Elsevier Publications.	2003
5.	Keyhani A., Marwali M.N., Dai M., "Integration of Green and Renewable Energy in Electric Power System," John Wiley Publications.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-546** Course Title: **Modelling and Simulation of Hydro-Electric Energy Systems**

2. Contact Hours: **L: 1** **T: 1** **P: 4**

3. Examination Duration (Hrs.): **Theory 2** **Practical 2**

4. Relative Weight **: CWS 20 PRS 20 MTE 0 ETE 40 PRE 20**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on modeling and simulation of hydro-electric energy systems.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	Electromagnetic energy conversion modelling and analysis: Energy relationships - Energy in coupling fields - Interpretation of energy conversion – Steady state and dynamic performance of an electromechanical system	**8**
2.	Modeling of converters: Modeling of back to back converters based on Two-Level VSC Topology used for synchronous and asynchronous generators in hydroelectric energy system, Pulse Generation of the Controlled Switches	**11**
3.	Synchronous generator: Modeling of synchronous machine, excitation system, Simulation of developed model to study real and reactive power delivery, Abnormal operating conditions of synchronous generators	11
4.	Squirrel cage induction generator: Modeling of Squirrel cage induction generator, Modeling of excitation system, Simulation of developed model to study real and reactive power under grid disturbances: voltage unbalance, voltage sag/swell	10
5.	Doubly-Fed Induction Generator: Modeling of doubly fed induction generator – steady state modelling – dynamic modelling, Modeling of excitation system, Real and reactive power control of rotor circuit power converters, Doubly-Fed Induction Generator under grid disturbances	12
	Total	**52**

List of Experiments:

1. Modelling and simulation of three phase back to back voltage source converters
2. Modelling and simulation of synchronous and asynchronous electric machines
3. Modelling and simulation of DC excitation systems used for synchronous generators
4. Modelling of closed loop control of electric generators: real and reactive power control
5. Modelling of hydraulic turbines
6. Simulation of synchronous and asynchronous generators under grid disturbances: voltage unbalance, voltage sag/swell, torque-frequency analysis
7. Dynamic analysis of Doubly-Fed Induction Generator

11. Suggested Books:

Sl. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Boldea I., "Variable Speed Generators," Taylor and Francis, CRC Press.	2006
2.	Boldea I., "Synchronous Generators," Taylor and Francis, CRC Press.	2006
3.	Barnes M., "Practical Variable Speed Drives and Power electronics," Elsevier Publications.	2003
4.	Abad G., López J., Rodríguez M., Marroyo L., Iwanski G., "Doubly fed induction machine- modeling and control for wind energy generation" John Wiley & Sons Publications	2010
5.	Ong C-M., "Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK" Prentice Hall Publisher,	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-547** Course Title: **Synchronous and Asynchronous generators Laboratory**

2. Contact Hours: **L: 1** **T: 0** **P: 6**

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

4. Relative Weight **: CWS** 0 **PRS** 50 **MTE** 0 **ETE** 0 **PRE** 50

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

8. Pre-requisite**: NIL**

9. Objective: To impart practical knowledge different electric generators and their control systems used in Hydropower plants.

10. Details of Course:

Sl.No	Contents/Experiments	Contact/Lab. Hours
1	**Synchronous Generators -*Stand-alone operation*:** Efficiency determination under part load operation, Voltage Regulation, Voltage and frequency control, Electronic load controller ***Grid connected operation:*** Synchronization, Real and reactive power control, Analysis of harmonic distortion	10
2	**Squirrel cage Induction generator**: **Stand-alone operation:** Excitation capacitance calculation, No-load saturation current and voltage buildup, Load-voltage characteristics with different p.f loads, Effects of load voltage by inserting capacitor in serious with load, Loss of residual magnetism, Generator under short circuit condition, Performance comparison of induction machine working as motor & Generator: stator current, Magnetizing current, Power factor, Efficiency, Core losses, Air gap voltage. **Grid connected operation:** Real and Reactive power control, Parallel operation of induction generator	12
3	**Doubly fed induction machine (DFIM):** Power and energy measurement: Operation at stator short circuit, operation at rotor short circuit, Startup transient during motoring mode, Active and reactive power control at motoring and generation modes, Equivalent circuit parameters	11
4	**Adjustable speed operation of hydro generators:** synchronous generator, squirrel cage generator and DFIM, Active and reactive power control at variable speed, Voltage and frequency control using PWM voltage fed converter and dSPACE controller	11
5	Measurements of harmonic distortions in machine side and grid side converters during variable speed operation.	10
	Total	**54**

11. Suggested Books:

Sl. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Bose B.K., “Modern Power Electronics and AC Drives” Prentice Hall PTR	2002
2.	Boldea I., “Variable Speed Generators,” Taylor and Francis, CRC Press.	2006
3.	Boldea I., “Synchronous Generators,” Taylor and Francis, CRC Press.	2006
4.	Barnes M., “Practical Variable Speed Drives and Power electronics,” Elsevier Publications.	2003
5.	R. Krishnan “Electric Motor Drives: Modeling, Analysis, and Control” Prentice Hall.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-548** Course Title**: Power Electronics Laboratory**

