ANNAMALAI UNIVERSITY

Annamalainagar

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

M.E.

(Water Resources Engineering and Management)

(Two year Degree Programme)

(Choice Based Credit System)

(Full-Time & Part-Time)

HAND BOOK

(2017-2018 onwards)

FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING
M.E. (WATER RESOURCES ENGINEERING AND MANAGEMENT)

VISION

To provide quality education and strive to mould students to scale new heights to become leaders in the area of Water resources Engineering & Management as practicing engineers, researchers or academicians through value-based technical education and congenial study environment.

MISSION

- To establish state-of-the-art infrastructure in a broad array of Water resources engineering & management disciplines and create technologically capable and intellectually motivated water resource engineers to enrich civil engineering research and practice.
- To impart fundamental engineering knowledge in Hydrology & Water resources Engineering, a broad set of required technical skills and an inquisitive attitude to take up the challenges of creating and sustaining the built environment that underpins our society and inspire them to be leaders of tomorrow.
- To ensure that ample opportunities are created to enable them to serve the community as responsible water resource engineers who successfully adapt and innovative solutions in the face of uncertain information, as well as ever-changing needs, risks and constraints.
- To equip students with communications skills, ethical values and an understanding of economic, societal and environmental impacts necessary to address modern water resource engineering challenges that will benefit all stake holders.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO 1: Graduates will have sound knowledge to identify and formulate challenging Water Resources Engineering problems and apply appropriate research methodologies and use modern engineering tools to provide technical solutions that are economically feasible and sustainable.

PEO 2: Graduates will possess analytical and lateral thinking ability to engage in lifelong learning for professional advancement to cope up with the rapidly evolving Water Resource Engineering profession which is multi-disciplinary.

PEO 3: Graduates will become socially responsible and will possess abilities to communicate effectively and work efficiently and accept leadership roles in their profession, public services and community.

PROGRAMME OUTCOMES

PO1: Understand the application of fluid mechanics, model studies and computational methods in solving a host of problems in hydraulic engineering.

PO2: Study types and classes of hydrologic simulation models and design procedures for safe and effective passage of flood flows for design of hydraulic structures.

PO3: Enable the students to understand the basic aquifer parameters and groundwater resources for different hydro-geological boundary conditions.

PO4: Apply systems concept, advanced optimization techniques to cover the socio-technical aspects in the field of water resources.

PO5: Apply the principles and applications of remote sensing, GPS and GIS in the context to hydrological extreme flood and drought events in water resources engineering.

PO6: Design and construct water resource system components for processes to meet desired needs within realistic constraints such as environmental, socio-economical, water governance, political, ethical, health and safety, and sustainability.

PO7: Understand the impact of water and water related issues in a global, economic, environmental, and societal context.

PO8: Choose and use Research methodologies, Integrated Water Resources Management and gender relations and roles, legal aspects as it applies to the field of Water Resources Management.

PO9: Use the techniques, skills, and modern modelling software tools necessary for water resource planning and management.

PO10: Understand the impact of engineering solutions to water management problems and also will be aware of contemporary issues.

Mapping POs with PEOs			
PO	**PEO1**	**PEO2**	**PEO3**
PO1	✓	✓	
PO2	✓	✓	
PO3	✓	✓	
PO4	✓	✓	✓
PO5	✓	✓	
PO6	✓		
PO7		✓	✓
PO8		✓	✓
PO9			✓
PO10			✓

ANNAMALAI UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

M.E. / M. Tech (Two-Year Full Time & Three-year Part Time) DEGREE PROGRAMME

CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

1. **Condition for Admission**
   Candidates for admission to the first year of the four-semester **M.E / M.Tech Degree programme in Engineering** shall be required to have passed B.E / B.Tech degree of Annamalai University or any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the condition regarding qualifying marks and physical fitness as may be prescribed by the syndicate of the Annamalai University from time to time. The admission for part time programme is restricted to those working or residing within a radius of **90 km** from Annamalainagar. The application should be sent through their employers.
2. **Branches of Study in M.E / M.Tech**
   The Branch and Eligibility criteria of programmes are given in **Annexure 1**
3. **Courses of study**
   The courses of study and the respective syllabi for each of the M.E / M. Tech programmes offered by the different Departments of study are given separately.
4. **Scheme of Examinations**
   The scheme of Examinations is given separately.
5. **Choice Based Credit System (CBCS)**
   The curriculum includes three components namely Professional Core, Professional Electives and Open Electives in addition to Thesis. Each semester curriculum shall normally have a blend of theory and practical courses.
6. **Assignment of Credits for Courses**
   Each course is normally assigned one credit per hour of lecture / tutorial per week and one credit for two hours or part thereof for laboratory or practical per week. The total credits for the programme will be 65.
7. **Duration of the programme**
   A student of **M.E / M.Tech** programme is normally expected to complete in four semesters for full-time / six semesters for part-time but in any case not more than four years for full-time / six years for part-time from the date of admission.
8. **Registration for courses**
   A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current

semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day. Registration for the Thesis Phase - I and II shall be done at the appropriate semesters.

9. Electives

The student has to select two electives in first semester and another two electives in the second semester from the list of Professional Electives. The student has to select two electives in third semester from the list of Open Electives offered by the department/ allied department. A student may be allowed to take up the open elective courses of third semester (Full Time program) in the first and second semester, one course in each of the semesters to enable them to carry out thesis in an industry during the entire second year of study provided they should register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselves-for clarifications. No specific slots will be allotted in the time table for such courses.

Further, the two open elective courses to be studied in III semester (Full Time programme) may also be credited through the SWAYAM portal of UGC with the approval of Head of the Department concerned. In such a case, the courses must be credited before the end of III Semester.

10. Assessment

The break-up of continuous assessment and examination marks for theory courses is as follows:

First assessment (Mid-Semester Test-I)	:	10 marks
Second assessment (Mid-Semester Test-II)	:	10 marks
Third Assessment	:	5 marks
End Semester Examination	:	75 marks

The break-up of continuous assessment and examination marks for Practical courses is as follows:

First assessment (Test-I)	:	15 marks
Second assessment (Test-II)	:	15 marks
Maintenance of record book	:	10 marks
End Semester Examination	:	60 marks

The thesis Phase I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. The number of reviews must be a minimum of three per semester. 60 marks are allotted for the thesis work and viva voce examination at the end of the third semester. The same procedure will be adopted for thesis Phase II in the fourth semester.

11. Student Counselors (Mentors)

To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counsellor for

those students throughout their period of study. Such student counsellors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester, monitor their progress in SWAYAM courses / open elective courses and obtain the final approval of the Head of the Department.

12. Class Committee

For each of the semesters of M.E / M.Tech programmes, separate class committees will be constituted by the respective Head of the Departments. The composition of the class committees from first to fourth semesters for Full time and first to sixth semesters for Part-time will be as follows:

- Teachers of the individual courses.
- A Thesis coordinator (for Thesis Phase I and II) shall be appointed by the Head of the Department from among the Thesis supervisors.
- A thesis review committee chairman shall be appointed by the Head of the Department
- One Professor or Associate Professor, preferably not teaching the concerned class, appointed as Chairman by the Head of the Department.
- The Head of the Department may opt to be a member or the Chairman.
- All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

The class committee shall meet **three** times during the semester. The first meeting will be held within two weeks from the date of class commencement in which the type of assessment like test, assignment etc. for the third assessment and the dates of completion of the assessments will be decided.

The second meeting will be held within a week after the completion of the first assessment to review the performance and for follow-up action.

The third meeting will be held after all the assessments but before the University semester examinations are completed for all the courses, and at least one week before the commencement of the examinations. During this meeting the assessment on a maximum of 25 marks for theory / 40 marks for practical and project work will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

13. Temporary Break Of Study

A student can take a one-time temporary break of study covering the current semester and / or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the mid-semester test. However, the student must complete the entire programme within the maximum period of **four years for Full time / six years for Part time.**

14. Substitute Assessments

A student who has missed, for genuine reasons accepted by the Head of the Department, one or more of the assessments of a course other than the end of semester examination may take a substitute assessment for any one of the missed assessments. The substitute

assessment must be completed before the date of the third meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.

15. Attendance Requirements

The students with 75% attendance and above are permitted to appear for the University examinations. However, the Vice Chancellor may give a rebate / concession not exceeding 10% in attendance for exceptional cases only on Medical Grounds.

A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register and repeat the same semester in the subsequent academic years.

16. Passing and declaration of Examination Results

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. Thereafter, the controller of examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average (GPA) and cumulative grade point average (CGPA) and prepare the mark sheets.

90 to 100 marks	Grade 'S'
80 to 89 marks	Grade 'A'
70 to 79 marks	Grade 'B'
60 to 69 marks	Grade 'C'
55 to 59 marks	Grade 'D'
50 to 54 marks	Grade 'E'
Less than 50 marks	Grade 'RA'
Withdrawn from the Examination	Grade 'W'

A student who obtains less than 30 / 24 marks out of 75 / 60 in the theory / practical examinations respectively or is absent for the examination will be awarded grade RA.

A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.\

A student who obtains letter grade RA / W in the mark sheet must reappear for the examination of the courses.

The following grade points are associated with each letter grade for calculating the grade point average and cumulative grade point average.

S - 10; A - 9; B - 8; C - 7; D - 6; E - 5; RA - 0

Courses with grade RA / W are not considered for calculation of grade point average or cumulative grade point average.

A student can apply for re-totaling of one or more of his examination answer papers within a week from the date of issue of mark sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After the results are declared, mark sheets will be issued to the students. The mark sheet will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester.

CGPA is similarly calculated considering all the courses taken from the time of admission.

17. Awarding Degree

After successful completion of the programme, the degree will be awarded with the following classifications based on CGPA.

For First Class with Distinction the student must earn a minimum of 65 credits within four semesters for full-time / six semesters for Part time from the time of admission, pass all the courses in the first attempt and obtain a CGPA of 8.25 or above.

For First Class, the student must earn a minimum of 65 credits within two years and six months for full-time / three years and six months for Part time from the time of admission and obtain a CGPA of 6.75 or above.

For Second class, the student must earn a minimum of 65 credits within four years for full-time / six years for Part time from the time of admission.

18. Ranking of Candidates

The candidates who are eligible to get the M.E /M.Tech degree in First Class with Distinction will be ranked on the basis of CGPA for all the courses of study from I to IV semester for M.E / M.Tech full-time / I to VI semester for M.E / M.Tech part-time.

The candidates passing with First Class and without failing in any subject from the time of admission will be ranked next to those with distinction on the basis of CGPA for all the courses of study from I to IV semester for full-time / I to VI semester for M.E / M.Tech part-time.

19. Transitory Regulations

If a candidate studying under the old regulations M.E. / M.Tech could not attend any of the courses in his/her courses, shall be permitted to attend equal number of courses, under the new regulation and will be examined on those subjects. The choice of courses will be decided by the concerned Head of the department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time.

ANNEXURE 1

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.Tech Programme *
1	**Civil Engineering**	i.	Environmental Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Industrial Engg, Chemical Engg, BioChemical Engg, Biotechnology, Industrial Biotechnology, Chemical and Environmental Engg.
		ii.	Environmental Engineering & Management	
		iii.	Water Resources Engineering & Management	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Agricultural and Irrigation Engg, Geo informatics, Energy and Environmental Engg.
2	**Civil & Structural Engineering**	i.	Structural Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg.
		ii.	Construction Engg. and Management	
		iii.	Geotechnical Engineering	
		iv.	Disaster Management & Engg.	
3	**Mechanical Engineering**	i.	Thermal Power	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical Engg (Manufacturing).
		ii.	Energy Engineering & Management	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical (Manufacturing) Engg, Chemical Engg
4	**Manufacturing Engineering**	i.	Manufacturing Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Mechatronics Engg, Industrial Engg.
		ii.	Welding Engineering	
		iii.	Nano Materials and Surface Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Chemical Engg

5	**Electrical Engineering**	i.	Embedded Systems	B.E. / B.Tech – Electrical and Electronics Engg, Electronics & Instrumentation Engg, Control and Instrumentation Engg, Information technology, Electronics and communication Engg, Computer Science and Engg
		ii.	Smart Energy Systems	B.E. / B.Tech – Electrical and Electronics Engg, Electronics and Instrumentation Engg, Control and Instrumentation Engg.
		iii.	Power System	B.E. / B.Tech – Electrical and Electronics Engg,
6	**Electronics & Instrumentation Engineering**	i	Process Control & Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electronics Engg, Control and Instrumentation Engg, Instrumentation Engg
		ii.	Rehabilitative Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electronics Engg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics.
		iii.	Micro Electronics and MEMS	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electronics Engg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg
7	**Chemical Engineering**	i.	Chemical Engineering	B.E. / B.Tech – Chemical Engg, Petroleum Engg, Petrochemical Technology
		ii.	Food Processing Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Biochemical Engg, Agricultural Engg.
		iii.	Industrial Bio Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Leather Technology
		iv.	Industrial Safety	B.E. / B.Tech – Any Branch of

			Engineering	Engineering
8	**Computer Science & Engineering**	i.	Computer Science & Engineering	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
9	**Information Technology**	i	Information Technology	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
10	**Electronics & Communication Engineering**	i.	Communication Systems	B.E. / B.Tech - Electronics and Communication Engg, Electronics Engg.

