DEPARTMENT OF
SOIL AND WATER CONSERVATION ENGINEERING

COURSE CURRICULA

M.Tech.

Soil and Water Conservation Engineering

&

Ph.D.

Soil and Water Conservation Engineering

COLLEGE OF TECHNOLOGY
SARDAR VALLABHBHAI PATEL UNIVERSITY OF AGRICULTURE & TECHNOLOGY
MEERUT-250110 (UP)

Syllabus for M.Tech. and Ph.D. Programmes

Credits Requirement:
The following nomenclature and Credit Hrs need to be followed while providing the syllabus for M.Tech. (Soil and Water Conservation Engineering) and Ph.D. (Soil and Water Conservation Engineering).

(i) Course Work	Masters' Programme	Doctoral Programme
• Major Courses	20	12
• Minor Courses	08	06
• Supporting Courses	06	05
• Common Courses	05	-
• Seminar	01	02
(ii) Thesis Research	30	75
TOTAL	**70**	**100**

Major Courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark.

Major Courses: From the subjects closely related to a student's major subject.

Supporting Courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments). The courses from subject matter fields (other than Major and Minor) relating to area of special interest and research problem can be taken as per recommendations of the student's advisory committee.

Common Courses: The following common courses (One credit each) will be offered to all students undergoing Master's degree programme.

1. Library and Information Services
2. Technical Writing and Communication Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/MOOCs. The students may be allowed to register these courses/similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, then he/she may be permitted to register for other related courses with the prior approval of the Head of the Department (HoD)/Board of Studies (BoS).

Syllabus of Common Courses for PG Programmes

LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e resources access methods.

TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); •Writing of abstracts, summaries, précis, citations, etc.;
- Commonly used abbreviations in the theses and research communications; Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- ~~Accentual pattern: Weak forms in connected speech;~~
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
2. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
3. Collins' Cobuild English Dictionary. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.
5. Holt, Rinehart and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
6. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
7. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. Speaking English Effectively. MacMillan India.
9. Richard WS. 1969. Technical Writing.
10. Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

1. Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
2. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

Course Contents
M.Tech. in Soil and Water Conservation Engineering

I. Course Title : Advanced Soil and Water Conservation Engineering
II. Course Code : SWCE 501
III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip students with the advances in soil and water conservation measures, use of RS and GIS and Software's for design of soil and water conservation structures.

V. Theory

Unit I

Concept of probability in design of soil and water conservation structures. Probability and continuous frequency distribution. Fitting empirical distributions.

Unit II

Relevance of soil and water conservation in agriculture and in the river valley projects. Layout and planning of soil and water conservation measures. Software's for design of conservation structures.

Unit III

Productivity loss due to soil erosion. Water stress and water excess. Types and mechanics of soil erosion. Software's for soil loss estimation, WEAP, EPIC

Unit IV

Theories of sediment transport. Control of runoff and sediment loss. Sediment deposition process. Estimation of sediment load.

Unit V

Design of soil and water conservation structures: Check dams, gully plugs, gabion structures, earth dams, silt detention dams, farm ponds, etc., and the alternate use of the stored water for agriculture. Application of Remote Sensing and GIS in Soil and Water Conservation.

VI. Practical

Assessment of erosive status of a watershed through field measurement or analysis of morphometric properties. Estimation of erosivity index of rainfall. Determination of soil physical properties: Texture, grain size distribution, Atterberg's limits, various moisture percentages. Locating best possible sites of soil and water conservation structures on the basis of map features and erosivity status. Estimation of costs of soil and water conservation measures.