2. Contact Hours: **L: 1** **T: 0** **P: 6**

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

4. Relative Weight **: CWS** 0 **PRS** 50 **MTE** 0 **ETE** 0 **PRE** 50

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

8. Pre-requisite**: NIL**

9. Objective: To impart practical knowledge ofdifferent switches and their control signal

10. Details of Course:

Sl.No	Contents/Experiments	Contact Teaching (T) and Practical (P) Hours
1	i) Characteristics of Silicon Controlled Rectifier (SCR) ii) Characteristics of Diode AC Switch (DIAC) iii) Characteristics of Triode AC Switch (TRIAC)	T-12, P-60
2	i)Characteristics of Power Metal Oxide Semiconductor Field Effect Transistor (Power MOSFET) ii)Characteristics of Insulated Gate Bipolar Transistor (IGBT)	
3	Study of Firing circuits and generation ofPWM signals for three phase converters.	
4	Single Phase SCR based Semi controlled and fully controlled Rectifier	
5	Three Phase SCR based Semi controlled Rectifierand fully controlled Rectifier	
6	Three Phase IGBT based PWM Rectifier(voltage source converter)	
7	Four quadrant DC Chopper (Class A,B,C,D & E)	
8	Single phase IGBT based PWM Inverter(voltage source Inverter)	
9	Three phase IGBT based PWM Inverter(voltage source Inverter)	
10	Three phase four quadrant back-to-back PWM Converter	
11	i)AC voltage controller using Thyristors ii)AC voltage controller using TRIAC	
12	Voltage and frequency control using Cycloconverter	
	Total	**T-12, P-60**

11. Suggested Books:

Sl. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Bose B.K., "Modern Power Electronics and AC Drives" Prentice Hall PTR	2002
2.	Ned Mohan, Tore M. Undeland and William P. Robbins "Power Electronics Application & Design"John Wiley & Sons	2007
3.	Muhammad Rashid "Power Electronics: Circuits, Devices & Applications" Pearson Education (4^{th} Edition)	2013
4.	Andrzej M. Trzynadlowski "Introduction to Modern Power Electronics" John Wiley & Sons	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-549** Course Title: **Control and Instrumentation Laboratory**

2. Contact Hours: **L: 1** **T: 0** **P: 6**

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

4. Relative Weight **: CWS** 0 **PRS** 50 **MTE** 0 **ETE** 0 **PRE** 50

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

8. Pre-requisite**:** WR-531 or Equivalent

9. Objective: To impart practical knowledge in control and instrumentation used in modern hydropower plants.

10. Details of Course:

Sl.No	Contents/Experiments	Contact Teaching (T)/ Practical (P) Hours
1	Control of Asynchronous hydro generators**:** Closed loop v/f control of squirrel cage induction machine using DSP controller, Time ratio and current limit control of induction machine using DSP/dSpace controller, Steady state Scalar and vector controls of induction machine	**T - 3, P-12**
2.	Sensorless control of induction machine using dSpace controller, Hysteresis current control, Closed loop speed control of Static Kramer drive, operation and control of Static scherius drive using back-to-back converter, Soft starting control of induction machine.	**T - 2, P-12**
3.	Closed loop speed control of wound rotor induction machine with rotor Power Converters, Start-up transient analysis	**T - 2, P-12**
4	Control of Synchronous hydro generators: standalone and grid connected operation, automatic voltage control, real and reactive power control, field oriented control of Synchronous machine using DSP/dSpace controller	**T -3, P-12**
5.	Automation of mini hydropower plants: condition monitoring of hydrogenating equipments based on stator current signal, vibration sensors and thermal image processing, Expert system design for automatic ON/OFF control of mini hydropower plants using PLC and sensors including level/speed/current/voltage sensors.	**T - 2, P-12**
	Total	**T-12, P-60**

List of Experiments

Control of Asynchronous hydro-generators

1. Closed loop v/f and vector control of squirrel cage induction machine using DSP controller
2. Sensorless control of induction machine using dSpace controller

3. Control of doubly fed induction machine with rotor circuit power converters

4. Hysteresis current control of induction machine using dSpace controller

5. Closed loop speed control of Static Kramer drive using dSpace controller

Control of Synchronous hydro-generators

6. Margin angle control and power factor control of Synchronous machine using dSpace controller

7. Closed loop v/f and vector control of Synchronous machine using dSpace controller

8. Soft starting control of Synchronous machine at motoring mode using dSpace controller

Automation of Mini Hydropower plants

9. Condition monitoring of hydro generators using Stator current signals

10. Condition monitoring of hydro generators including thrust bearings using vibration sensors

11. Condition monitoring of stator windings using thermal image processing

12. Automatic ON/OFF control of mini hydropower plants using PLC

11. Suggested Books:

Sl. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Bose B.K., "Modern Power Electronics and AC Drives" Prentice Hall PTR	2002
2.	Boldea I., "Variable Speed Generators," Taylor and Francis, CRC Press.	2006
3.	Boldea I., "Synchronous Generators," Taylor and Francis, CRC Press.	2006
4.	Barnes M., "Practical Variable Speed Drives and Power electronics," Elsevier Publications.	2003
5.	Littler, D.J., Davies, E.J., Johnson, H.E., Kirkhy, F., Myerscough, P.B. and Wright, W., "Modern Power Station Practice (Vol. F)", ASM International.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-551** Course Title: **Design of Hydro Mechanical Equipment**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge of hydro-mechanical equipments used in water resources development projects like turbines, pumps, penstocks, gates, valves, and hoists.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Different types of hydro turbines with their constructional details including reversible pump turbines, tubular, bulb and straflow turbines their characteristics and selection.	6
2.	Pumps for pumping water-characteristics; selection of size and type and constructional features .	8
3.	Gates for different types of spillways; barrages; under sluice and dam outlet, their general features and comparative merits; structural design of radial and vertical lift gates.	10
4.	Different types of hoists for gates- design of rope drum hoist; different types of valves and their selection.	6
5.	Different types of penstock layout- hydraulic and structural design of penstocks.	8
6.	Fabrication, handling, alignment, erection and support arrangement, painting and testing of penstocks.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Davis, C. V. and Sorensen, K. E., "Hand book of Applied Hydraulics", Mc Graw Hill.	1969
2.	Nigam, P. S., "Hand book of Hydroelectric Engineering", Nem Chand and Brothers.	1985
3.	Brown, G.J., "Hydroelectric Engineering Practice", Blackie and Sons.	1958
4.	Mosoyni, E., "Water Power Development", Nem Chand and Brothers.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-552** Course Title: **Construction Planning and Management**