*** AMIE in the relevant discipline is considered equivalent to B.E**

DEPARTMENT OF CIVIL ENGINEERING
Curriculum for M.E.(WATER RESOURCES ENGINEERING AND MANAGEMENT)

Full-Time

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – I										
1	PC-I	WREC 101	Statistics For Water Resources And Environmental Engineers	4	-	-	25	75	100	3
2	PC-II	WREC 102	Open Channel Hydraulics	4	-	-	25	75	100	3
3	PC-III	WREC 103	Surface Water Hydrology	4	-	-	25	75	100	3
4	PC-IV	WREC 104	Ground Water Hydrology	4	-	-	25	75	100	3
5	PE-I	WREE 105	Professional Elective – I	4	-	-	25	75	100	3
6	PE-II	WREE 106	Professional Elective – II	4	-	-	25	75	100	3
7	PC Lab-I	WREP 107	Advanced Computer Programming Laboratory	-	-	3	40	60	100	2
			Total	**24**	**-**	**3**	**190**	**510**	**700**	**20**

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – II										
1	PC-V	WREC 201	Computational Methods in Water Resources Engineering	4	-	-	25	75	100	3
2	PC-VI	WREC 202	Water Resources System Analysis	4	-	-	25	75	100	3
3	PC-VII	WREC 203	Remote Sensing & GIS in Water Resources Engineering and Management	4	-	-	25	75	100	3
4	PC-VIII	WREC 204	Water Distribution Networks	4	-	-	25	75	100	3
5	PE-III	WREE 205	Professional Elective – III	4	-	-	25	75	100	3
6	PE-IV	WREE 206	Professional Elective – IV	4	-	-	25	75	100	3
7	PC Lab-II	WREP 207	Remote Sensing and GIS Laboratory	-	-	3	40	60	100	2
8	Seminar	WRES 208	Seminar	-	-	2	100	-	100	1
			Total	**24**	**-**	**5**	**190**	**510**	**700**	**21**

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – III										
1	OE-I	WREE 301	Open Elective – I	4	-	-	25	75	100	3
2	OE-II	WREE 302	Open Elective – II	4	-	-	25	75	100	3
3	Thesis	WRET 303	Thesis Phase-I	-	4	-	40	60	100	4
4	Ind Train	WREI 304	Industrial Training	-	*	-	100	-	100	2
			Total	**8**	**4**	-	**90**	**210**	**300**	**12**

Note: * - Four weeks during the summer vacation at the end of II Semester.

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – IV										
1	Thesis	WRET 401	Thesis Phase-II	-	8	-	60	40	100	12
			Total	**-**	**8**	**-**	**40**	**60**	**100**	**12**

DEPARTMENT OF CIVIL ENGINEERING
Curriculum for M.E.(WATER RESOURCES ENGINEERING AND MANAGEMENT)

Part Time

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
S e m e s t e r – I											
1	PC-I	PWREC 101	Statistics For Water Resources And Environmental Engineers	4	-	-	25	75	100	3	WREC 101
2	PC-II	PWREC 102	Open Channel Hydraulics	4	-	-	25	75	100	3	WREC 102
3	PC-III	PWREC 103	Surface Water Hydrology	4	-	-	25	75	100	3	WREC 103
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
S e m e s t e r – II											
1	PC-IV	PWREC 201	Computational Methods in Water Resources Engineering	4	-	-	25	75	100	3	WREC 201
2	PC-V	PWREC 202	Water Resources System Analysis	4	-	-	25	75	100	3	WREC 202
3	PC-VI	PWREC 203	Remote Sensing & GIS in Water Resources Engineering and Management	4	-	-	25	75	100	3	WREC 203
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
S e m e s t e r – III											
1	PC-VII	PWREC 301	Ground Water Hydrology	4	-	-	25	75	100	3	WREC 104
2	PE-I	PWREE 302	Professional Elective – I	4	-	-	25	75	100	3	WREE 105
3	PE-II	PWREE 303	Professional Elective – II	4	-	-	25	75	100	3	WREE 106
4	PC Lab-I	PWREP 304	Advanced Computer Programming Laboratory	-		3	40	60	100	2	WREP 107
			Total	**12**		**3**	**115**	**285**	**400**	**11**	

S.No	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
S e m e s t e r – IV											
1	PC-VIII	PWREC 401	Water Distribution Networks	4	-	-	25	75	100	3	WREC 204
2	PE-III	PWREE 402	Professional Elective – III	4	-	-	25	75	100	3	WREE 205
3	PE-IV	PWREE 403	Professional Elective – IV	4	-	-	25	75	100	3	WREE 206
4	PC Lab-II	PWREP 404	Remote Sensing and GIS Laboratory	-	-	3	40	60	100	2	WREP 207
5	Seminar	PWRES 404	Seminar	-	-	2	100	-	100	1	WRES 208
			Total	**12**		**5**	**115**	**285**	**400**	**12**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
S e m e s t e r – V											
1	OE-I	PWREE 501	Open Elective – I	4	-	-	25	75	100	3	WREE 301
2	OE-II	PWREE 502	Open Elective – II	4	-	-	25	75	100	3	WREE 302
3	Thesis	PWRET 503	Thesis Phase-I	-	4		40	60	100	4	WRET 303
4	Ind Train	PWREI 504	Industrial Training	-	*	-	100	-	100	2	WREI 304
			Total	**8**	**4**		**90**	**210**	**300**	**12**	

Note: * - Four weeks during the summer vacation at the end of IV Semester.

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
S e m e s t e r – VI											
1	Thesis	PWRET 601	Thesis Phase-II	-	8	-	40	60	100	12	WRET 401
			Total	**-**	**8**	**-**	**40**	**60**	**100**	**12**	

L- Lecture ; **P-** Practical; **T-** Thesis; **CA-** Continuous Assessment; **FE-** Final Examination

List of Professional Electives

S. No.	Name of Elective Courses
1	Water Power and Dam Engineering
2	Environmental Impact Assessment of Water Resources Development
3	Hydraulic Structures
4	Ground Water System Planning and Management
5	Urban Hydrology
6	Watershed Conservation and Management
7	River Engineering
8	Soft computing in Water Resources Management
9	Water Quality Management for Agriculture
10	Flood Modeling and Drought Assessment
11	Advanced Hydrological Analysis and Design
12	Isotope techniques in Water Resources Management
13	Climate Change and Adaptation
14	Mini projects

List of Open Electives

S. No.	Name of Elective Courses
1	Water Quality Modeling
2	Integrated Water Resources Management
3	Environmental Systems Engineering
4	Groundwater Contaminant Transport Modeling
5	Coastal Engineering
6	Research Methodology

WREC 101	STATISTICS FOR WATER RESOURCES AND ENVIRONMENTAL ENGINEERS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To provide commonly used hypothesis tests, present univariate statistical methods, provide methods for gaining a preliminary understanding of a multivariate data base
- To summarize some important concepts related to the assessment of model reliability
- To discuss the commonly used bivariate and multivariate regression methods, spurious modeling, contrasting methods for calibrating multivariate models, stepwise regression , PCRA
- To introduce the basics of times series and stochastic modeling

Introduction: Statistical decision making – Definition of a model – The Modeling process Hypothesis Tests on Means: The Analysis of Variance problem – Objective – One-sample and Two – sample t Tests – One-Way ANOVA – Multiple comparisons in the ANOVA test – Randomized Block Design – Two-Way ANOVA; Hypothesis Tests of Variances: One-sample χ^2 test – Two sample F test – Bartlett's test for group variances

Frequency Analysis: Probability paper – plotting the data – Fitting Normal, Log-Normal and Log-Pearson Type-III distributions – Low-flow frequency analysis – Binomial risk Nonparametric Methods: One-sample run test for randomness – Pearson test and Spearman tests for serial dependence – Durbin-Watson test for autocorrelation – Kendall test for trend – Mann-Whitney test for distribution inequality – Chi-square test for goodness of fit – Kolmogorov – Smirnov One-sample and Two-sample tests

Assessing Model Reliability: Model rationality – Bias in estimation – SEE – Correlation coefficient – Accuracy of model coefficients – Analysis of the residuals. Correlation and Regression Analysis: Bivariate correlation – correlation in multivariate systems; Bivariate linear regression – statistical optimization – principle of least squares – reliability of the regression equation – reliability of point estimates of regression coefficients – confidence interval of the regression equation – correlation versus regression Multiple Regression Analysis: Matrix solution of the standardized model - criteria for evaluating a multiple regression model – Analysis of residuals

Spurious Correlation and Regression: Transformation of a bivariate regression equation – Transformation involving ratios of variables – the ratio correlation problem – ratio correlation cases; Stepwise Regression: Objective – model structure – Total and partial F tests. Principal components Regression Analysis – PCRA method; Polynomial regression analysis: Transformation and calibration – Analysis of variance of polynomial models – PCRA of polynomial equations

Numerical Optimization: Nonlinear model structures – objective function – response surfaces – Phase I search – Step sizes – Constraints – Goodness of fit - Calibration of power models – criteria for measuring optimality. Time Series and Stochastic Modeling: Components of a

Time Series – Moving-Average filtering – Autocorrelation analysis – Cross-correlation analysis – Identification of random component – Autoregression and Cross-regression models

REFERENCES

1. Gupta, S.C. and Kapoor, V. K., Fundamentals of Applied Statistics, Fourth Edition (Reprint), Sultan Chand & Sons, 2014
2. Gupta, S.C. and Kapoor, V. K., Fundamentals of Mathematical Statistics, Eleventh Edition (Reprint), Sultan Chand & Sons, 2014
3. Kottegoda, N. T and Rosso, R, Applied Statistics for Civil and Environmental Engineers, Wiley-Blackwell, Second edition,2008.
4. Paul Mac Berthouex and Linfield C. Brown, Statistics for Environmental Engineers, Second Edition, Lewis Publishers, Washington D.C., 2002
5. Richard H McCuen and Willard M Snyder, Hydrologic Modelling: Statistical Methods and Applications, Prentice-Hall, Englewood Cliffs, N.J., 1986
6. Richard H McCuen, Microcomputer Applications in Statistical Hydrology, Prentice-Hall, Englewood Cliffs, N.J., 1993
7. Richard H McCuen, Statistical Methods for Engineers, Prentice-Hall, Englewood Cliffs, N.J., 1985
8. Vic Barnett, Environmental Statistics: Methods and Applications, John Wiley & Sons, Inc., 2003

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Recognize that statistical methods are decision-making tools and will view them as a part of a process.
2. Use a different example to illustrate each statistical method, the student will recognize that there are a great many possible applications of statistical methods
3. To explore the use of statistical software and develop microcomputer applications for solving real-time problems in Water Resources and Environmental Engineering
4. Overall, at the end of the course, the students will realize that the course contains the statistical methods necessary to solve a wide array of real-world problems in Water Resources and Environmental Engineering.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓		✓		✓		✓	✓	
CO2		✓		✓						✓
CO3	✓	✓		✓				✓	✓	
CO4				✓					✓	✓

WREC 102	OPEN CHANNEL HYDRAULICS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To know the principles of fluid mechanics
- The solution of problems encountered in both natural and constructed water systems.
- Use of model studies and computers in solving a host of problems in hydraulic engineering

Definition, comparison with pressure flow; discussion on pressure and velocity distributions – Pressure and velocity distribution coefficients. Energy principles for prismatic and non-prismatic channels – Specific energy; Critical flow Computations and applications; controls, Transitions.
Uniform flow – Basic concepts of uniform flow - computations. Specific energy and specific force concepts – applications. best hydraulic sections. Design of irrigation canals.