VII. Learning outcome

The students will able to plan and design soil and water conservation measures in particular watershed using RS and GIS techniques. They can estimate the sedimentation and capacity losses, design of gully control structures and earthen dams using software.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Concept of probability in design of soil and water conservation structures	2
2.	Probability and continuous frequency distribution	2
	Fitting empirical distributions	2
3.	Relevance of soil and water conservation in agriculture and in the river valley projects	2
4.	Layout and planning of soil and water conservation measures	2
5.	Software's for design of conservation structures	1
6.	Productivity loss due to soil erosion	1
7.	Water stress and water excess	1
8.	Types and mechanics of soil erosion	1
9.	Software's for soil loss estimation, WEAP, EPIC	3
10.	Theories of sediment transport	2
11.	Control of runoff and sediment loss	1
12.	Sediment deposition process and estimation of sediment load	2
13.	Design of soil and water conservation structures: Check dams, gully plugs, gabion structures, earth dams, silt detention dams, farm ponds, etc., and the alternate use of the stored water for agriculture	6
14.	Application of Remote Sensing and GIS in Soil and Water Conservation	3
	Total	**31**

IX. List of Practicals

S. No.	Topic	No. of Practicals
1.	Assessment of erosive status of a watershed through field measurement	2
2.	Morphometric analysis of a watershed	2
3.	Estimation of erosivity index of rainfall	1
4.	Determination of soil texture	1
5.	Determination of soil grain size distribution	1
6.	Determination of Atterberg's limits of soil	1
7.	Determination of various soilmoisture percentages	1
8.	Locating best possible sites of soil and water conservation structures on the basis of map features and erosivity status	2
9.	Design of Check dams, gully plugs, gabion structures, earth dams, silt detention dams and farm ponds	4
10.	Estimation of costs of soil and water conservation measures	2
	Total	**17**

X. Suggested Reading

- Garg SK. 1987. *Irrigation Engineering and Hydraulic Structures*. Khanna Publishers, New Delhi.
- Kirkby MJ and Morgan PPC (eds). 1980. *Soil Erosion*. John Wiley and Sons. New York, USA.
- Suresh R. 2016. *Soil and Water Conservation Engineering*. Standard Publishers and Distributors, Delhi.

I. Course Title : **Applied Watershed Hydrology**

II. Course Code : **SWCE 502**

III. Credit Hours : **2+1**

IV. Aim of the course

To provide in depth knowledge of surface and sub-surface hydrology of watershed including stream flow measurement and computer simulation of hydrological processes in small watersheds.

V. Theory

Unit I

Hydrology in water resources planning, rainfall, surface runoff and sub-surface runoff as components of hydrologic cycle. Runoff phenomena, relationship between precipitation and runoff. Stream flow measurement and analysis of data in detail.

Unit II

Synthetic unit hydrograph. Recent advances in analysis of hydrologic data and flow from small watersheds. Methods of runoff estimation from small watersheds. Use of IUH and various methods of estimation. Runoff estimation models: SCS, CN software.

Unit III

Micro climate, estimation methods of evaporation. Advances and improvements in rational approach. SCS approach criticism and improvements.

Unit IV

Hydrological hazard functions. Methods of estimation of hydrologic parameters. Data transformation.

Unit V

Calibration and evaluation of hydrologic models. Computer simulation of hydrological process in small watersheds.

VI. Practical

Delineation of watershed and study of watershed characteristics. Measurement of rainfall and runoff in a watershed and data analysis. Estimation of infiltration and runoff from a watershed. Analysis and derivation of various types of hydrographs. Flood routing. Reservoir sedimentation. Watershed model components. Visit to a watershed.

VII. Learning outcome

The students will be able to understand and analyze the process and the effect of various climatic parameters on rainfall-runoff relationship. They can also be able to develop the competency for calibration and evaluation of hydrologic models and computer simulation.