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

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

4. Relative Weight : **CWS** **25** **PRS** **0** **25** **50** **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on CPM and PERT applications in construction planning and management of water resources projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Problems in planning and control of present day construction-applications of System Design Techniques; advantages and limitations of systems approach.	3
2.	Linear Programming applications like transportation and assignment models.	5
3.	Waiting line models for construction planning and management	4
4.	Inventory Models and Replacement Models in construction planning and management.	8
5	Network systems in project planning; use of CPM in planning scheduling and controlling of construction projects.	4
6	Network development and monitoring of construction projects.	4
7.	Network crashing and time-cost trade off in construction planning and management.	4
8.	Use of different techniques for resource allocation and leveling in construction planning and management.	4
9.	Use of PERT in construction planning- PERT analysis; use of dynamic programming in project evaluation and construction planning and management.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Punmia, B.C. and Khandelwal, K.K., "Project. Planning and Control with PERT and CPM", Laxmi Publications.	2004
2.	Srinath, L.S., "PERT and CPM, Prionciples and applications", EastWest Press.	2005
3.	Taha, H.A., "Operatioins Research- An Introduction", Pearson Education.	2005
4.	Varma, M., "Construction Planning and Management through System Techniques", Metropolitan Book Co.	1985

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-553** Course Title: **Design of Construction Job Facilities**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on different facilities required for construction of water resources development projects and their design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Requirements of material handling, mechanization of material movements on construction for construction sites for handling of earth and concrete	3
2.	Belt and bucket conveyors, bucket elevators, screw conveyors and calculations for sizes and capacities of conveyors including design of principal components	8
3.	Selection of type and design of pneumatic conveyors for conveying bulk cement	4
4.	Hoisting equipment and its design and selection for different working conditions	4
5.	Selection of type and design of cable-ways for aerial transportation and placement of concrete	5
6.	Design of compressed air and water supply system on construction projects; Estimating construct ion power requirements	6
7.	Design and layout of plant for production of aggregates including scalping crushing screening, washing, stockpiling and reclaiming	8
8.	Planning for shop services; base and field workshops; layouts for workshops and principal workshop equipment; equipment for structural fabrication.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Author /Book /Publisher	Year of Publication/Reprints
1.	Havers, J.A. and Stubbs, F. Jr., "Handbook of Heavy Construction", 2nd Edition, McGraw-Hill.	1971
2.	Peurifoy, R.L., Schexnayder, C.J., Shapira, A. and Schmitt, R., "Construction Planning, Equipment, and Methods", Tata McGraw Hill.	2010
3.	Peurifoy, R.L., Schexnayder, C.J. and Aviad, S., "Construction Planning, Equipment and Methods", Mcgraw-Hill Series in Civil Engineering.	2002
4.	Varma, M., Construction Equipment and its Planning and Application, 3rd Edition, Metropolitan.	1983

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-554** Course Title: **Construction Plant Machinery**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on construction equipment and machinery for water resources development projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Mechanized nature of modern construction and responsibilities of mechanical engineers on construction projects, functional classification of construction equipment; Different types of prime movers, power ratings, power available, useable power, power requirements	8
2.	Grade-ability and pull ability, analysis of combined influence of rolling resistance and traction on ability to negotiate grade and ability to pull trailing load by track-mounted and wheel-mounted construction equipment	8
3.	Analysis and application of different types of planetary, hydraulic and hybrid transmissions for track-mounted and wheel-mounted construction equipment	6
4.	Analysis and application of different types of mechanical, hydraulic, electric and hybrid controls for steering and braking of track-mounted and wheel-mounted construction equipment	6
5.	Equipment specifications and procurement procedures, old versus new and indigenous versus imported equipment; Performance computations and production estimates	6
6	Sizing, matching and efficient utilization for optimal production of principal construction plant and machinery	4
7	Cost accounting, maintaining records and preventive maintenance of construction plant and machinery	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Author /Book /Publisher	Year of Publication/Reprints
1.	Nunnally, S. W., "Construction Planning, Equipment, and Methods", Eighth edition, Pearson.	2010
2.	Peurifoy, R.L., Schexnayder, C.J., Shapira, A. and Schmitt, R., "Construction Planning, Equipment, and Methods", Tata McGraw Hill.	2010
3.	Varma, M., "Construction Equipment and its Planning and Application", Metropolitan.	1983
4.	Wong, J.Y., "Theory of Ground Vehicles", John Wiley.	1978