Gradually varied flow – theory, the basic equation, various forms; profiles, combination of slopes and sections; computation of gradually varied flow- Direct step method and direct integration methods.

Rapidly varied flows - Momentum principle; Hydraulic Jump in prismatic channels; uses of hydraulic jump – Energy dissipation and stilling basins. Basic Introduction to spatially varied flows and unsteady flows.*Unsteady flows* -Equations of motion-Uniformly progressive wave -Rapidly varied unsteady flow – positive and negative surges. Dam break problem.

Sediment Transport - Sediment properties – inception of sediment motion – bed forms. Bed load suspended load – Total sediment transport. Design of stable channels and regime channels. Reservoir sedimentation and trap efficiency.

REFERENCES

1. Chaudhry M. H., "Open Channel Flow", Springer Publishers, 2008.
2. French, R. H., "Open Channel Hydraulics", Water Resource Publication, First Edition, 2007
3. Henderson, K.M. , "Open Channel Flow"- Macmillan, Pearson Publishers,1966
4. Ranga Raju, K.G., "Flow through open channels" – Tata-McGraw Hill Education, 1981.
5. Srivastava R, "Flow through Open Channels", Oxford University Press, New Delhi, 2007.
6. Sturm T.W., "Open Channel Hydraulics", Tata-McGraw Hill Education, 2nd Edition, New Delhi, 2009
7. Subramanya, K., "Flow in open channels" – Tata-McGraw Hill Education, 3rd Edition, New Delhi, 2009

8. Ven Te Chow, “Open channel Hydraulics” –The Blackburn Press, 2009
9. Wurbs R.A., and James W.P. "Water Resources Engineering", Pearson Publishers, 2001.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Acquire a knowledge of the principles of mechanics of open surface flow of fluids, and able to express these in terms of mathematics;
2. Analyze problems associated with flow of water in streams and canals;
3. Design canals and associated structures;
4. Pursue research in the field of water resources engineering and management.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓		✓	✓						
CO2				✓	✓					
CO3						✓				
CO4								✓	✓	✓

WREM 103	SURFACE WATER HYDROLOGY	L	T	P
		4	0	0

COURSE OBJECTIVES:

- The subject aims at making the students to understand the relevance of various components of hydrologic cycle, which are responsible for spatial and temporal distribution of water availability in any region.
- To study the various aspects of precipitation and abstractions and their analysis
- To understand the concepts of catchment and the factors influencing runoff
- To enable the students to gain knowledge in flood routing.

Hydrologic cycle – Concept – Hydrologic systems model – Classification – Hydrologic Process– Continuity equations – Momentum equations – Energy balance. Hydrometeorology. Atmosphere – constituents - structure– General circulation – Transitory system – Transport processes. Climate and Weather– Meteorological Observations.

Precipitation –Formation - Types – characteristics- Rainfall hyetograph, Intensity-Duration analysis- Frequency analysis- Intensity-duration-frequency (IDF) relationships- Average areal rainfall - Depth-Area –Duration analysis(DAD) –-Estimating missing rainfall data – PMP - Gauge consistency.

Evaporation–Process- Factors affecting evaporation- Measurement –Estimation- Energy balance method, aerodynamic method, combination method – Evapotranspiration – Reference evapotranspiration – Penman – Montieth method – Crop coefficients. Interception-

Infiltration – Process, Factors affecting infiltration, Measurement, Modeling –– Horton's equation , Richard's equation, Green Ampt model, Philip Two Term model, SCS model-Depression storage.

Concepts of catchment -Runoff process –Factors affecting Runoff - Estimation- Infiltration, Strange and SCS methods - Rain fall - Runoff modeling. Streamflow measurement- Stage-velocity - Discharge-measurement - Gauges– Current meter- Stage Discharge relationship – Selection of a Stream Gauging Site - Hydrograph — Base flow separation - Unit Hydrograph –derivations- Synthetic Hydrograph-Applications.

Floods- Flow routing – Lumped system routing – Level pool routing – Hydrologic river routing – Linear–reservoir model – Distributed flow routing – Saint-Venant's equations – Classification of distributed flow routing models – Wave motion, Kinematic wave routing, Finite-difference approximations – Numerical solution of the kinematic wave – Muskingum-Cunge method. Hydrologic design – Hydrologic design scale – Selection of the design level – Flood control measures.

REFERENCES

1. Bedient, P.B., Huber, W.C., Vieux, B.E., "Hydrology and Floodplain Analysis", Pearson Education India, 5th Edition, 2012
2. Chow V.T., Maidment D.R., Mays L.W., "Applied Hydrology", McGraw Hill Publications, NewYork, 1995.
3. Jaya Rami Reddy.P, "Hydrology", Laxmi Publications, New Delhi, 2004
4. McCuen, R.H., "Hydrologic Analysis and Design", Prentice Hall, 2004
5. Patra.K.C, "Hydrology and Water Resources Engineering", Narosa Publications, 2008, 2ndEdition, New Delhi, 2008.
6. Singh, V.P., "Elementary Hydrology", Prentice Hall, 1991

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Obtain the complete knowledge on hydrologic cycle, hydrometeorology and formation of precipitation.
2. Apply the various methods of field measurements and empirical formulae for estimating the various losses of precipitation, stream flow and runoff.
3. Know the various methods of runoff estimation. Apply the knowledge of soil erosion and sedimentation to estimate the life of the reservoir.
4. Understand the aspects of hydraulic and hydrologic flow routing in rivers and channels.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		✓								
CO2		✓				✓			✓	
CO3		✓							✓	
CO4		✓								

WREC 104	GROUNDWATER HYDROLOGY	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To understand the ground water movement and aquifer characteristics.
- To study groundwater well hydraulics
- To know the methods of construction, completion, protection and rehabilitation of water wells
- To study the causes and impact on groundwater level fluctuations

Introduction: Scope, historical background, utilization of groundwater, groundwater in the hydrologic cycle, origin and age of groundwater. *Rock properties affecting groundwater*: Geologic formations as aquifers, types of aquifers, porosity, soil classification, specific surface, vertical distribution of groundwater, zone of aeration, zone of saturation, specific retention, specific yield, storage coefficient, springs.

Groundwater movement**:** Darcy's law and its validity, intrinsic permeability, hydraulic conductivity, transmissivity, techniques for determination of hydraulic conductivity, groundwater flow rates, flow nets, flow in relations to ground water contours, flow across a water table, flow across a hydraulic conductivity boundary, dispersion, general flow equations in rectangular and radial co-ordinations.

Groundwater well hydraulics: Steady unidirectional flow steady radial flow to a well, unsteady radial flow in a confined aquifer, unsteady radial flow in an unconfined aquifer, unsteady radial flow in a leaky aquifer, well flow near aquifer boundaries, multiple well systems, partially penetrating wells, characteristic well losses, specific capacity and well efficiency.

Water wells: surface geophysical methods - electrical resistivity method - seismic method - subsurface investigation - test drilling - resistivity logging - application of remote sensing method. Test holes and well log;, methods for constructing shallow wells and deep wells, well completion, pumping equipment for wells, protection of wells, well rehabilitation, infiltration galleries, horizontal pipes, collector wells.

Groundwater Levels and Environmental Influences: Time variations of levels, stream flow and groundwater levels, fluctuations due to evapotranspiration, meteorological phenomena urbanization, earthquakes, external loads and land subsidence.

REFERENCES

1. "Groundwater Manual", "A water resources Technical Publication", U.S. Department of the interior - Edition. 1985
2. Karanth, K. R., A text book "Ground Water Assessment: Development and Management" Tata McGraw-Hill Education, 1987
3. Raghunath H.M , "A text book on Groundwater", IIIrd Edition, New age Publications,2007
4. Todd, D.K., "Groundwater Hydrology", John Wiley & Sons edition, 1980

COURSE OUTCOMES:

At the end of the course, the student should be able.

1. To evaluate the ground water resources and aquifer parameters for different hydro-geological boundary conditions.
2. To know and apply the techniques of detaining how much groundwater can be safely withdrawn from the aquifers.
3. To understand the different methods of well design, well construction and well maintenance
4. To solve groundwater real life problems and estimate the groundwater potential in the region under consideration.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				✓						
CO2						✓				
CO3							✓			
CO4									✓	

WREC 107	ADVANCED COMPUTER PROGRAMMING LABORATORY	L	T	P
		0	0	3

COURSE OBJECTIVE:

- To practice on C - Programming of Hydrological and Water Resources problems

Programming of various Hydrological and Water Resources problems in

1) Statistical Hydrology
2) Time series analysis
3) Hydrological analysis

4) System analysis
5) Open Channel flow

WREC 201	COMPUTATIONAL METHODS IN WATER RESOURCES ENGINEERING	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To learn the direct and indirect methods for finding the roots of transcendental and polynomial equations
- To learn the direct and iterative methods for the solution of a system of linear equations
- To learn the methods based on integration, finite difference operation and undetermined coefficients and extrapolation methods in numerical differentiation
- To provide a detailed treatment of single step and multi-step methods for solving first-order initial value problems
- To discuss the shooting method, finite difference methods and finite element methods for solving boundary value problems
- To make the students have a feel of application of relevant numerical methods covered in the course to pertinent hydraulics, hydrology and water resources engineering problems

Introduction – Sources of errors in numerical solutions: truncation error, round off error – significant digits and numerical stability.*Transcendental and Polynomial equations*: Direct and indirect methods – initial approximation – Bisection method, Secant and Regula-Falsi methods, Newton-Raphson method, Muller method, Chebysheve method – Solving system of nonlinear equations-Applications in determination of flow depth in Manning's equation.

System of linear algebraic equations – Direct methods: Crammer rule, Gauss elimination method, Gauss-Jordan elimination method, Triangulation method, Cholesky method, Partition method; iteration methods: Jacobi method, Gauss-Seidel method, SOR method – convergence criteria-Application of iteration methods to determine the potential infiltration rate in Green Ampt method.

Numerical differentiation: Methods based on integration, methods based on finite difference operation and methods based on undetermined coefficients – optimal choice of step length – extrapolation methods-Application of finite difference methods to solve the linear kinematic wave equation in flood routing.

Ordinary differential equations: Initial value problems – Reduction of higher order equation to the system of first order differential equations – existence and uniqueness of solution – test equation – numerical solution of differential equations – Euler method, Backward Euler method, Mid-point method; Solution of the initial value problem: Taylor series method, Runge-Kutta methods of second order and fourth order, Predictor-Corrector methods-Applications to route the inflow hydrograph and computation of surface profile for GVF.

Ordinary differential equations: Boundary value problems- Shooting method - Finite difference methods – Use of finite difference approximations in development of dynamic response equations of groundwater systems - Finite element method – Method of weighted residuals – Galerkin model – Applications in Water resources engineering.

REFERENCES

1. Balagurusamy, E, "Numerical methods", Tata McGraw-Hill Education, First edition, 1999.
2. Desai, Y. M., Eldho, T. I, Shah, A. H, "Finite Element Method with Applications in Engineering", Pearson,2011.
3. Jain M. K, Iyengar, S. R. K, Jain, R. K, "Numerical Methods for Scientific and Engineering Computation", New Age International Publishers, New Delhi, Fifth Edition, Reprint 2008.
4. Rajasekaran, S, "Numerical Methods in Science and Engineering", S. Chand and company, Second edition, 2003.
5. Robert Willis and William W-G. Yeh, "Groundwater Systems Planning and Management", Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1987.
6. Subramanya, K., "Flow in Open Channels", Tata McGraw-Hill publishing Company Limited, 2001.
7. VenTe Chow, David. R. Maidment, Larry W, Mays, "Hydrology", Tata McGraw Hill Education Limited, 2010.

COURSE OUTCOMES:

At the end of the course, the students will be able to

1. Know the solution procedures of direct and indirect methods for finding the roots of transcendental and polynomial equations and apply them in relevant problems in open channel hydraulics
2. Apply the direct and iterative methods for the solution of a system of linear equations and use them in relevant hydrological applications
3. Have hands on experience in applying numerical differentiation methods for solving flood routing problems
4. Understand the different methods of obtaining numerical solution of differential equations and numerical solution of initial value problems and apply them to relevant hydraulic and hydrological problems.
5. To apply the finite difference methods and finite element methods in solving boundary value problems in groundwater systems planning and management

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓								✓	
CO2		✓							✓	
CO3		✓							✓	
CO4	✓		✓			✓			✓	
CO5										

WREC 202	WATER RESOURCES SYSTEMS ANALYSIS	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To gain a better understanding of the complex interactions among all the hydrologic, ecologic, economic, engineering and social components of water resource systems, analyses based on systems perspectives
- To introduce the science and art of developing and applying various modeling approaches in support of water resources planning and management
- To emphasize the practice of developing and using models to address specific water resources planning and management issues and problems.
- To provide relevant, objective, timely and meaningful information to those who are responsible for deciding how we develop, manage, and use our water resources.