VIII. Lecture Schedule

S. No.	Topic	No. of lectures
1.	Hydrology in water resources planning, surface runoff and sub-surface runoff as components of hydrologic cycle	2
2.	Basics of watershed hydrology and processes, global and watershed perspectives	3
3.	Runoff phenomena, relationship between precipitation and runoff	1

4.	Synthetic unit hydrograph, Unit hydrograph and its derivation including for complex storm	3
5.	S-hydrograph and derivation, Use of IUH and various methods of estimation	3
6.	Runoff estimation models: SCS_CN, CN software	3
7.	Flood routing principles	2
8.	Recent advances in analysis of hydrologic data and flow from small watersheds. Methods of runoff estimation from small watersheds.	3
9.	Micro climate estimation methods of evaporation. Advances and improvements in rational approach. SCS approach criticism and improvements.	3
10.	Process of sedimentation of reservoirs	2
11.	Hydrological hazard functions, Methods of estimation of hydrologic parameters, Data transformation.	3
12.	Hydrologic modeling approaches, component conceptualization, types of watershed hydrologic models and choice of model.	3
13.	Calibration and evaluation of hydrologic models. Computer simulation of hydrological process in small watersheds	2
	Total	**32**

VIII. List of Practicals

S. No.	Topic	No. of Practicals
1.	Delineation of watershed and study of watershed characteristics	1
2.	Measurement of rainfall and runoff in a watershed	1
3.	Analysis of hydrologic data and flow from small watersheds	1
4.	Estimation of infiltration and runoff from a watershed	1
5.	Measurement and analysis of stream flow data	1
6.	Analysis of synthetic unit hydrograph for complex storm	1
7.	Analysis of S-hydrograph for complex storm	1
8.	Use of runoff estimation models: SCS, CN software	2
9.	Study of different types of flood routing methods	2
10.	Computer simulation of hydrological process in small watersheds	1
11.	Study of reservoir sedimentation	1
12.	Study of watershed model components	1
13.	Visit to a watershed	1
	Total	**16**

IX. Suggested Reading

- Haan CT. *Hydrologic Modeling of Small Watershed.*
- Singh VP. 2010. *Rainfall-Runoff Modeling* (Vol. I)—Prentice Hall, New York.
- Singh VP. 2010. *Environmental Hydrology.* Springer, New York.

I. Course Title : **Soil and Water Conservation Structures**

II. Course Code : **SWCE 503**

III. Credit Hours : **2+1**

IV. Aim of the course

To acquaint students with the planning and design of soil and water conservation structures, their stability checks and mechanized soil conservation techniques.

V. Theory

Unit I

Design, planning and layout of soil and water conservation structures. Criteria of selection of appropriate structures as per soil, land use and climatic conditions.

Unit II

Design and construction of earthen dam, stability analysis of land slopes and soil mass including landslides.

Unit III

Hydrological and structural design including stress analysis. Hydraulic jump and energy dissipaters for soil conservation structures.

Unit IV

Seepage through dams, flow net and determination of uplift pressure in drop structures, design of energy dissipaters.

Unit V

Design of water harvesting structures, construction, maintenance and utilization of stored water. Mechanized construction techniques for soil and water conservation structures.

VI. Practical

Numerical approach on probability distribution functions. Stability analysis and structural design of masonry water harvesting structures. Design of earthen dams and other energy dissipating structures. Cost analysis of water harvesting structures. Field visit to already constructed water harvesting structures in the nearby area/ watershed.

VII. Learning outcome

The student will be able to design the soil and water conservation structures as well as permanent gully control structures and water harvesting structures. They can have understanding of mechanized construction of soil and water conservation structures.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	Introduction and need of Soil and Water Conservation in agricultural watershed	1
2	Runoff process and factors affecting it and estimation of runoff using various methods	3
3	Analysis of rainfall data, Probability concepts in the design of structures	3
4	Introduction, classification and functional requirement of soil and water conservation structures-Straight Drop spillway, chute spillway and drop inlet spillway	1