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-555** Course Title: **Air Conditioning and Ventilation**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**
9. Objective: To impart knowledge on various aspects of air-conditioning and ventilation systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Types of air-conditioning systems, design conditions, heat transfer coefficients for indoor and outdoor conditions	8
2.	**Load Estimation:** Refrigeration and air conditioning load estimation, heat gains through structures	8
3.	**Ventilation:** Necessity; ventilation standards; natural and mechanical ventilation; forces for natural ventilation; general ventilation rules; advantages of mechanical ventilation; various methods; ejector systems; determining ventilation requirement; use of decay equation.	8
4.	**Air cleaning:** Physical and chemical vitiation of air, permissible concentration of air contaminants, mechanical and electronic air cleaners, dry and wet filters, air sterilization, odour control	4
5.	**Air-conditioning and ventilation ducts:** Layout and design	8
6.	**Others:** Refrigerants; System noise and its control, Environmental issues; Controls for air conditioning and ventilation systems	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Arora, C.P., "Refrigeration and Air conditioning", Tata-McGrawHill.	1998
2.	ASHRAE, "ASHRAE Handbooks", ASHRAE.	2006
3.	Howell, Ronald, H., Sauer, Harry J. and Coad, William J., "Principles of Heating, Ventilating, and Air Conditioning: A Textbook with Design", American Society of Heating, Refrigerating, and Air-Conditioning Engineers.	2010
4.	Tobias, H. , and Otto, K., "Air Conditioning Systems: Performance, Environment and Energy Factors", Nova Science Pub.	2010
5.	William, M. J., William, C. W., Eugene, S. and John, A. T., "Refrigeration and Air Conditioning Technology", Delmar Pub..	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-556** Course Title: **Construction Techniques**

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

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

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on various aspects of construction techniques for water resources development projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Construction planning, job and resource planning, construction scheduling, mechanization in heavy construction, construction plant and its functional classification	4
2.	Selection of type, size and number of construction equipment and techniques for excavation at borrow-pits, transportation from borrow-pits to fill sites, placement, compaction, and quality control for construction of embankments and earth and rockfill dams	6
3.	Selection of type, size and number of construction equipment and techniques for manufacture, transportation, cooling, placement and quality control of concrete for construction of concrete dams/spillways/other structures	8
4.	Selection of type, size and number of construction equipment and techniques for tunneling and underground powerhouses in squeezing, weak, moderate and sound strata	6
5.	Flood frequencies for design of river diversion works, techniques for river diversion, economical height of coffer dams and diameter of diversion tunnels; Different techniques for dewatering, design of pumping and well-point dewatering systems	6
6.	Foundation treatment of concrete and earth dams; Consolidation and curtain grouting, dental treatment and cutoff trenches	6
7.	Equipment and techniques for aggregate recovery, processing and conveyance; Construction utility services	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprints
1.	Nunnally, S. W., "Construction Planning, Equipment, and Methods", Eighth edition, Pearson.	2010
2.	Peurifoy, R.L., Schexnayder, C.J., Shapira, A. and Schmitt, R., "Construction Planning, Equipment, and Methods" Tata McGraw Hill.	2010
3.	Sharma, S.C., "Construction Equipment and its Management", Khanna Publishers.	2007
4.	Varma, M., "Construction Equipment and its Planning and Application", Metropolitan.	1983

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-571** Course Title: **Design of Irrigation Structures and Drainage Works**

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

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

4. Relative Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on various design aspects of irrigation and drainage works.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Planning and layout of irrigation system: Necessity, advantages and types of irrigation, techniques of water distribution, alignment.	4
2.	Crop water requirement: Duty, delta base period, irrigation efficiencies, consumptive use, net irrigation requirement, frequency of irrigation; canal capacity, rotational delivery, conveyance and seepage losses.	4
3.	Design of lined and unlined channels: Design for clear and sediment laden water, principles of maximum and minimum permissible velocities, theory of sediment transport, regime concept; Kennedy theory; Lacey`s theory; economics of canal lining, discharge measuring devices.	8
4.	Design of distributary head regulator and cross regulator: Hydraulic design principles, seepage theory, exit gradient, invert filter, protection works.	8
5.	Design of canal falls/drops: Definition, location and types of canal falls, design principles of vertical drop and fall, Sarda type fall; Glacis type fall; canal escape and their function as safety valve.	6
6.	Water logging: Causes of water logging, types of drainage system, surface drains; layout and design of surface drains their operation and maintenance.	8
6.	Flood control/protection: Design flood and its importance, flood management, structural and non-structural measures	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publisher	Year of Publication/Reprint
1.	Arora, K.R., "Irrigation, Water Power and Water Resources Engineering", Standard Publishers Distributers.	2007
2.	Asawa, G.L., "Irrigation and Water Resources Engineering", New Age International Publishers.	2005
3.	"Design Practices of Open Drainage Channels", ICID Publication	1984
4.	Singh, B., "Fundamentals of Irrigation Engineering", Nem Chand and Brothers.	2005
5.	"Design of Small Canal Structures". U.S.B.R. Publication	1978
6.	Varshney, R.S., Gupta S.C. and Gupta, R.L., "Theory and design of Irrigation Structures". Nem Chand and Brothers.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-572** Course Title: **Soil and Agronomy**

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

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

4. Relative Weight : CWS 25 PRS 0 25 50 0

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge of agro-climatic conditions, soil characteristics and cultivation of crops for efficient use of water.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Scenario of agriculture in the world characterization of irrigated and rain-fed agriculture.	4
2.	Crops and plants: Definitions, morphological and physiological features, classification, adaptation and ecology.	4
3.	Agro-climate: Elements of weather, analysis of weather data and agro-climatic classification, biomass production potential assessment and yield estimation.	8
4.	Soils: Physical, chemical and biological properties, Taxonomic classification and characterization.	4
5.	Soil survey for land evaluation: Irrigability and drainability classification, evaluation and productivity assessment of land.	4
6.	Principles and practices of cultivation of crops: Husbandry of cereal, pulses, oilseeds and cash crops; package and practices of crops.	4
7.	Agro Technology Software: Use of computer software like Decision Support System in Agro Technology Transfer (DSSAT) and other crop yield models.	6
8.	Statistical analysis of experimental data: Field experimental techniques; yield estimation and production forecasting.	4
9.	Optimization Techniques: Application of system techniques in crop planning and management.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book/Publisher	Year of Publication/Reprint
1.	"Hand Book of Agriculture", Indian Council of Agricultural Research (ICAR).	2008
2.	John, R., George, E., and Rashid, A., "Soil and Plant Analysis - Laboratory Manual", Scientific Publishers.	2009
3.	Kakade, J.R., "Agricultural Climatology", Metropolitan Book Company.	1989
4.	Martin, J.H., Leonard, W.H. and Stamp, D.L., "Principles of Field Crop Production", Mcmillan Publishing Company.	1979
5.	Metcalfe, D.S. and Elkins, D.M., "Crop Production: Principles and Practices", Mcmillan Publishing Company.	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-573** Course Title: **Principles and Practices of Irrigation**