Introduction Concept of system – Issues in hydrosystems engineering – Comparison between conventional and optimization procedures – Introduction to various uncertainties in hydrosystem design and analysis – Application of optimization in hydrosystem Economics for hydrosystem - Engineering economic analysis – discount factors – Benefit - COst analysis

Linear programming - Concept – Assumptions – Forms of LP - Solution algorithms for LP – Formulation of LP models for water resources engineering projects Dynamic programming - Elements of a DP model – Bellman's principle of optimality – Recursive equations for forward and backward dynamic programming techniques – Application of DP to Hydrosystems

Nonlinear programming - Applications to Hydrosystems – Unconstrained nonlinear optimization – Constrained optimization – Constrained non-linear optimization Water resources planning under uncertainty - Planning with uncertainty – Sensitivity analysis – Utility theory. Water resources planning objectives - Economic Benefit –COst objectives – Benefit and COst estimation – Long –and Short-run Benefit functions

Deterministic river basin modeling - Estimating reservoir storage and requirements for water supply – flood control alternatives - hydroelectric power production - Integer programming models

Stochastic planning models - Reservoir operation – SDP operating model – Single reservoir design and operation – SLP Design model

REFERENCES

1. Chaturvedi, M. C., "Water Resources Systems Planning & Management", McGraw-Hill Inc., US, second edition,1992.
2. Daniel P. Loucks and Eelco Van Beek, "Water Resources systems Planning and Management – An Introduction to Methods, Models and Applications" Studies and Reports in Hydrology, UNESCO Publishing, Edition, Paris. 2005
3. Daniel P. Loucks, Jery R. Stedinger and Douglas A. Smith, "Water Resource Systems Planning and Analysis", Prentice-Hall, Inc, Englewood Cliffs, New Jersey, USA, Edition, 1981
4. Larry W Mays and Yeou-koung Tung, "Hydrosystems Engineering and Management", McGraw-Hill Inc., International Edition, 1992
5. Pramod R. Bhave , "Water Resources Systems", Alpha Science International Limited, 2011.
6. Vedula, S., and Mujumdar, P. P., "Water Resources Systems – Modelling Techniques and Analysis", Third Reprint 2007, Tata McGraw-Hill Publishing Company Limited, New Delhi, Edition 2005.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Learn the art of systems modeling and analyses
2. Gain the knowledge to make appropriate choices regarding model complexity
3. Develop their skills in the use of quantitative methods of identifying and evaluating effective water resources management plans and policies.
4. Become a skilled water resources systems modeler, analyst and planner through the modelling approaches, examples and case studies they have learnt.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓									
CO2	✓	✓		✓						
CO3	✓	✓		✓		✓				
CO4	✓	✓		✓		✓			✓	

WREC 203	REMOTE SENSING & GIS IN WATER RESOURCES ENGINEERING AND MANAGEMENT	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To teach the principles and applications of spatial information technologies namely remote sensing, GPS and GIS in the context of water resources.
- To understand the basic concepts of Remote sensing and GIS in Spatial modeling
- To educate the students on application of remote sensing and GIS in solving the spatial problems in water resources.

Spatial data source: Remote sensing, GPS surveying, topomap and other secondary sources. Physical principle of Remote sensing, classification of Remote sensing system-concepts of microwave remote sensing - Remote sensing platforms- LANDSAT, SPOT, IRS, ERS, INSAT, IKONOS and others – types of aerial photography-methods of viewing aerial photographs- scanning systems – passive and active – Digital processing of Remote sensing data- Image enhancement – Image classification.

Definition- basic components of GIS-standard GIS packages-maps, mapping process, projections, coordinate systems-spatial data –spatial data model-spatial relationship-topology-spatial data structure: raster, vector – attribute data- database-database management systems-database models: Hierarchical, network, relational, object oriented models-data input, editing-integrated GIS database.

Thematic mapping-measurement in GIS: length, perimeter and areas- Query analysis-Reclassification-Buffering-Neighborhood functions-Integrating data: map overlay, overlay functions, vector overlay and raster overlay – Interpolation-Network analysis-Data output types- Output devices-Error- Types of errors.

Application of Remote sensing: Evaluation of water resources- water penetration and depth measurement- water quality-water temperature-soil moisture-study of Geology, geomorphology, drainage, morphological and land use\land cover of watersheds-groundwater resources.

Application of GIS: Base map preparation - catchment survey - regional rainfall mapping-Flood inundation mapping, drought monitoring - surface water resources- Inventory-groundwater potential mapping, water quality assessment - site selection for artificial recharge - reservoir sedimentation - water quality mapping ; performance evaluation of irrigation commands, Agricultural management; - National, Regional and Local water resources planning

REFERENCES

1. Anji Reddy, M, "Remote Sensing and Geographical information systems", B.S Publications-2001
2. Basudeb Bhatta , "Remote Sensing and GIS", Oxford University Press, 2nd Edition, 2011.
3. Bernhardesen. T., "Geographic Information Systems: An Introduction", John Willy and Sons, inc. 1999.
4. Burrough P.A. and McDonnell R.A., "Principles of Geographical Information System", Oxford University Press. New York. 1998.
5. Ian Heywood Sarah, Cornelius and Steve Carver "An Introduction to Geographical Information Systems". Pearson Education. New Delhi. 2002.
6. Lillesand, T.M. and Kiefer, R.W., "Remote Sensing and Image Interpretation" III Edition. John Wiley and Sons, New York. 1993.
7. Lo,C.P. and Yeung, A.K.W., "Concepts and Technologies of Geographic Information System", Prentice-Hall of India, New Delhi. 2004.
8. Srinivas, M.G., "Remote Sensing Applications", Naosa Publishing House-(Edited By) 2001

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Apply Remote sensing, GPS and GIS tools to solve the spatial problems in water resources
2. Understand the technology and principles of Satellite Imaging
3. Know the functional explication of GIS and integrating Satellite data products into the GIS platform for decision making
4. Understand the application of Remote Sensing and GIS on solving a host of problems in Water Resources engineering through case studies

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1					✓				✓	
CO2					✓	✓			✓	
CO3					✓	✓			✓	
CO4					✓				✓	✓

WREC 204	WATER DISTRIBUTION NETWORKS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To introduce the students the concepts and various methods of network analysis in pipe line Engineering.
- To learn about the understanding of basic principles, analysis and design aspects of water distribution pipe Networks.

Basic principles of pipe flow - Surface Resistance - Form Resistance - Pipe Bend, Elbows, Valves, Transitions, Pipe Junction, Pipe Entrance, Pipe Outlet, Overall Form Loss, Pipe Flow Under Siphon Action - Pipe Flow Problems, Nodal Head, Discharge and Diameter Problem.

Introduction – types of water supply systems, piping systems, water distribution network - labeling network elements - Equivalent Pipe, Pipes in Series, Pipes in Parallel - Resistance Equation for Slurry Flow - Resistance Equation for Capsule Transport - Head Loss in a Pipe Link, Head Loss in a Lumped Equivalent and Head Loss in a Distributed Equivalent - Analysis of Water Transmission Lines - Analysis of Distribution Mains - Pipe Network Geometry - Analysis of Branched Networks.

Analysis of Looped Networks: Hardy Cross Method, Newton–Raphson Method and Linear Theory Method - Multi-Input Source Water Network Analysis, Pipe Link Data, Input Point Data, Loop Data, Node–Pipe Connectivity, and Analysis - Flow Path Description - Node flow analysis- Classification of Nodes – NFA theory – Problem formulation, problem solution and solution procedure – Practical applications.

Single-Input Source, Branched Systems, Gravity-Sustained, Branched System, Radial and Branch Systems - Single-Input Source, Looped Systems, Gravity Sustained Looped Systems, Continuous Diameter and Discrete Diameter Approach - Multi-Input Source, Branched Systems , Gravity Sustained Branched Systems, Continuous Diameter and Discrete Diameter Approach - Multi-Input Source, Looped Systems, Gravity Sustained Looped Systems, Continuous Diameter and Discrete Diameter Approach. Computer application and software packages: EPANET, LOOP,SEWER & BRANCH

REFERENCES

1. AWWA Water transmission and distribution, second edition, Principles and Practices of water supply operation series, American water works Association. (1996),
2. Bhare. P.R “Optimal Design of Water Distribution Networks”, Narosa Publishing Home, New Delhi. 2003
3. Bhave P.R and Gupta R Analysis of “Water Distribution Networks” Narosa Publishing House, New Delhi, 2008

4. Prabhata K. Swamee, Ashok K. Sharma "Design of Water supply pipe Networks", A John wiley & sons, INC., Publication (Canada), 2008
5. Wurbs, R. A and James, W.P, "Water Resources Engineering, Pearson", First edition,2001.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Understand the basic principles of pipe flow and pipe appurtenances
2. Know the types of water supply systems and water supply networks
3. Apply the analysis of Looped Networks in water supply distribution and Pipe network analysis of single-input and multi-input sources to meet water demand at various withdrawal points
4. Use Computer software packages for Water distribution network analysis

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓									
CO2		✓								
CO3				✓		✓			✓	✓
CO4									✓	✓

WREP207	REMOTE SENSING AND GIS LABORATORY	L	T	P
		0	0	3

Course Objective

- To conduct laboratory studies on Remote Sensing & GIS and its applications on Civil Engineering

Remote Sensing Laboratory**:** Study with pocket, mirror and prism stereoscopes – Marginal Information of aerial photograph – Height measurement (i) Monoscopic measurement (ii) Stereoscopic measurement – Slope measurement – Referencing system of various resource satellite images – Marginal information of satellites images – Constructing spectral reflectance curves – Interpretation of satellite images – Interpretation of Radar images.

GIS Laboratory: Map – map projection – Transformation – Different data format – Creating coordinating system – Creating Geo Reference – Digitization - spatial data – Attribute data entry – Spatial data analysis – Reclassification – Overlay analysis – Interpolation – Digital Elevation model.

Hands on exercise – various GIS software – QGIS – Project works.

WRES208	SEMINAR	L	T	P
		0	0	2

COURSE OBJECTIVES:

- To work on a technical topic related to Water Resources Engineering and acquire the ability of written and oral presentation
- To acquire the ability of writing technical papers for Conferences and Journals

The students will work for two periods per week guided by student counselor and a seminar will be conducted for not less than fifteen minutes and not more than thirty minutes on any technical topic of student's choice related to relevant subject. The students will defend their presentation and interact with audience. A brief copy of their presentation also should be submitted. Evaluation will be done by the student counselor based on the technical presentation and the report and also on the interaction shown during the seminar.

COURSE OUTCOMES:

1. The students will be getting the training to face the audience and to interact with the audience with confidence.
2. To tackle any problem during group discussion in the corporate interviews.

WRET303	THESIS PHASE-I	L	T	P
		0	4	0

COURSE OBJECTIVES

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE OUTCOMES

Upon completion of this course, the students will be able to:

1. Take up any challenging practical problems and find solution.
2. Learn to adopt systematic and step-by-step problem solving methodology.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

WREI304	INDUSTRIAL TRAINING	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To train the students in the field work related the Water Resources Engineering and to gain a practical knowledge in procuring relevant and related field primary data.
- To train and develop skills in solving problems during execution of certain works related to the subject of specialization.

The students individually undergo a training program in the field and concerned government departments during the summer vacation (at the end of second semester for full – time / fourth semester for part – time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training obtained, within ten days from the commencement of the third semester for Full-time / fifth semester for part-time. The students will be evaluated by a team of staff members nominated by head of the department through a viva-voce examination.

COURSE OUTCOMES:

1. The students can face the challenges in the practice with confidence.
2. The student will be benefited by the training with managing the situation arises during the execution of works.