5	Specific energy and specific force	2
6	Hydraulic jump and its application, type of hydraulic jump, energy dissipation due to jump, jump efficiency, relative loss of energy	2
7	Straight drop spillway- Components and their functions, hydrologic, hydraulic and structural design	4
8	Drop inlet spillway- Components and their functions, hydrologic, hydraulic and structural design	2
9	Chute Spillway- Components and their functions, hydrologic, hydraulic and structural design	3
10	Criteria of selection of appropriate structures as per soil, land use and climatic conditions	1
11	Design of energy dissipaters in soil and water conservation structures	1
12	Introduction, types, design, criteria and construction of earthen dam, causes of failure of earthen dam, retaining wall and its design	3
13	Stability analysis of land slopes and soil mass including landslides, seepage control in earthen dams, flow net in earthen dams	2
14	Water harvesting: principles, importance and issues. Water harvesting techniques: classification based on source, storage and use. Runoff harvesting: short-term and long-term harvesting techniques, purpose and design criteria.	3
15	Mechanized construction techniques for soil and water conservation structures	1
	Total	**32**

IX. List of Practicals

S. No.	Topic	No. of Practicals
1.	Study of various probability distribution function for rainfall analysis	1
2.	Construction of specific energy and specific force diagram	2
3.	Measurement of hydraulic jump parameters and amount of energy dissipation	1
4.	Hydrologic and hydraulic design of a straight drop spillway	1
5.	Determination of uplift force and construction of uplift pressure diagram	1
6.	Determination of loads on headwall and construction of triangular load diagram	1
7.	Stability analysis of a straight drop spillway	1
8.	Hydraulic design of a chute spillway	1
9.	Design of drop inlet spillway	1
10.	Design of energy dissipating structures	1
11.	Design of earthen dam	1
12.	Seepage analysis in earthen embankment	1
13.	Design of water harvesting structures	1
14.	Economic analysis of water harvesting structures	1
15.	Field visit to already constructed water harvesting structures in the nearby area/watershed.	1
	Total	**16**

X. Suggested Reading

- Mahnot SC, Singh PK and Chaplot PC. 2011. *Soil and Water Conservation and Watershed Management*. Apex Publishing House, Udaipur.
- Murty VVN. 1988. *Land and Water Management Engineering*. Second Edition Kalyani Publishers, New Delhi.

- Singh Gurmel C, Venkataraman G, Sastri and Joshi BP. 1991. *Manual of Soil and Water conservation Practices*. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
- Singh PK. 2000. *Watershed Management (Design and Practice)*. e-media publications, Udaipur.
- Suresh R. 2006. *Soil and Water Conservation Engineering*. Fourth Edition Standard Publishers and Distributors, Delhi.
- Singh Raj Vir. 2003. *Watershed Management*. Second Edition, Yash Publishing, Bikaner.

I. Course Title : Stochastic Hydrology

II. Course Code : SWCE 504

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint students about the stochastic processes in hydrology including statistical characteristics of hydrological time series data, modeling hydrologic uncertainty and analysis of multivariate hydrologic series,

V. Theory

Unit I

Hydrologic cycle, Systems concept, Hydrologic systems model. Classification of hydrologic models, Statistical, stochastic and deterministic approaches. Statistical characteristics of hydrological data, probability distribution of hydrologic variables. Deterministic and stochastic hydrology, Cause and effect analysis. Hydrologic time series analysis – nature, stationarity and ergodicity, components of time series, trend, periodicity and stochastic parts, parameter estimation of probability distributions. Analysis of hydrologic extremes.

Unit II

Multivariate regression analysis, correlation analysis, correlation coefficient and its significance in regional analysis. Developing prediction equation by simple and multiple linear regression. Reliability of the Model.

Unit III

Stochastic Process: Classification, stationary process. Time series: Classification, component of time series. Methods of investigation: Auto correlation coefficient, moving average process, auto regressive process, auto regressive moving average process, auto regressive integrated moving average process. Spectral analysis, analysis of multivariate hydrologic series.

Unit IV

Thomas Fiering model, Box Jenkins model. Model formulation: Parameter estimation, calibration and validation. Application to hydrologic data. Generation and forecasting. Regional flood frequency analysis. Transformations, Hypothesis testing.