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

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

4. Relative Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on principles of irrigation and irrigation practices.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, basic definitions and approach, water resources and its status, problems of irrigation development	4
2.	Soil water plant atmosphere relationship, monitoring of crop water stress and soil moisture, water uptake and release in the atmosphere and root zone, consumptive use determination from field and Lysimetric experiments	8
3.	Rainfall-runoff analysis, water availability assessment, infiltration, hydraulic conductivity and water balance study	8
4.	Approaches of estimating reference crop evapotranspiration, crop coefficient; Effective rainfall, net irrigation requirement, gross irrigation requirement, project irrigation requirement; Preparation of water demand sheet	4
5.	Crop growth stages; Soil moisture depletion; Miscellaneous uses of irrigation	6
6.	Basin, border, furrow, sprinkler and drip irrigation and their design procedures; Evaluation of irrigation performance; Irrigation pumps; Automation in irrigation	8
7.	Water quality testing, classification, treatment and management; Groundwater quality contamination, effluent and wastewater use in agriculture	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication /Reprint
1.	Asawa, G.L., "Irrigation and Water Resources Engineering", New Age International Publishers.	2006
2.	FAO, "Crop Water Requirements", FAO Irrigation and Drainage Paper No. 24.	1992
3.	Jensen, M.E., "Design and Operation of Farm Irrigation System", American Society of Agricultural Engineers.	1981
4.	Majumdar, D.K., "Irrigation Water Management Principles and Practices", Prentice Hall.	2000
5.	Michael, A.M., "Irrigation Theory and Practice', Vikas Publishing House	2008
6.	Garg, S. K., "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.	2004
7.	Varshney, R.S., Gupta S.C. and Gupta, R.L., "Theory and Design of Irrigation Structures". Nem Chand and Brothers.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-575** Course Title: **On Farm Development**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on the watershed level development of the canal commands.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, techno-economic and environmental issues of canal commands; Command area development programme- Objectives and approach	4
2.	On Farm Development Planning- Delineation of watershed, land acquisition, delineation of farm roads, field channels, field drains and escapes; Land leveling, shaping and earth work estimation	7
3.	Identification and reclamation of waterlogged and salt-affected lands through cultural, chemical and engineering practices	4
4.	Water distribution practices in India and other neighboring countries in canal, tube well, small storage and diversion structures; On farm system design- Modernization and rehabilitation of water-courses and their structures	8
5.	Agricultural extension- Farmer's organization, leadership development and linking farmers- with agriculture, irrigation and financing; Rural and infrastructural development agencies	4
6.	Participatory irrigation management- Irrigation management transfer, responsibility of irrigation department and farmers' organization, constitution, laws and bye laws, social, economic and environmental control of water users' society	6
7.	Runoff recycling, planning mixed use of fresh and effluent water in agriculture	3
8.	Conjunctive use planning- Use of surface and ground water to improve water productivity, safeguard against land degradation and environmental protection; Sub surface drainage- Layout and Design	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication /Reprint
1.	Jensen, M.E., "Design and Operation of Farm Irrigation System", American Society of Agricultural Engineers.	1981
2.	Michael, A.M., "Irrigation Theory and Practice', Vikas Publishing House	2008
3.	Murthy, V.V.N., "Land and Water Management Engineering", Kalayani Pubishers.	1998
4.	Garg, S. K., "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.	2004
5.	Singh, B., "Fundamentals of Irrigation Engineering", Nem Chand and Brothers.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-576** Course Title: **Operation Maintenance and Management of Irrigation Systems**