WRET401	THESIS PHASE-II	L	T	P
		0	**8**	**0**

COURSE OBJECTIVES

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE OUTCOMES

Upon completion of this course, the students will be able to:

3. Take up any challenging practical problems and find solution.
4. Learn to adopt systematic and step-by-step problem solving methodology.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

PROFESSIONAL ELECTIVES

WREE***	WATER POWER AND DAM ENGINEERING	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES

- The student is exposed to the design aspects of hydro-power plants, transient analysis, various components of hydropower plants and their layout.
- To know the technical information on dams and associated structures on aspects of the suitability of the site, planning, design, different type loads and maintenance

Introduction, sources of energy, role of hydropower in a power system, development of water power potential in India and the world, Features and characteristics of water power generation, Data requirement for assessment of water power potential-flow duration and mass curves, energy flow diagram, demand and prediction, Types of Hydropower generation plants- site selection and Planning – Environmental Considerations and its layouts,
Components of a hydropower structure- regulatory structures-intake structures –types, location, losses, air entrainment, anti-vortex device, air vent, fore bay, trash racks, power canals, tunnels, surge tanks, settling basins, anchor blanks , penstocks- classification, resonance in penstocks, design criteria, losses, anchor blocks, valves, bends and manifolds, tunnels- geometric and hydraulic design, water hammer and surges, surge tank- functions, type, design of surge tank, methods of surge analysis, channel surges

Types of water power house- structural and geotechnical aspects of power house design, location, site and general arrangements, draft tubes, tail trace and their hydraulic design, draught and cooling towers, turbines - characteristics, hydraulics of turbines, cavitations, transients caused by turbine and foundations, pumps-efficiency and characteristics, generators, exciters, switchboard, transformers and other accessories

Water retaining structures-Dams-Classifications, types, planning and investigation of reservoir and dam sites, reservoir capacity and regulation, reservoir silting, dam optimization, analysis and design of earthen and rockfill dams, internal seepage, stability and stress, settlement and deformation, foundation treatment, analysis for failure and safety criteria. Gravity dam - forces acting and criteria, elementary and practical profile, stability analysis , modes of failures, joints, seals, keys and galleries in gravity dams, spillways-types, location and design, energy dissipaters, dam break analysis, dam safety and hazard mitigation

REFERENCES

1. Barrows, H. K, “Water Power Engineering”, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2000.
2. Creager, W.P, Justin, J. D and Hinds J, “Engineering for dams”, Nem Chand and Brothers, Roorkee ,1995.

3. Dandekar, M.M., and Sharma, K.N, "Water Power Engineering", Vikas Publishing House, New Delhi ,1994.
4. Garg S. K, "Irrigation Engineering and Hydraulic Structures" Khanna Publishers, New Delhi, 1998.
5. Khatsuria, R. M, "Hydraulics of spillways and energy dissipaters", CRC Press, New Delhi, 2005.
6. Sharma, R.K and Sharma,T.K, "Water Power Engineering", S. Chand and company Ltd, New Delhi,2003.
7. Streeter, V.L and Wylie B, "Fluid Transients", McGraw-Hill Book Company. New Delhi, 1967.
8. Varshney, R .S, "Hydro Power Structures", Nem Chand & Bros, Roorkee, 2001.
9. Novak, P, Moffat, A.I.B, Nalluri, C and Narayanan, R, "Hydraulic Structures", CRC press, Fourth Edition, 2006.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Get knowledge of planning and designing hydropower plants and solve the hydropower related problems arising in real life situation
2. Design the various dam structures on the basic of design flood flow and their proper regulations
3. Understand the important aspects of water retaining structures, types of dams and planning and investigation of reservoir.
4. Assess the problems on structural and geotechnical aspects of power house design.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			✓							
CO2						✓				
CO3									✓	
CO4										✓

WREE***	ENVIRONMENTAL IMPACT ASSESSMENT OF WATER RESOURCES DEVELOPMENT	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To study the fundamentals and concepts of environmental impact assessment of water resources projects
- To study the various Environmental impacts on ECOsystem
- To study the methods of EIA and environmental management
- To assess the impact of Water Resources development on the environment

Environmental Issues: Water resources development issues – Environment in water resources project planning – Environmental regulations and requirements – EIA (Environmental Impact Assessment) Notification, 2006 – MoEF & CC Guidance document an major Hydroelectric and Irrigation Projects – ESA (Ecologically Sensitive Area) Notification.

EIA Fundamentals: Environmental impact Assessment (EIA) - Environmental impact statement – EIA in project cycle – Legal and regulatory aspects in India according to Ministry of Environment and Forests – Types and limitations of EIA – Cross sectoral issues and Terms of Reference in EIA – Due Diligence Survey – Value Environmental components – Flora & Fauna; Endanged Species

Environmental Impacts: Hydrological and water quality impacts – Ecological and biological impacts – Social and cultural impacts – Soil and landscape changes – Agro economic issues – Human health impacts – ECOsystem changes.

Methods of EIA: EIA team formation – Development of scope, mandate and study design – Base line theory – Check lists – Network and matrix methods – Semi-quantitative methods – ICID check list – Economic approaches – Environmental Impact Statement (EIS) preparation.

Environmental Management: In-stream ecological water requirements – Public participation in environmental decision making – Sustainable water resources development – Ecorestoration – Hydrology and global climate change – Afforestation – R & R (Resettlement & Rehabitation) Programmes - Environmental monitoring programs.

REFERENCES

1. Biswas, A.K and Aggarwal, S.B.C, “Environmental Impact Assessment for developing Countries”, Oxford Butterworth – Heinemann, 1992.
2. Canter, L.W, “Environmental Impact Assessment”, McGraw Hill International Edition, New York,2008.
3. Lawrence, D.P, “Environmental Impact”, Wiley-Interscience, New delhi, 2003.
4. Petts, J, “Handbook of Environmental Impact Assessment”, Blackwell Science London, 1999.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Understand and analyse the various methods of Environmental Impact Assessment
2. Prepare EIA repots of Water Resources and Environmental projects
3. Prepare checklist and EIA using various tools for water resources development projects
4. Understand the various aspects of EIA on environmental management.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1							✓			
CO2										✓
CO3							✓		✓	✓
CO4								✓		

WREE***	HYDRAULIC STRUCTURES	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To provide planning and engineering design concepts
- Application to various structures in hydropower projects including turbines and other structures.

Reservoir Planning: Classification of reservoirs, storage zones of a reservoir, fixing capacity of reservoirs, life of a reservoir.

Dams: Investigation surveys, selection of dam site, selection of types of dam, classification of dams. Gravity Dams Forces acting on dam, combination of forces for design, design parameters, design of gravity dam, profiles of a dam, stability analysis, foundation treatment, galleries in gravity dams.

Earth and Rock fill Dams: Types, design criteria for earth dams, design consideration in seismic region, phreatic line, flow net, stability analysis, methods of analysis, slope protection, seepage, dam section to suit available materials and foundation, causes of failure of earth dams, safety measures.

Spillways: Components factors affecting type and design of spillway, types, energy dissipation below spillways, hydraulic jump type stilling basins spillway gates, types.
Weirs and Barrages: Design of impervious floor on pervious foundation. Blighis Lane's creep theories, potential theory cut offs, weir design, Khosla's method.

Unlined irrigation channels: Design parameters, transmission losses, determination of water losses, design formulae, Kennedy's and Lacey's theories, channels on non-alluvial soils.

REFERENCES

1. Creager, W.P, Justin, J and Daud Hinds, "Engineering for Dams", Vol. I-III, Wiley, N.Y, USA.
2. Satyanarayana Murthy, C, "Design of Minor Irrigation and Canal Structure",Wiley Eastern, 1990.
3. Sharma, R.K, "Text Book of Irrigation Engineering and Hydraulic Structures ", - Oxford & IBH, 1984
4. Sharma, S.K, "Design of Irrigation Structures", S. Chand & Co, 1988.
5. Varshney, R, S, "Theory and Design of Irrigation Structures", Nem Chand & Bros, 2009.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Understand Reservoir planning and analysis
2. Design Major irrigation structures like dams, spillways, Weirs and barrage structures
3. Get a wide knowledge on design of Unlined irrigation channel

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓								
CO2		✓				✓			✓	
CO3						✓			✓	✓

WREE* **	**GROUNDWATER SYSTEM PLANNING AND MANAGEMENT**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- This course provides the fundamental know-how on groundwater flow and transport processes, Sources of pollution, techniques for groundwater resources assessment, environmental issues of overcharging and overexploitation of groundwater development, management of groundwater resources development and groundwater pollution.
- To know the groundwater systems and development
- To study the groundwater transport problems and quality modeling
- To understand the various types of methods and analysis
- To know the technical programming about the groundwater systems and management.

Introduction – An overview of groundwater systems – Model formulation and development.

Groundwater flow equations – Darcy's Law – the Continuity equation – Partially saturated flow – Partially unsaturated flow – Conservation of mass in a deforming porous medium – Groundwater flow equations for a confined or leaky aquifer and unconfined aquifer.Groundwater quality – the mass transport problem – Mass transport equation – Groundwater quality model – Vertically averaged mass transport equations – Boundary and initial conditions – Non conservative processes – Partially saturated flow systems.

Numerical methods in Groundwater Management – the response equation – Finite difference numerical models – Finite element models – the method of weighted residuals – Solution methods for the dynamic response equation – Non linear systems – Matrix method for the solution of linear system of equations – Finite difference stability analysis – Finite element analysis.

Optimization methods for Groundwater Management – Preliminaries of mathematical programming – Linear programming – Stochastic linear programming – Quadratic programming – Dynamic programming – Stochastic dynamic programming – Non linear programming – Unconstrained optimization – Constrained optimization – Multi-objective programming.

Groundwater Supply Management Models – Groundwater allocation model – Groundwater operation model – Capacity expansion model – Conjunctive groundwater and surface water planning model .Groundwater Quality Management Modeling – Groundwater quality simulation models – Solution methods for the groundwater quality prediction problem – Optimal groundwater quality management model – Solution algorithms for the conjunctive management model.

The Inverse Problem in Groundwater Systems – Parameter estimation problem – Parameter dimension and parameterization – Parameter identification methods – Equation error criterion – Parameter estimation model – Output error criterion parameter estimation model – Gauss-Newton algorithm – Computation of sensitivity coefficients – Parameter uncertainty and optimum parameter dimension – Bayesian estimation – Statistical methods.

REFERENCES

1. Dantzig, G.B, "Linear programming and extensions", Princeton University Press, Princeton, New Jersey, 1963.
2. Huyakorn, P.S. and Pinder, G.F, "Computational methods in subsurface flow", Academic Press.
3. Lee, S.M, "Linear optimization for management", Petrocelli/ Charter, New York, 1976.
4. Rastogi, A.K, "Numerical Groundwater Hydrology", Penram International Publications, 2007.
5. Remson, I, Hornberger, G.M. and Molz, F.J, "Numerical methods in subsurface Hydrology", Wiley-Interscience, New York

6. Robert Williams and William W-G. Yeh, "Groundwater System Planning and Management", Prentice – Hall Inc, 1987.
7. Rushton, K.R., Redshaw, S.C., "Numerical analysis by analog and digital methods", John Wiley and sons

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Understand the groundwater systems management
2. Solve problems groundwater modeling
3. Know and apply the technical programming to the groundwater management
4. Evaluate the problems on groundwater development.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		✓								
CO2									✓	
CO3					✓					

WREE* **	**URBAN HYDROLOGY**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To introduce to the concepts of urbanization and its impact on the natural water cycle.
- To prepare Master plans for urban water management.

Urban hydrologic cycle: Water in the urban eco-system - Urban water resources - Major problems – Urban hydrological cycle - Storm water management objectives and limitations - Storm water policies - Feasibility consideration.

Urban Water Resources Management Models: Types of models - Physically based - conceptual or unit hydrograph based -Urban surface runoff models - Management models for flow rate and volume control rate - Quality models.

Urban Storm Water Management: Storm water management practices (Structural and Non-structural Management measures) - Detention and retention concepts – Modelling concept - Types of storage - Magnitude of storage - Hydraulic analysis and design guidelines - Flow and storage capacity of urban components - Temple tanks.

Master plans: Planning and organisational aspects - Inter dependency of planning and implementation of goals and measures - Socio - economics financial aspects - Potential COsts

and benefit measures - Measures of urban drainage and flood control benefits - Effective urban water user organizations.

Operation and Maintenance: General approaches to operations and maintenance - Complexity of operations and need for diagnostic analysis - Operation and maintenance in urban water system - Maintenance Management System - Inventories and conditions assessment - Social awareness and involvement.