Unit V

Modeling hydrologic uncertainty. First order Markov process, Markov chain, Data generation, Hydrologic time series analysis, Modelling of hydrologic time series.

VI. Practical

To estimate various statistical parameters of the hydrologic variables, estimating missing data in historical series, various parameter estimation methods like method of moments, method of maximum likelihood, method of mixed moments, probability

of weighted moments fitting discrete and continuous distribution functions to variables, application of transformation techniques to historical data for estimating variables at different return periods, determining correlation and regression coefficients, analyzing multivariate regression, autocorrelation coefficient for independent and correlated events, fitting ARMA models, fitting Markov models of first and second order, regional frequency analysis, time series analysis of the historical data, estimating and fitting Thomas Fiering Model.

VII. Learning outcome

The students are enabled to understand the stochastic process of hydrology including statistical based analysis of hydrological time series data. They are exposed to stochastic and deterministic modeling of small watersheds.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Hydrologic cycle, Systems concept, Hydrologic systems model	1
2.	Hydrological models, processes and systems - Physical Characterization of watersheds; Rainfall measurements	1
3.	Classification of hydrologic models, Statistical, stochastic and deterministic approaches	1
4.	Statistics and probabilities in hydrology – Basic concepts – Experiment, Sample space, element, event, complement, intersection, disjoint, union, statistical parameters; Uncertainty in hydrological event; Statistical homogeneity, Permutation, combination, probability, conditional probability; Independent events, random variables, discrete and continuous sample space, Probability and Return period	3
5.	Statistics and probabilities in hydrology- Frequency Analysis – Mean, Median, Mode, Variance, Frequency Analysis - Standard deviation, Coefficient of Variance, Skewness, Kurtosis Theorems on Probability; Total probability theorem and Baye's theorem	3
5.	Statistics and probabilities in hydrology- Discrete and Continuous probability - Random Variable and Variate; Probability Distribution of hydrological variables; Co-relation and regression analysis.	3
6.	Introduction and examples of stochastic processes; Specification of stochastic process- nature, stationarity and ergodicity, components of time series,	2
7.	Hydrologic time series analysis –trend, periodicity	1
8.	Stochastic time series analysis- Methods of analysis -Auto correlation coefficient,	1
9.	Stochastic time series analysis- moving average process, auto regressive process,	2
10.	Stochastic time series analysis- auto regressive moving average process,	2
10.	Stochastic time series analysis- auto regressive integrated moving average process.	2
11.	Spectral analysis, analysis of multivariate hydrologic series	2
12.	Thomas Fiering model, Box Jenkins model	2
13.	Model formulation: Parameter estimation, calibration and validation.	2
14.	Application to hydrologic data	2
15.	Generation and forecasting- Regional flood frequency analysis Transformations,	1
16.	Hypothesis testing	1
	Total	**32**

S. No.	Topic	No. of Practicals
1.	Development of regression models	1
2.	Estimation of missing data in historical series	1
3.	Parameter estimation-Method of Moments	1
4.	Parameter estimation-method of maximum likelihood	1
5.	Parameter estimation- method of mixed moments, Probability of weighted moments	1
6.	Fitting discrete and continuous distribution functions to variables	1
7.	Transformation techniques to historical data for estimating variables at different return periods	1
8.	Regression analysis, Correlation analysis,	1
9.	Analyzing multivariate regression,	1
10.	Autocorrelation coefficient for independent and correlated events,	1
11.	Fitting ARMA models to rainfall runoff data	1
12.	Fitting Markov models of first and second order,	1
13.	Regional frequency analysis,	1
14.	Estimating parameters of Thomas Fiering Model	1
15.	Fitting of Thomas Fiering Model	1
	Total	**15**

X. Suggested Reading

- Clarke RT. *Mathematical Models in Hydrology*. FAO Publication.
- Haan CT. 2002. *Statistical Methods in Hydrology*. Iowa State Press.
- Kotteguda NT. 1982. *Stochastic Water Resources Technology*. The Macmillan Press, New York.
- McCuen RH and Snyder WM. *Hydrological Modelling–Statistical Methods and Applications*. Prentice Hall Inc., New York.
- Yevjevich V *Stochastic Processes in Hydrology*. Water Resources Publications, Colorado.