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

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

4. Relative Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on operation, maintenance and management of irrgation systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definition of terms, elements of organizational management; Comparative analysis of irrigation organization, organizational change mechanism	4
2.	Maintenance problems- physical and social phenomena, examples; Maintenance types- essential, structural, catch up, preventive and normal; Budget control and accountability development of maintenance program	5
3.	Maintenance practices- catchment protection to check soil erosion, headworks; Maintenance of channels, structures, communication and ancillary works; Maintenance of tertiary systems and drains	5
4.	Diagnostic analysis of operation and maintenance of a canal system; Purpose, planning, field work, walk-through survey, field experiments, report preparation and presentation	8
5.	Reservoir and canal operation- reservoir operation rules for flood control and water supply; Canal capacity, discharge measurement, water allowance, water distribution, planning and sharing in water deficit	6
6.	Automatic regulation of canal operation- concept of automation, hardware and software requirements, gate discharge, pool volume control; Algorithm for canal operation	4
7.	Information management- geographic information system based record keeping and analysis, information flow and feedback	6
8.	Water charges, revenue recovery and performance budgeting	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication /Reprint
1.	MOWR, GOI, "Guidelines for Farmers Participation in Water Management', Command Area Development and Water Management Division.	1987
2.	INCID, "Guide for Preparation of Plans of Operation and Maintenance of Irrigation Systems in India".	1994
3.	INCID, "Guidelines for Irrigation Performance Evaluations".	2005
4.	Modi, P.N., "Irrigation Water Resources and Water Power Engineering", Standard Book House.	1995
5.	Garg, S.K., "Irrigation Engineering and Hydraulic Structures", Khanna Publishers.	2004
6.	Singh, B., "Fundamentals of Irrigation Engineering", Nem Chand and Brothers.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN- 577** Course Title: **Water and Land Laws**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits**: 04** 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**: NIL**
9. Objective: To impart knowledge on laws pertaining to water and land use for sustainable agricultural production.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Water laws in India**: Basic concepts of resource economics applied to water resource management, fugitive nature of water resources, common property rights; Constitutional right, surface and ground water use regulations	8
2.	**National policies:** Agriculture, water, forest and science policies; North India canal and drainage act	6
3.	**Land laws in India:** Legal aspects of land ownership, inheritance, disputes and their resolution	6
4.	**Environmental protection act:** Rules and regulation, effluent disposal and pollution control laws	6
5.	**Water rights:** Comparative analysis of surface and subsurface water rights, legal procedures for establishment of water rights, groundwater legal issues, group versus individual rights	6
6.	**Water disputes and their resolution:** Interstate, inter-basin and trans-boundary disputes; Conflict resolution, development of accountability mechanism	6
7.	**Organizational setup:** Water boards and authorities; Case studies of users' interactions with government agencies	4
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Book /Publishers	Year of Publication/ Reprint
1.	Indian Council of Agricultural Research, "Hand Book of Agriculture" , Govt. of India.	2008
2.	Joseph, L. S., "Water Laws Planning and Policy", Bobbs Meril.	1968
3.	Luis, V. C., "Management and Law for Water Resources", Water Resources Publication.	1977
4.	Ministry of Agriculture, "National Agricultural Policy", Govt. of India.	2000
5.	Ministry of Environment and Forest, "National Forest Policy", Govt. of India.	1992
6.	Ministry of Health and Family Welfare, "National Health Policy", Govt. of India.	2002
7.	Ministry of Water Resources, "National Water Policy", Govt. of India.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN- 578** Course Title: **Rural Sociology and Irrigation Economics**

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

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

4. Relative Weight **:** CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on various socio-economic groups and their role in economic use of irrigation water.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Rural sociology:** Elements of rural sociology, social structure and their interaction, moral values, irrigation for social service and rural development,	6
2.	**Social structure:** Rural psychology, leadership, communication and motivation for effective governance	4
3.	**Panchayati raj act:** Panchayati raj institution and rural development programs	6
4.	**Social upliftment:** Social conflicts and their resolution, role of NGOs and women in irrigation management	6
5.	**Principles of economics:** Definitions, basic concepts of water resource economics, analysis and project planning for irrigation management	4
6.	**Farm accounting:** Production response, functions of irrigation application	6
7	**Pricing of water:** Socio-economic aspects, time-value of money, determination of demand; Pricing policy- guidelines and estimation	6
8	**Socio-economic surveys:** Principles and guidelines	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	Bhattacharya, S.N., "Rural Development in India and Other Developing Countries", Metropolitan.	1983
2.	Indian Council of Agricultural Research, "Hand Book of Agriculture", Govt. of India.	2008
3.	James, L. D. and Lee, R. R., "Economics of Water Resources Planning", McGraw Hill.	1971
4.	Stevenson, V., "Social Change", Prentice Hall.	1989

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN- 579** Course Title: **Evaluation of Irrigation Projects**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**
4. Relative Weight : CWS **25** PRS **0** **25** **50** **0**
5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: PEC**
8. Pre-requisite**: NIL**
9. Objective: To impart knowledge on evaluation of irrigation projects for their performance improvement.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Need for evaluation of irrigation projects; Principles of system diagnosis, health of an irrigation system for its functioning	4
2	**Cropping system:** Cropping pattern, cultivation techniques, crop diversification, intensification and rotation; Yield estimation	6
3	**Performance evaluation:** Benchmarking, guidelines and procedures for command area project evaluation	8
4	**Water productivity:** Modern concepts, economics, limits and opportunities for improvement, management of floods and droughts	6
5	**On farm system:** Field level assessment of efficiencies, efficient use of rain water	6
6	**Main system:** Basic concepts of irrigation systems, system boundaries, interaction between environment and system, system deficiency	6
7	**Socio-economic:** Social structure, per capita income, livelihood improvement	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	David, J., Molden, R., Sakthivadivel, C., Perry, J. and Charlotte de F., "Indicators for Comparing Performance of Irrigated Agricultural Systems", International Water Management Institute.	1998
2.	Hector, M. and Martin, B., "Guidelines for Benchmarking Performance in Irrigation and Drainage", Food and Agricultural Organisation.	2001
3.	ICID, "Benchmarking of Irrigation and Drainage Projects", International Commission on Irrigation and Drainage.	2004
4.	Yoder, R., "Identification and Utilization of Farm Resources in Irrigation Development", Cornell University Press.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./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 Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits**:** **4** 6. Semester**: Spring** 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:** Definition, history, current state-of-the-art, future use and penetration of renewable energy technologies; Types of renewable energy sources - Solar radiation, tidal and waves, hydro cycle, geothermal	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, batteries, charge controllers, inverters, 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 Hydro:** Small hydropower generation using synchronous and induction generators– characteristic, standalone and grid connected operations, voltage and frequency control, Electronic load control.	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;	6