REFERENCES

1. Geiger.W.F., Marsalek.F., Rawls.W.J., and Zuidena.F.C., (Ed), manual on drainage in urbanized areas - Vol.I and Vol.II, UNESCO, 1987.
2. Hengeveld H. and C.DeVoch.t (Ed)., "Role of Water in Urban Ecology", 1982.
3. Martin P.Wanelista and Yousef A.Yousef., "Storm Water Management", John Wiley and sons, 1993.
4. Neil S.Grigg., "Urban Water Infrastructure planning, management and Operations", John Wiley and Sons, 1986.
5. Overtens D.E. and Meadows M.E., "Storm Water Modelling", Academic Press, New York, 1976.
6. Warren Viessman, "Introduction to Groundwater Hydrology", Pearson, Fifth edition, 2002.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Apply appropriate management techniques for planning, operating and maintaining the different components of urban and drainage system.
2. Gain knowledge in operation and maintenance of urban water system.
3. Solve the problems on socio-economic financial aspect
4. Know about urban eco-system and urban hydrological cycle

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		✓								
CO2			✓							
CO3						✓				
CO4								✓		

WREE***	WATERSHED CONSERVATION AND MANAGEMENT	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To make the student understand the watershed based water resources development and implementation of conservation practices
- To Implant the sustainable management of natural resources of the watershed

Introduction: Watershed – Definition and Classification – Components- Basic factors influencing watershed development – Codification - Watershed delineation - Characteristics of watershed: size, shape, physiography, slope, climate, drainage, land use, vegetation, geology and soils, hydrology and hydrogeology – Socio - economic characteristics.

Soil conservation measures: Types of Erosion – Water and Wind Erosion: Causes, Factors, Effects and Control – Estimation of Soil Erosion- Soil Loss Models- Sedimentation - Soil Conservation Practices: Vegetative and Mechanical.

Water harvesting and conservation: Types of storage Structures-Water yield from Catchments-Losses of stored water- Water Conservations Methods-Water harvesting methods and Techniques-Rainwater Harvesting-Catchment, Harvesting structures, Roof water harvesting- Soil Moisture Conservation-Check Dams-Artificial Recharge-Farm Ponds-Percolation tanks.

Watershed management: Project Proposal Formulation - Watershed Development Plan – Entry Point Activities – Estimation – Watershed Economics - Agroforestry – Grassland Management – Wasteland Management – Watershed Approach in Government Programmes –Developing Collaborative know how – People's Participation – Evaluation of Watershed Management

Watershed management plan: Methodology of planning a watershed management, identification of watershed problems, socio-economic issues - application of Remote Sensing and GIS in watershed management.

REFERENCES

1. Dhuruvanarayana.V.V, Sastry.G and Patnaik.U.S, "Watershed Management", Publications and information division, Indian Council of Agriculture Research, New Delhi, 1990.
2. Gelnn O. Schwab, "Soil and Water Conservation Engineering", john Wiley and sons, New York, 1981.
3. Ghanashyam Das, "Hydrology and Soil Conservation engineering", Prentice Hall of India Private Limited, New Delhi, 2000.
4. Murthy J.V.S, "Watershed Management in India", Wiley Eastern Limited, New Delhi, 1995.

5. Suresh, R., “Soil and Water Conservation Engineering”, Standard Publishers.
6. Tideman E.M., “Watershed Management”, Omega Scientific Publishers, New Delhi, 1996.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Suggest technical measures for soil erosion and water harvestings
2. Apply the knowledge of overall concepts of watershed which would help to comprehend Analyze for better management and conservation.
3. Access better watershed management plan for applications of Remote Sensing and GIS

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1									✓	
CO2							✓			
CO3					✓					

WREE* **	**RIVER ENGINEERING**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand theoretical concepts of water and sediment movements in rivers
- To inculcate the benefits of fluvial system to the society

RIVER FUNCTIONS**:** Primary function of a river – River uses and measures – Water and Sediment loads of river – Rivers in India, Himalaya and Peninsular.

RIVER HYDRAULICS**:** Physical Properties and Equations – Steady flow in rivers – uniform and non uniform – Turbulence and velocity profiles – resistance coefficients – Boundary conditions and back waters – Transitions – Rating Curve – Unsteady flow in rivers : Propagative of surface waves – Characteristics, flood waves – kinematic and diffusion analogy – velocity of propagation of flood waves – Flood wave –Maximum

RIVER MECHANICS **:** River Equilibrium : Stability of Channel – regime relations – river bend equilibrium – hydraulic geometry of downstream - Bars and meandering - River dynamics – degradation and aggradations of river bed – Confluences and branches – River Data base.

RIVER SURVEYS AND Model**:** Mapping – Stage and Discharge Measurements – Sediments – Bed and suspended load Physical hydraulic Similitude – Rigid and mobile bed – Mathematical – Finite one dimensional – multi – dimensional – Water Quality and ecological model

RIVER MANAGEMENT **:** River training works and river regulation works – Flood plain management – waves and tides in Estuaries - Interlinking of rivers – River Stabilization

REFERENCES

1 Janson PL.Ph., Lvan BendegamJvanden Berg, Mdevries A. Zanen (Editors), Principles of River Engineering – The non tidal alluvial rivers – Pitman, 1979.
2. Pierre Y. Julien ., River Mechanics ,Cambridge University Press, 2002.
3. K.L Rao , INDIA's WATER WEALTH – Orient Longman Ltd., 1979.
4. R. J. Garde River Morphology New Age International (P) Limited, Publishers New Delhi 2011.
5. R.J.Garde and K.G.Ranga Raju Mechanics of Sediment Transportation and Alluvial Stream Problems New Age International (P) Limited Publishers New Delhi 2000

COURSE OUTCOMES:

1. Appreciate the complex behavior of rivers.
2. Gain the skills to take up research activities in river engineering.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓			✓					
CO2		✓			✓					
CO3		✓			✓					

WREE***	**SOFT COMPUTING IN WATER RESOURCES MANAGEMENT**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To enable students to understand application of the latest information technology to Water Resources Engineering.
- To provide the mathematical background for carrying out optimization associated with neural network and fuzzy logic learning.

- To develop skills of students in software usage for Water Resources Management.

Introduction: Basic concepts of Neural Networks and Fuzzy Logic – Difference between conventional computing and Neuro-Fuzzy computing – Characteristics of Neuro- Fuzzy Computing.

Fuzzy Set Theory: Basic definitions, terminology and membership functions – formulation and parameters – basic operations of fuzzy sets – complement, intersection, vision – T – norm and T – conorm. Fuzzy Reasoning and Fuzzy Inference: Fuzzy rules – Fuzzy reasoning – Fuzzy Inference Systems – Fuzzy modeling – Applications of Fuzzy reasoning and modeling in Water Resources Engineering.

Fundamental concepts of Artificial Neural Networks: Model of a Neuron – Activation functions – neural processing – Network architectures – learning methods.

Neural Network Models: Feed forward Neural Networks – Back propagation algorithm – Applications of Feed forward networks – Recurrent networks – Hopfield networks – Hebbian learning – Self organizing networks – unsupervised learning – competitive learning.

Neuro-fuzzy computing: Hydrologic Modelling – Time series Analysis and Modelling in Water Management. Basic concepts of few other soft computing algorithms – Genetic algorithms – Evolutionary algorithms – Simulated Annealing – Honeybee mating algorithms –Applications to water resources engineering problems.

REFERENCES

1. Daniel. P. Loucks and Eelco Van Beek with contributions from Jery R. Stedinger Jos. P.M. Dijkman and Monique. T. Villars (2005), “Water Resources Systems Planning and Management - An Introduction to Methods, Models and Applications”, UNESCO Publishing Company.
2. Jang, JSR, Sun, C.T. and Mizutani, E. (1997), “Neuro-Fuzzy and Soft Computing”, Prentice Hall, NJ.
3. Klir, George, J, Forger, T.A. (1995), “Fuzzy Sets, Uncertainty and Information”, Prentice Hall of India Pvt. Ltd., New Delhi.
4. Kosko, B. (1997), “Neural Networks and Fuzzy Systems”, Prentice Hall of India Pvt.
5. Ltd., New Delhi.
6. Rajasekaran, S. and Pai, G.A.V. (2003), “Neural Networks, Fuzzy Logic and Genetic algorithms", PHI.
7. Rao. V and H. Rao, (1996), “C++, Neural Networks and Fuzzy Logic”, BPB Publications, New Delhi.
8. Simon Haykin, (1994), “Neural Networks, A Comprehensive Foundation”, McMillan College Publishing Company.

COURSE OUTCOMES:

At the end of the course students will be able to

1. Understand and apply the concepts of Artificial Neural Networks for computations.
2. Adopt Fuzzy logic in modeling water resource systems and evolve optimum solutions.

3. Employ Neuro-Fuzzy computing to Water resource problems in finding quick solutions.
4. Appreciate the advantages of soft computing techniques to real time water systems.
5. Choose appropriate soft computing algorithms for various Water Resource Engineering problems.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓									
CO2	✓			✓						
CO3				✓					✓	
CO4									✓	
CO5									✓	

WREE***	WATER QUALITY MANAGEMENT FOR AGRICULTURE	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- These courses introduce water quality concepts, its evaluation for irrigation purposes including scientific approach to crop productivity, besides relevant environmental problems and recycle and reuse concepts.
- At the end of the course, the students will understand the importance of water quality and Management for irrigation and major uses of water and the role environmental issues.

Water quality evaluation – Water quality problems – Approach to evaluating water quality – Water quality guidelines - Salinity problem – Build up of soil salinity - salinity effects on crops – Management of salinity Problems.

Infiltration problems – Problem evaluation – Management of infiltration problem – Soil and water amendments – blending water supplies – Cultivation and deep tillage – Irrigation management.

Toxicity Problems – Specific ions and their effects – Management of toxicity problems – leaching – Crop selection – Cultural practices – Blending water supplies – Toxicity effects due to sprinkler Irrigation.

Miscellaneous Problems – Excess Nitrogen – Abnormal pH, Scale deposits – Magnesium problems – Trace elements and their toxicity – Nutrition and water quality – Clogging problems in localized drip irrigation systems – Corrosion and incrustation – Vector problems.

Experiences using water of various qualities – Reuse of agricultural drainage water – High carbonate water used for overhead sprinkler irrigation – High salinity water use – Use of marginal quality water – Agricultural use of treated waste – Wastewater irrigation.

REFERENCES

1. Ayers, R.S. and Westcott, D.W, "FAO Irrigation and Drainage paper"– 29 (Revised), FAO, Rome, Italy, 1985
2. George Tchobanoglous, Franklin Louis Burton, Metcalf & Eddy, David Stense H, "Wastewater Engineering: Treatment and Reuse", McGraw-Hill, 2002.
3. Jack Keller and Rond Belisher., "Sprinkler and Trickle Irrigation", Van Nostrand Reinhold, New York, 1990.
4. Lloyd, J.W. and Heathcote, J.A., "Natural inorganic chemistry in relation to groundwater resources", Oxford University Press, Oxford, 1988.
5. Vladimir Novonty, "Water Quality: Diffuse pollution and watershed Management", 2nd edition, John Wiley & Sons, 2003.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Relate water quality and its dependence on sources of water supplies.
2. Understand and interpret water quality data for beneficial uses and in water quality management to increase crop yield.
3. Understand the use of treated waste water for irrigation
4. Know the experiences /conservation of using water of various qualities

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1							✓			
CO2								✓		
CO3						✓				
CO4										✓

WREE* **	**FLOOD MODELING AND DROUGHT ASSESSMENT**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To make the students to understand the hydrologic extremes of floods and droughts
- To combat them for estimation of severity and extent of damages and the mitigation measures

Flood Estimation: Flood – Types of Flood – Effects of Flood - Methods of estimation of flood discharge frequency – stage–frequency curves – design storm – design flood.

Flood Control: Methods of controlling floods – dams, storage reservoirs, levees, improved channel ways, flood ways – flood plain zoning – Non-structural methods of flood damage reduction – flood proofing, flood forecasting, flood warning and flood fighting.

Flood Modelling and Management : Hydrologic and Hydraulic Routing – Reservoir and Channel Routing - Flood Inundation Modelling – HEC HMS and HEC RAS software - Flood control methods – Structural and non-structural measures - Flood Plain Zoning – Flood forecasting – Flood Mitigation - Remote Sensing and GIS for Flood modelling and management

Drought Assessment : Drought indices – Drought severity assessment – meteorological, hydrological and agricultural aspects – IMD, Palmer, Herbst, Aridity Indices and Ramaprasad Methods.