I. Course Title : Watershed Management and Modeling

II. Course Code : SWCE 505

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint students with watershed management concept and its benefit for sustainable rural development through participatory approach, including environmental impact as well as policy frame work.

V. Theory

Unit I

Concept of watershed, its hydrological and geomorphological characteristics. Status of watershed management programs in India. Problems of desertification and degradation.

Unit II

Concept of watershed management and sustainability, participatory approach and operational watershed. Surveys, monitoring, reclamation and conservation of agricultural and forest watersheds, hill slopes and ravines. Watershed management research instrumentation and measurement, problem identification, simulation and synthesis. Rainfed farming and drought management. Modeling of flood and drought phenomenon.

Unit IV

Use of Remote Sensing and GIS in watershed management and modeling. Watershed

modeling approaches, mathematical bases and structure of existing watershed models.

Unit V

Environmental impact assessment of watersheds. Quantitative evaluation of management techniques. National land use policy, legal and social aspects. Case studies of watershed management.

VI. Practical

Selection and delineation of a watershed. Benchmark surveys. Preparation of watershed land use map. Preparation of watershed development proposal. Preparation of watershed evaluation and impact assessment report. Application of watershed models for evaluation of conservation treatments. Use of Remote Sensing and GIS in watershed management and modeling.

VII. Learning outcome

The students will be able to understand different conservation practices and their effect on watershed behavior. They can also estimate the geomorphologic parameters of particular watershed which is quite useful for watershed planning and development of watershed models.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	Concept of watershed, its hydrological and geomorphological characteristics	2
2	Status of watershed management programs in India	2
3	Problems of desertification and degradation	2
4	Concept of watershed management and sustainability, participatory approach and operational watershed	3
5	Surveys, monitoring, reclamation and conservation of agricultural and forest watersheds, hill slopes and ravines	3
6	Watershed management research instrumentation and measurement, problem identification, simulation and synthesis	2
7	Rainfed farming and drought management	2
8	Modeling of flood and drought phenomenon	2
9	Use of Remote Sensing and GIS in watershed management and modeling	2
10	Watershed modeling approaches, mathematical bases and structure of existing watershed models	3
11	Environmental impact assessment of watersheds	2
12	Quantitative evaluation of management techniques	2
13	National land use policy, legal and social aspects	2
14	Case studies of watershed management	3
	Total	**32**

IX. List of Practicals

S. No.	Topic	No of Practicals
1	Selection and delineation of a watershed	3
2	Benchmark surveys	2
3	Preparation of watershed land use map	2
4	Preparation of watershed development proposal	3
5	Preparation of watershed evaluation and impact assessment report	2
6	Application of watershed models for evaluation of conservation treatments	2
7	Use of Remote Sensing and GIS in watershed management and modelling	2
	Total	**16**

X. Suggested Reading

- Dhaliwal GS Hansra BS and Ladhar SS. 1993. *Wetlands, their Conservation and Management*. Punjab Agricultural University, Ludhiana.
- Dhruvanarayana VV, Sastry G and Patnaik US. *Watershed Management*. Publ. and Inf. Dv., ICAR, Krishi Anusandhan Bhavan, New Delhi.
- Singh RV. 2000. *Watershed Planning and Management*. Second Edition Yash Publishing House, Bikaner.
- Suresh R. 2017. *Watershed Planning and Management*. Standard Publication and Distribution, Delhi.
- Tideman EM. 1999. *Watershed Management* (*Guidelines for Indian Conditions*). Omega Scientific Publishers, New Delhi.