	Pyrolysis and alcohol fuels	
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	7
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors /Books /Publishers**	**Year of Publication**
1.	Messenger, R.A. and Ventre, J., "Photovoltaic System Engineering," CRC Press.	2003
2.	Peuser, F. A., Remmers, Karl-Heinz and Schnauss, M., "Solar Thermal Systems: Successful Planning and Construction", Solar Press.	2009
3.	Rai, G.D., "Non conventional Energy Sources," Khanna Publishers.	2001
4.	Rosa, A.V. Da, "Fundamentals of Renewable Energy Processes", Elsevier.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-581** Course Title: **Water Quality Monitoring and Modelling**

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

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

4. Relative Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits**:** **4** 6. Semester**: Spring** 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	9
2.	**Water quality monitoring:** Physical, chemical and biological monitoring of rivers; Guidelines for sample size and location of monitoring stations, Sample analysis	8
3.	**Modelling:** Characteristics of point and non-point sources of pollution; Solution of diffusion and dispersion problems; Water quality models, case studies	9
4.	**Water purification:** Physical, chemical and biological processes, response of streams to biodegradable organic waste; Engineered systems for water and waste water purification	8
5.	**Groundwater quality:** Parameters; Sources of salinity, short and long term monitoring; Remedial and preventive measures	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication
1.	Biswas, A. K., "Models for Water Quality Management", Mc Graw Hill.	1981
2.	Chapra, S. C., "Surface Water Quality Modeling", Waveland Press.	2008
3.	David, A. Chin, "Water Quality Engineering in Natural Systems", Wiley Interscience.	2006
4.	Loucks, D. P., Stedinger, J. R. and Haith, D. A., "Water Resource Systems Planning and Analysis", PH.	1981
5.	Orlob, G. T., "Mathematical Modelling of Water Quality- Streams, Lakes, and Reservoirs", John Wiley.	1983
6.	Thomn, R. V. and Mueller, J. A., "Principles of Surface Water Quality Modelling", Harper and Row Publishers.	1987
7.	Zhen, G. J., "Hydrodynamics and Water Quality- Modelling Rivers, Lakes and Estuaries", John Wiley.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-582** Course Title: **Theory of Seepage**

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

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

4. Relative Weight : CWS **25** PRS **0** **25** **50** **0**

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

8. Pre-requisite**:** **NIL**

9. Objective: To impart knowledge of seepage theory applicable to water resources projects.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Fundamentals, characteristics and boundary conditions of groundwater flow; Darcy's law; General hydrodynamic equations; Flownet	6
2	Application of Dupuit theory; Basic consideration; Two dimensional flow; Free surface subject to infiltration and evaporation; Radial flow in fully penetrating well	6
3	Conformal mapping and special mapping techniques; Application of mapping function; Fundamentals of solution of two dimensional flow problems by conformal mapping; Bilinear transformation	6
4	Unconfined flow through earthen structures and its seepage analysis; Unconfined flow around cutoffs; Earth structure with a cutoff wall and with horizontal drain; Rockfill dams with central core and seepage analysis	8
5	Confined flow, methods of solving confined flow problems; Hydraulic structure on surface of finite depth of porous media; Inclined sheet pile; Finite lower impervious boundary; Depressed structure on a permeable base of infinite extent; Double-wall sheet-pile cofferdam	8
6	Seepage from small water bodies, reservoirs and canals; Seepage towards well- steady and unsteady flows; Stream-aquifer interaction	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	Bear, J., "Dynamics of Fluids in Porous Media" McGraw Hill.	1972
2.	Bear., J. "Hydraulics of Groundwater" McGraw Hill.	1979
3.	Harr, M.E., "Groundwater and Seepage", McGraw Hill.	1990
4.	Reddi, L. N., "Seepage in Soils-Principles and Applications' John Wiley.	2005
5.	Walton, W.C. "Groundwater Resources Evaluation" McGraw Hill.	1970

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN-583** Course Title: **Remote Sensing and GIS Applications in Agriculture**

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

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

4. Relative Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on applications of remote sensing and GIS techniques in agriculture and water resources management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, history of remote sensing, sensors, platforms and their characteristics; Satellite data products	6
2.	Principles of remote sensing and data analysis, electromagnetic spectrum, atmospheric effects, energy interaction with earth surface features, basic interaction mechanism of soil, vegetation and water	8
3.	Image interpretation virtual and digital; Image rectification, image enhancement, image classification and accuracy assessment, use of image processing software	8
3.	Geographical information system (GIS), definition, essential components of GIS, spatial data structure- raster and vector, spatial and non-spatial relationship, geographic database concepts and analysis, GIS packages and salient features	8
4.	Use of remote sensing and GIS techniques in agriculture, vegetation cover mapping, crop acreage estimation and disease detection	4
5.	Application of remote sensing and GIS for estimation of surface and groundwater irrigation potential, erosion hazard assessment, water quality assessment, flood inundation mapping and modeling; Drought monitoring; performance evaluation of irrigation commands; Selection of site for artificial recharge, agricultural management and planning	8
	Total	**42**

Suggested Books:

S. No.	Name of Authors /Books /Publishers	Year of Publication
1.	Burrough, P. A., "Principles of Geographic Information System for Land Resources Assessment", Clarendom Press.	1998
2.	Chandra, A.M. and Ghosh, S.K., "Remote Sensing and Geographic Information System", Narosa Publishers.	2007
3.	Jensen, J.R. "Remote Sensing of the Environment an Earth Resources Perspective", Pearson Education.	2003
4.	Lillesand, T. M. and Kiefer, R. W., "Remote Sensing and Image Interpretation", Fourth Edition, John Wiley.	2000
5.	Curan, P.J., "Principles of Remote Sensing", English Language Book Society, Longman.	1983