Drought Monitoring and Management :Drought monitoring – Supply and demand oriented measures – Traditional water conservation – Drought Prone Areas Programme (DPAP) – Integrated drought management – Remote sensing applications for drought mitigation – NDVI concepts- Water Scarcity Management in Urban, Industrial and Agricultural sectors

REFERENCES

1. Chow V.T., Maidment D.R., Mays L.W., "Applied Hydrology", McGraw Hill Publications, New York, 1995.
2. Ghosh, S.N, “Flood control and drainage engineering”, Oxford international publishing house, third edition,2012.
3. Rangapathy V., Karmegam M., and Sakthivadivel R., Monograph in Flood Routing Methods as Applied to Indian Rivers, Anna University Publications
4. Vijay P.Singh., "Elementary Hydrology", Prentice Hall of India, New Delhi, 1994.
5. Yevjevich V., Drought Research Needs, Water Resources Publications, Colorado State University, USA, 1977.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Know the different methods of design flood estimation and perform channel reservoir routing. They carryout flood inundation modeling and suggest suitable flood control measures.
2. Acquire the knowledge about different types of drought and their impacts. They asses the severity, duration and frequency of drought using drought using drought indices.
3. Get exposed to various approaches, measures and case studies of drought indices.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		✓								
CO2					✓					
CO3					✓					

WREE***	ADVANCED HYDROLOGICAL ANALYSIS AND DESIGN	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To introduce the concepts of systems approach to hydrological modeling.
- To analyze Hydrologic time series and stochastic hydrologic models.
- To study types and classes of hydrologic simulation models.
- To design safe and effective passage of flood flows and discuss the design methods.

Hydrologic cycle – System concept – Hydrologic system Model – Classification of Hydrologic Models – Statistical, Stochastic and Deterministic Approaches – Statistical characteristics of Hydrological Data – Probability distribution of Hydrologic Variables - Correlation Analysis – Developing Prediction Equation by Simple and Multiple Linear Regression – Reliability of the Model.

Stochastic Process – Classification – Stationary Process – Time series – Classification – Component of Time series – Method of Investigation – Auto Correlation coefficient – Moving Average Process – Auto Regressive Process - Auto Regressive Moving Average Process - Auto Regressive Integrated Moving Average Process – Thomas Fiering Model – Box Jenkins Model – Model formulation – Parameter Estimation – Calibration and Validation – Application to hydrologic data Generation and Forecasting.

Classification of Deterministic Model – Black Box, Conceptual and Physically based Models – Rational method - Models of IUH, Nash and Chow-Kulandaiswamy Models – Lumped and Distributed Conceptual Models – Single event and Continuous Conceptual Models – HEC HMS, Tank Model, WBNM and other Models – Physically based Models – SWAT and MIKE SHE – Model Calibration and Validation

Hydrologic Design Scale – Estimating Limiting Value – Hydrologic Design level – Hydrologic Design Data - Hydraulic structure Design methods - Estimation of PMP - Computation of Design Storm - IDF Relationships - Design Flows - Hydrologic Risk, Reliability and Safety Factor.

Hydrologic Design Standard and Criteria - Design storms for Minor and Major structures – Hydrologic Design of Culverts, Highway and Railway Bridges - Urban Storm Drainage Design – SWMM – Airport Drainage Design - Detention Storage Design – Design of Spillway.

REFERENCES

1 Charles T. Haan, "Statistical method in Hydrology", Iowa State University Press, first edition,1977.
2 Jayarami Reddy P, Stochastic Hydrology, Laksmi Publications, New Delhi, 1995
3 Kottegoda, N. T, "Stochastic Water Resources Technology", Palgrave Macmillan UK, First edition,1980.
4 Makauidakis, Mc Gee and Wheel Wright, Forecasting methods, John Wiley and Sons, New York, 1992
5 Vente chow, David R. Maidment, Larry w. mays, "Applied Hydrology", McGraw-Hill Science, first edition, 1988
6 Vijay P.Singh, Elementary Hydrology, Prentice Hall of India, New Delhi,1994

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Develop prediction equation between hydrologic variables using simple and multiple linear regression.
2. Apply the time series models for hydrologic data generation and forecasting.
3. Identify the different types and procedures for calibration and validation of deterministic simulation models.
4. Apply the hydrologic design concepts and methods for estimating the design flows for minor, medium and major hydraulic structures.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓									
CO2	✓								✓	
CO3		✓				✓			✓	
CO4	✓	✓				✓				

WREE* **	**ISOTOPE TECHNIQUES IN WATER RESOURCES MANAGEMENT**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To introduce the student on the emerging tools such as isotope hydrology
- To demonstrate the application of this advance technique to solve practical problems in hydrology and water resources engineering

Basic Principles: Introduction to elements, nuclides, isotopes- Isotopes and their characteristics - Classification of isotopes -Theory of Radioactivity - Stable and radioactive isotope in hydrology;

Measurement Techniques: Sampling-sample preparation for isotope analysis-Mass spectrometric techniques – Instrumentation - Continuous Flow and Dual injection systems;

Hydrometeorology: Isotope fractionation-partitioning of isotopes in the hydrologic cycle - Meteoric Water Line (MWL) - Deuterium excess - Rayleigh fractionation model - isotope effects distillation;

Applications of Isotopes in Surface water hydrology: Water balance - Lake dynamics- sub-surface inflow and outflow estimates sedimentation in lakes and reservoirs – seepage from dams, reservoirs, canals -stream flow measurements;

Applications of Isotopes in Ground Water Hydrology: Soil moisture movement - Groundwater velocity in saturated zone - Identification of source of recharge and recharge mechanism - Seawater intrusion - Contaminant hydrogeology;

REFERENCES

1. Clark I. D and Fritz P, “Environmental isotopes in hydrogeology”, Lewis Publishers, Boca Raton, The Netherlands, 1997.
2. Criss R. E, "Principles of stable isotope distribution". Oxford University Press.1999.
3. Environmental Isotopes in Hydrological Cycle, Principles and Applications (Ed. WG Mook), IHP-V, Technical Documents in Hydrology, No 39, Vol 1, UNESCO, Paris, 2000
4. Fritz P and Fontes J. Ch(Eds.) "Handbook of environmental isotope Geochemistry"- Vol I and II. Elsevier scientific publishing Company, The Netherlands, 1980
5. Kendal C. and McDonnell J.J., “Isotopes in Catchment Hydrology”, Elsevier, 1998.
6. Mook W.G. (Ed), “Environmental Isotopes in Hydrological Cycle, Principles and Applications”, IHP-V, Technical Documents in Hydrology, No 39, Vol 1, UNESCO, Paris, 2000.
7. Rao S.M., “Practical Isotope Hydrology”, New India Publishing Agency, 2006.
8. “Use of Artificial Tracers in Hydrology”, Proc. Adv. Group Meeting, Vienna, IAEA, 1990.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Apply isotope fingerprints for better understanding of hydrological processes and mechanism for water resources development and management.
2. Evaluate surface water inflow and outflow in lakes and reservoirs using isotopes
3. Apply isotopes in ground water hydrology including soil moisture, ground water velocity, recharge, seawater intrusion and hydrogeology

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				✓						
CO2	✓									
CO3			✓							

WREE***	CLIMATE CHANGE AND ADAPTATION	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the earth's climate change and its system classification
- To introduce the observed changes in the climate and concept of modelling and Institutional arrangements existing for monitoring this phenomenon

Earth's Climate System**:** Introduction – Climate in the spotlight - The Earth's Climate Machine – Climate Classification – Global wind systems – Trade Wind Systems– Trade Winds and the Hadley Cell – The Weserlies – Cloud formation and Monsoon Rains – Storms and Hurricanes – The Hydrological Cycle – Global Ocean Circulation – EI Nino and its Effect – Solar Radiation – The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle.

Observed Changes and Its Causes: Observation of Climate Change – Changes in pattern of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol – UNFCCC – IPCC – Evidences of Changes in Climate and Environment – on a Global Scale and in India – Climate Change modeling.

Impacts Of Climate Change: Impacts of Climate Change on various sectors – Agriculture, Forestry and ECOsystem – Water resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts for different regions – Uncertainties in the Projected Impacts of Climate Change – Risk of irreversible changes.

Climate Change Adaptation and Mitigation Measures: Adaptation Strategy/options in various sectors – Water – Agriculture – Infrastructure and Settlement including coastal zones. Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and practices – Energy supply – Transport – Buildings – Industry – Agriculture – Forestry – Carbon sequestration – Carbon Capture and Storage (CCS) – Waste (MSW &

Biowaste, Biomedical, Industrial waste – International and Regional co-operation.

Clean Technology and Energy: Clean Development Mechanism – Carbon Trading – Examples of future Clean Technology – Biodiesel – Natural Compost – Eco-friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding

REFERENCES

1. Al core 'Inconvenient Truth" – video form
2. Dash Sushil Kumar, "Climate Change – An Indian Perspective", Cambridge University Press India Pvt. Ltd, 2007
3. IPCC Fifth Assessment Report – www.ipcc.ch
4. Jan C. van Dam, Impacts of "Climate Change and Climate Variability on Hydrological Regimes", Cambridge University Press, 2003

COURSE OUTCOMES:

At the end of the course students will be able to

1. Understand the earth's climate change and its system classification
2. Introduce the observed changes in the climate and concept of modeling and Institutional arrangements existing for monitoring this phenomenon
3. Show the impact of climate change on various sectors and its irreversibility
4. Prepare the adaptation and mitigation measures of climate change on various sectors.
5. Choose the clean Technology for the Fuel and energy through natural and eco friendly techniques.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				✓		✓				
CO2							✓			
CO3				✓						
CO4						✓	✓			
CO5										✓

OPEN ELECTIVES

WREE***	WATER QUALITY MODELING	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To provide a fundamental understanding of water quality models are formulated, so that the students are able to adapt existing models to new situations.
- To provide the students with direct exposure to models currently used in environmental engineering practice for predicting water quality in rivers and lakes.
- To equip the students to apply such models to solve simple waste load allocation problems.
- To instruct as to how water quality data can be analyzed and interpreted.
- To show how water quality models may be calibrated, verified, and applied to environmental engineering problems, such as total maximum daily loads or fate and transport modeling of toxic organic chemicals.

Introduction, Water Quality-Fundamental Quantities-Mathematical models, Historical Development of Water-Quality Models. Basic modeling concepts - Reaction Kinetics-Reaction fundamentals - Analysis of Rate - Data-Stochiometry – Temperature Effects.

Transport phenomena – Advection, diffusion, dispersion- simple transport models –Diffusive transport: Diffusion and Fick's first law, Calculation of molecular diffusion coefficients Plug flow models- Application of PFR and MFR model - Steady state and time variable solutions-completely mixed systems, concept and models in Completely Stirred Tank Reactors, mass balance equations, loading types, feed forward vs. feedback reactor systems.

Water quality modeling of Streams, Lakes and impoundments and Estuaries – Water quality–model sensitivity – assessing model performance; Models for dissolved oxygen, pathogens and BOD-Streeter Phelps model for point and distributed sources - Modified Streeter Phelps equations -Toxicant modeling in flowing water.

Groundwater flow and mass transport of solutes, Degradation of organic compounds, application of concepts to predict groundwater contaminant movement, seawater intrusion –

Basic concepts and modeling - Exposure to surface water and groundwater quality modeling software – MIKE 21, QUAL2E and MODFLOW Models and their application - Case studies.

REFERENCES

1. Benedini, Marcello, Tsakiris, George, “Water Quality Modelling for Rivers and Streams”, Springer Netherlands, 2013.

2. Jacob Bear, A, Cheng, H.D, "Modeling Groundwater Flow and Contaminant Transport", Springer Science & Business Media, 2010.
3. Steven C. Chapra, "Surface Water Quality Modelling", The McGraw-Hill Companies, Inc., New Delhi, 1997.
4. Thomann, V, John A. Mueller, "Principles of Surface Water Quality Modeling and Control", Harper & Row, 1987.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Understand the context of water quality management and engineering.
2. Apply mass balance principles to develop and solve simple water quality models.
3. Understand eutrophication, the principal of biochemical and physical factors affecting algae growth, management problems and solutions, and modelling approaches and their limitations.
4. Get exposed to surface water and ground water quality modeling software and case studies in water quality modeling.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				✓		✓				
CO2						✓	✓			
CO3				✓				✓		
CO4								✓	✓	✓

WREE* **	**INTEGRATED WATER RESOURCES MANAGEMENT**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- Students will be introduced to the role of disciplines of ecology and socio-economic play in management of water resources.
- They will be exposed to global food security and public-private participation issues and legal and regulatory settings, in the context of IWRM

CONTEXT FOR IWRM**:** Water as a global issue: key challenges and needs – Definition of IWRM within the broader context of development – Complexity of the IWRM process – Examining the key elements of IWRM process.