I. Course Title : Flow Through Porous Media

II. Course Code : SWCE 506

III. Credit Hours : 2+0

IV. Aim of the course

To provide comprehensive knowledge to the students in aquifer and fluid properties, unsaturated flow theory and movement of groundwater in fractured and swelling porous media.

V. Theory

Unit I

Aquifer and fluid properties, forces holding water in soils, hydrodynamics in porous media and limitations of governing laws.

Unit II

Differential equations of saturated flow, initial and boundary conditions. Dupuit and Business approximations and linearization techniques.

Unit III

Stream functions, potential functions and flow net theory. Analysis of seepage from canals and ditches.

Unit IV

Unsaturated flow theory, Infiltration and capillary rise flux dynamics. Movement of groundwater in fractured and swelling porous media.

Unit V

Hydro-dynamic dispersion in soil-aquifer system. Velovity hydrograph, flow characteristics at singular points, examples of velocity hydrograph, solution by complex velocity, solution of triangular dam, drainage in retaining structures, influence of seepage on stability of slopes, drainage methods for stability of slopes.

VI. Learning outcome

The students will be able to understand physical properties of flow through porous media. Competence on various laws governing dynamics of flow through porous media. Understanding of hydrodynamics in porous media, governing laws and boundary conditions.

VII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Aquifer and its classification, properties of aquifers and fluids	1
2.	Forces responsible for holding water in soil and movement, hydrostatic pressure distribution	1
3.	Porosity, permeability and hydraulic conductivity: its importance in fluids flow	1
4.	Hydrodynamics in porous media: Continuum approach to porous media, Representative Elementary Volume (REV), linear and aerial porosity, velocity and specific discharge relationship in porous medium	3
5.	Generalization of Darcy Law in isotropic and anisotropic layered porous medium, deviation from Darcy Law and limitations of governing laws in flow through porous media	3
6.	Saturated flow: Differential equations for flow through saturated medium, initial and boundary conditions, types of boundary conditions, boundary and initial value problems	3
7.	Dupuit and Boussinesq approximations and linearization: Dupuit assumption and equation, Boussinesq linearization Techniques and solutions	3
8.	Unsaturated flow theory: Continuity and conservation equations for a homogeneous fluid in non-deforming medium and deforming medium, continuity equation for compressible fluid and moveable solid matrix	6
9.	Infiltration and capillary rise flux dynamics, movement of groundwater in fractured and swelling porous media	2
10.	Stream and potential functions: Stream functions in two and three dimensional flow, potential functions and flow net theory	3
11.	Analysis of seepage from canals and ditches	2
12.	Hydro-dynamic dispersion in soil-aquifer system: Hydro-dynamic dispersion, derivation of dispersion and diffusion equation	3
13.	Velocity hydrograph: Flow characteristics at singular points, examples of velocity hydrograph, solution by complex velocity, solution of triangular dam, drainage in retaining structures, influence of seepage on stability of slopes, drainage methods for stability of slopes	3
	Total	**34**

X. Suggested Reading

- Bears J. 1972. *Dynamics of Fluids in Porous Media*. American Elsevier Publishing Co. Inc. New York.

- Bear J and Arnold V. *Modeling Groundwater Flow and Pollution.* D. Reidel Publishing Company.
- Collins RE. 1961. *Flow of Fluids through Porous Materials.* Reinhold publishing cooperation, New York.
- Core AT *Flow in Porous Media.*
- De Wiest Roger JM. 1969. *Flow through Porous Media.* Academic press, New York.
- Helmut K *Soil Physics.* pp. 7-79.
- Verruijt A. 1982. *Theory of Groundwater Flow.* 2nd Edn., Macmillan, London

I. Course Title : GIS and Remote Sensing for Land and Water Resource Management

II. Course Code : SWCE 507/IDE 507

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint students with recent technology of RS and GIS including satellite data analysis, digital image processing and thematic mapping of land use, surface and ground water.