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN- 584** Course Title: **Cropping System Modeling**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite**: NIL**

9. Objective: To impart knowledge on decision making in agro-techniques for crop cultivation.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Need of crop modeling, crop modeling, advanced crop cultivation techniques	4
2	**Constraint analysis:** Crop, soil and hydrological constraints, analysis of problems, remedies for optimal crop yield	4
3	**Agricultural lands problems:** Land and water degradation problems due to use of fertilizers, water and agro-chemicals	6
4	**Crop diversification:** Need, process and forms; Crop intensification, intensive cropping systems	4
5	**Systems approach:** Use of linear programming in crop planning and management	6
6	**Crop models:** Use of CROPWAT for yield estimation, water uptake and nitrogen uptake forecasting	6
7	**Decision support system (DSS)**: Basic concepts, development of DSS for agro-technology transfer	6
8	**Remote Sensing & GIS application:** Introduction to remote sensing & GIS and application for yield forecasting	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	IBSNAT, "Decision Support System in Agrotechnology Transfer", International Benchmark Sites Network for Agrotechnology Transfer**.**	2004
2.	National Bureau of Soil Survey, "Agro-Climate Regional Planning in India", Indian Council of Agriculture and Research, Vol.1-2.	2004
3.	Thornily J.M. and Johnson, I.R., "Plant and Crop Modeling", Scientific Publication.	2009
4	Lillesand, T. M. and Kiefer, R. W., "Remote Sensing and Image Interpretation", Fourth Edition, John Wiley.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Water Resources Development and Management**

1. Subject Code: **WRN- 585** Course Title: **Environmental Impact of Irrigated Agriculture**

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

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

4. Relative Weight : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge on environmental implications of intensive irrigated agriculture.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Definition, basic environmental issues in irrigated agriculture, scope	4
2	**Ecology**: Flora and fauna in irrigated areas, soil and water-borne pathogens of crops and trees, fertility and productivity of lands	6
3	**Ecological adaptation:** Competition, adaptation and adoption of crop and weeds under variable soil moisture condition	4
4	**Nutrient and water balance**: Organic carbon, major and micronutrient requirements of crops and soils, nutrient and water use efficiency; Model studies in nutrient and water balance studies	6
5	**Soil, water and plant chemical analysis:** Collection of samples, preparation of standard solution and analysis; Use of advance techniques for chemical analysis	4
6	**Climatologically changes in irrigated areas:** Soil degradation; Crop extinction; Human and animal diseases	6
7	**Microclimate**: Micro environment study of field crops, instrumentation for microclimatic study	4
7	**Field studies:** Project work on field observation, recording of data and statistical analysis	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Book /Publishers	Year of Publication/Reprint
1.	Dougherty, T.C. and Hall, A. W., "Environmental Impact Assessment of Irrigation and Drainage Programme", FAO Irrigation and Drainage Paper.	1995
2.	Shiva, V., "Sustainable Agriculture and Food Security", Sage Publishers.	2002
3.	Wainwright, J., "Environmental Modeling Finding Simplicity and Complicity", John Wiley.	2004
4.	Jaiswal, P.C., "Soil, Plant and Water Analysis", Kalyani Publishers.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./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 Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

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

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge on groundwater development and management for irrigation water management.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Use of groundwater and its impact on irrigation water management; Hydrologic properties of water bearing formation, occurrence, storage and distribution of groundwater; Use of groundwater zone maps; Groundwater resource assessment and budget	8
2	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	Pumps and their selection, installation and testing of pumps; Monitoring and maintenance of wells, causes of failure	6
4	Ground water conservation and artificial recharge, sustained yield, water balance equation; Ground-water and surface-water interaction, interference of wells; Watershed conservation measures in irrigation commands	8
5	Groundwater flow parameter estimation; Groundwater simulation and conjunctive use models, comparative analysis for management of conjunctive use system	6
6	Groundwater quality- agricultural sources of pollution, causes and monitoring; Technical, socio-economic and organizational aspects of groundwater management	6
	Total	**42**

11. Suggested Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./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 Weight **:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits**:** **4** 6. Semester**: Spring** 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.	Components of watershed and need of watershed management; Principal factors influencing watershed operations; Delineation of watersheds; Engineering surveys; Data requirement	4
2.	Watershed hydrology, water resources assessment in watershed, hydrological cycle; Surface water assessment- rainfall-runoff analysis; Groundwater assessment, infiltration and its measurement	8
3.	Watershed Behavior- Physical elements of watershed, effects of land use changes on hydrological cycle components, watershed experiments	4
4.	Land capability classification; Erosion process- factors affecting erosion, types of erosion, soil erosion models	6
5.	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
6.	Rainwater harvesting, direct and indirect methods, filter design, planning and design; Layout and execution; Impact assessment, operation and maintenance issues	6
7.	Watershed management plan- Methodology of planning a watershed, identification of watershed problems, 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 /Publishers	Year of Publication/Reprint
1.	Das, G., "Hydrology and Soil Conservation Engineering", Prentice Hall.	2002
2.	Debarry, P. A., "Watershed: Processes, Assessment and Management", John Wiley.	2004
3.	Lyon, J. G., "GIS for Water Resources and Watershed Management", Taylor and Francis.	2003
4.	Schwab, G.O., Fangmeier, D.D., Elliot, W. J., Frevert, R. K., "Soil and Water Conservation Engineering", John Wiley.	2002
5.	Suresh, R., "Soil and Water Conservation Engineering", Standard Publishers.	2006
6.	Tideman, E.M., "Watershed Management", Omega Scientific Publisher.	2002