WATER ECONOMICS**:** Economic view of water issues: economic characteristics of water good and services – Non-market monetary valuation methods – Water economic instruments, policy options for water conservation and sustainable use – Case studies. Pricing: distinction

between values and charges – Private sector involvement in water resources management: PPP objectives, PPP options, PPP processes, PPP experiences through case studies – Links between PPP and IWRM.

WATER SUPPLY AND HEALTH WITHIN THE IWRM CONSIDERATION**:** Links between water and human health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Health impact assessment of water resources development.

AGRICULTURE IN THE CONCEPT OF IWR: Water for food production: 'blue' versus 'green' water debate – Virtual water trade for achieving global water security – Irrigation efficiencies, irrigation methods and current water pricing.

WATER LEGAL AND REGULATORY SETTINGS**:** Basic notion of law and governance: principles of international and national law in the area of water management. Understanding UN law on non-navigable uses of international water courses – Development of IWRM in line with legal and regulatory framework.

REFERENCES

1. Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.
2. Technical Advisory Committee, Poverty Reduction and IWRM, Technical Advisory Committee Background paper no: 8. Global water partnership, Stockholm, Sweden, 2003.
3. Technical Advisory Committee, Regulation and Private Participation in Water and Sanitation section, Technical Advisory Committee Background paper No: 1. Global water partnership, Stockholm, Sweden, 1998.
4. Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.
5. Technical Advisory Committee, Water as social and economic good: How to put the principles to practice". Technical Advisory Committee Background paper No: 2. Global water partnership, Stockholm, Sweden, 1998.
6. Technical Advisory Committee, Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003.
7. Cech Thomas V., Principles of water resources: history, development, management and policy. John Wiley and Sons Inc., New York. 2003.

8 Mollinga .P, "Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2006.

COURSE OUTCOMES:

1. Paradigm shift in attitude of the students towards interdisciplinary research.
2. Gain knowledge about economic aspects of water.
3. Understanding of the complexities of dealing with water resources problems.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				✓		✓	✓			
CO2				✓						✓
CO3							✓	✓	✓	

WREE***	ENVIRONMENTAL SYSTEMS ENGINEERING	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

To emphasize the various physical, chemical and Biological Phenomena applicable to Environmental Systems Engineering.

- To expose the students to different ecological systems and natural transport systems.

Physical Phenomena: Transport, Gas Transfer, thermal Phenomena, Sedimentation, Continuous Flow Models. Chemical Phenomena: Solution Equilibriums, Reaction Kinetics, Carbonate Equilibriums, Thermo-chemistry, Colloidal Behavior.

Biologic Phenomena: Organic Materials, Microorganisms, Growth Kinetics, Biochemical Oxygen Demand, Anaerobic Decomposition, Photosynthesis, Food Chains.Ecological Systems: Models, Analytical Solutions, Time Domain Simulation, Continuous Flow Microbiological System, Pesticide Concentration, Eutrophication.

Natural Transport Systems: Basic Models, Dissolved Oxygen System, Streams, Estuaries, Transport in the Air Environment.

Planning Factors: Water Quality Criteria and Standards, Air Pollution and its Control, Radiological Health, Environmental Impact Statements, Population Growth Models, Regional Growth Model, Time Capacity & Expansion of Systems.

Engineered Transport Systems: Pipe Network Analysis - Water Distribution Systems.Water Treatment Systems: Treatment drains, Lagoon Systems Individual Household Systems.

REFERENCES

1. Hammer M.J. and Hammer M.J. Jr. (1996), "Water & Wastewater Technology", Prentice Hall of India, NewDelhi.
2. Peavy H.S. Row D.R. and Tchobanaglous G (1995) "Environmental Engineering", McGraw Hill International Edition.
3. Rich, L.G. (1973) "Environmental Systems Engineering", McGraw Hill Inc.
4. Sincero, A.P. and Sincero, G.A. (1999) "Environmental Engineering –A Design Appproach:, Prentice Hall of India, New Delhi.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Know the concepts of Environmental systems
2. Gain the knowledge in modeling of ecological and natural transport systems
3. Design the water treatment systems

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				✓		✓			✓	
CO2						✓		✓	✓	
CO3						✓		✓	✓	

WREE* **	**GROUNDWATER CONTAMINANT TRANSPORT MODELING**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVE:

- To make the students understand the different methodologies for contaminant transport modeling with emphasis on groundwater; to introduce the various software codes available for various solution schemes in contaminant transport modeling.

Review of Groundwater Principles: Aquifer Properties – Darcy's Law – Principal Directions – Partial Differential Equation (PDE) for Groundwater Flow.PDE for Mass (contaminant) Transport: Hydrodynamic dispersion – Advective Transport – Advection Dispersion Equation – Principal Directions – Conservative versus Reactive Transport.

Numerical Groundwater Contaminant Transport Modeling: Finite difference Method (FDM): Numerical dispersion – Stability analysis – Implicit and Explicit Finite difference solutions – Mixing Cell Approach.Method of Characteristics (MOC): Characteristics Equations – Particle Tracking solutions - Stability Considerations – Advantages and Disadvantages.Random Walk Method (RWD): Theoretical Basis – Advantages /Disadvantages Finite Element Method (FEM) - Modified Method of Characteristics (MMOC) - Total Variation Diminishing (TVD) Method.

Analytical Solutions: Transformed Advection/Dispersion Equation – Fundamental solution – Continuous Point Solution – Instantaneous Line Solution – Normal Distribution of Contaminants.Major Numerical Modeling Codes: ModFlow Companion Models: MT3D (Modular 3D Transport) – RT3D (Reactive 3D Transport) – SEAWAT (Seawater intrusion)

USGS Codes: MOC (Method of Characteristics) – Bio MOC (MOC Biodegradation Reactions) – Other – PHAST (Multicomponent Geochemical reactions) – SUTRA (Variable Density Variable Saturation) – VS2DT (Variable Saturated 2D Transport) – RUNSAT (Reactive Unsaturated).EPA/CMOS Codes: Bio Plume (Oxygen limited biodegradation) – MOFAT (Multiphase Multicomponent Transport).

Modeling Chemical Reactions: Types of Geochemical Reactions – Adsorption – Desorption Reaction – Freundlich Isotherm – Radioactive Decay – Hydrolysis – Equilibrium Reactions and Law of Mass Action – Microbial Degradation – Modeling Multi Component contaminant Transport.Natural Attenuation / Intrinsic Bioremediation: Bioremediation of petroleum hydrocarbons – Electron Acceptors/ Donors – Bioavailability – Equilibrium Chemical reactions Technical Protocol for Implementation.Soil/ Groundwater Remediation Systems: Soil Vapor Extraction (SVE) – Air Sparging Systems (AS) – Pump and treat Systems (PT).

REFERENCES

1. Chunmiao Zheng and Gordon D. Bennett, “Applied contaminant transport Modeling”, Wiley Interscience, 2nd Edition, 2002.
2. Fetter C.W, Contaminant Hydrology, Prentice Hall, 2nd Edition, 1998.
3. Gadeon Dagan, “Flow and Transport in Porous Formations”, Springer Verlag, 1989.
4. James Dragun, “The soil Chemistry of Hazardous materials”, 2nd Edition, Hazardous materials Control Research Institute, 2001.
5. Martin Alexander, “Bioremediation and Biodegradation”, Academic Press, 2nd Edition, 1999.
6. Phillip Bedient, Handadi Rifai, and Charles Newell, “Groundwater Contamination Transport and Remediation”, Prentice Hall ,1999
7. Randall Charbeneau, “Groundwater Hydraulics and Pollutant Transport”, Prentice Hall, 2000.
8. Todd Widemeier, Handai Rifai, Charles Newell, and John Wilson, “Natural attenuation of Fuels and Chlorinated solvents in the Subsurface”, Wiley, 1999.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Gain the knowledge on principles of groundwater flow and various governing equations
2. Learn the different methods of analysis and modeling of contaminant transport in aquifers.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			✓	✓		✓		✓		✓
CO2			✓	✓			✓		✓	

WREE***	COASTAL ENGINEERING	L	T	P
		4	**0**	**0**

COURSE OBJECTIVE:

- The main purpose of coastal engineering is to protect harbors and improve navigation. The students to the diverse topics as wave mechanics, wave climate, shoreline protection methods and laboratory investigations using model studies.

Introduction to Coastal Engineering: Indian Scenario – Classification of Harbours. Introduction - wind and waves – Sea and Swell - Introduction to small amplitude wave theory – use of wave tables- Mechanics of water waves – Linear (Airy) wave theory, Introduction to Tsunami.

Wave Properties and Analysis: Behaviour of waves in shallow waters, Introduction to non-linear waves and their properties – Waves in shallow waters – Wave Refraction, Diffraction and Shoaling –Hindcast wave generation models, wave shoaling; wave refraction; wave breaking; wave diffraction random and 3D waves- Short term wave analysis – wave spectra and its utilities - Long term wave analysis- Statistics analysis of grouped wave data.

Coastal Sediment Transport: Dynamic beach profile; cross-shore transport; along shore transport (Littoral transport), sediment movement

Coastal Defense: Field measurement; models, groins, sea walls, offshore breakwaters, artificial nourishment - planning of coast protection works - Design of shore defense structures –Case studies.

Modeling in Coastal Engineering: Physical modeling in Coastal Engineering – Limitations and advantages – Role of physical modeling in coastal engineering – Numerical modeling – Modeling aspects – limitations – Case studies using public domain models, Tsunami mitigation measures.

REFERENCES

1. "Coastal Engineering Manual (CEM)". US Army Coastal Engineering Research Center, 2002-2006. (http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ARTICLES;104)

2. "Coastal Engineering Manual", Vol. I-VI, Coastal Engineering Research Centre, Dept. of the Army, US Army Corps of Engineers, Washington DC, 2006.
3. Dean, R.G. and Dalrymple, R.A., "Water wave mechanics for Engineers and Scientists", Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1994.
4. Ippen, A.T., "Estuary and Coastline Hydrodynamics", McGraw-Hill, Inc., New York, 1978.
5. Kamphuis, J.W., "Introduction to Coastal Engineering and Management"
6. Mani J.S., "Coastal Hydrodynamics". PHI Pvt.Ltd. New Delhi – 2012.
7. Narasimhan S., Kathiroli S. and Nagendra Kumar B. "Harbour and Coastal Engineering (Indian Scenario)" Vol.I and II.NIOT Chennai 2002.
8. Sorensen, R.M., "Basic Coastal Engineering", 3rd Edition, Springer, 2006.
9. Sorenson, R.M., "Basic Coastal Engineering", A Wiley-Interscience Pub. New York, 1978.

COURSE OUTCOMES:

At the end of the course, students will be able to

1. Understand coastal engineering aspects of harbors methods to improve navigation, shoreline protection and other laboratory investigations using model studies.
2. Use the skills and techniques in ICM.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				✓			✓		✓	
CO2						✓		✓		✓

WREE* **	**RESEARCH METHODOLOGY**	L	T	P
		4	**0**	**0**

COURSE OBJECTIVES:

- To introduce concepts of research process in hydrology and water resources and water management.
- To enable students to get basic understanding of scientific research methods.
- To develop capacity to independently analyse and define a research problem.

Scope**:** Objectives and types of research – Identification of research problem – Research process – Research design – Bibliography.

Sample: Sampling theory and sampling design – Types of samples – Sources of data – Qualitative and quantitative data – Data collection methods.

Data: Measurement levels and scaling – Types of errors – Sampling adequacy – Data collection and editing – Coding of data – Analysis and statistical inference.

Report: Report preparation – Structure of report – graphs and illustration tools – Tables and charts – Draft – Finalising research report.
Design of a Research Project a mini project design

REFERENCES

1. Pannerselvam. R Research Methodology, Prentice-Hall of India Private Ltd., New Delhi, 2007.
2. Upagade. V and A.Shende, Research Methodology, S.Chanda & Co., New Delhi, 2010.

COURSE OUTCOME:

At the end of the course, students will be able to

1. Understand applied research methods in Science and Engineering and will able to define and formulate a research problem independently.

MAPPING PROGRAMME OUTCOMES WITH COURSE OUTCOMES										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				✓		✓		✓	✓	