V. Theory

Unit I

Physics of remote sensing, electromagnetic radiation (EMR), interaction of EMR with atmosphere, earth surface, soil, water and vegetation. Remote sensing platform, monitoring atmosphere, land and water resources: LANDSAT, SPOT, ERS, IKONOS and others, Indian Space Programme.

Unit II

Satellite Data analysis: Visual interpretation, digital image processing, image pre-processing, image enhancement, image classification and data merging.

Unit III

Definition: Basic components of GIS, map projections and co-ordinate system, spatial data structure-raster, vector, spatial relationship, topology, geodatabase models, hierarchical network, relational, object-oriented models, integrated GIS database-common sources of error–data quality: Macro, micro and usage level components, meta data, Spatial data transfer standards.

Unit IV

Thematic mapping, measurements in GIS: Length, perimeter and areas. Query analysis, reclassification: Buffering, neighbourhood functions, map overlay: Vector and raster overlay: Interpolation, network analysis, digital elevation modelling. Analytical Hierarchy Process, Object oriented GIS–AM/FM/GIS, Web Based GIS.

Unit V

Spatial data sources: 4M GIS approach water resources system, Thematic maps, rainfall runoff modelling, groundwater modelling, water quality modelling and flood inundation mapping and modelling. Drought monitoring, cropping pattern change analysis, performance evaluation of irrigation commands. Site selection for artificial recharge, reservoir sedimentation.

VI. Practical

Familiarization with the Remote sensing instruments and satellite imagery. Aerial

Photograph and scale determination with stereoscope. Interpretation of satellite imageries and aerial photographs. Determination of Parallaxes in images. Introduction to digital image processing software and GIS software and their working principles. Generation of digital elevation model (DEM) for land and water resource management. Case studies on mapping, monitoring and management of natural resources using remote sensing and GIS.

VII. Learning outcome

Students will be able to use satellite remote sensing to perform image analysis and classification for developing thematic maps. Able to integrate satellite data with GIS to undertake recourse mapping and planning studies.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Introduction and brief history of RS and GIS, applications of RS and GIS	1
2.	Physics of remote sensing. Electromagnetic radiation (EMR), interaction of EMR with atmosphere, earth surface, soil, water and vegetation	1
3.	Remote sensing platforms: Monitoring atmosphere, land and water resources: LANDSAT, SPOT, ERS, IKONOS and others. Indian Space Programme	2
4.	Satellite data analysis. Visual interpretation.	1
5.	Digital image processing- Image pre-processing, Image enhancement, Image classification, data merging.	3
6.	Basic components of GIS- Map projections and co-ordinate system.	2
7.	Spatial data sources,Thematic maps	1
7.	Spatial data structure: Raster, vector data, Spatial relationship-Topology	1
8.	Geodatabase models: Hierarchical, network, relational, object-oriented models. Integrated GIS database	3
9.	Data quality, Common sources of error, Macro, micro and Usage level components, Meta data and Spatial data transfer standards	2
10.	Measurement in GIS- Length, perimeter and areas	1
10.	Query analysis. Reclassification, Buffering and Neighbourhood functions	1
11.	Map overlay: Vector and raster overlay	1
12.	Interpolation and network analysis	1
13.	Digital elevation modelling. Analytical Hierarchy Process. Object oriented GIS, AM/FM/GIS and Web Based GIS	3
14.	GIS approach to Rainfall runoff modelling, Flood inundation mapping and modelling	2
15.	GIS approach to Groundwater modelling and water quality modelling	2
16.	Site selection for artificial recharge. Reservoir sedimentation	1
17.	Drought monitoring	1
18.	Performance evaluation of irrigation commands	1
19.	Cropping pattern change analysis	1
	Total	**32**

IX. List of Practicals

S. No.	Topic	No. of Practicals
1.	Familiarization with the remote sensing instruments and satellite imagery	1
2.	Methods of establishing ground truth survey and Comparison between ground truth and remotely sensed data	2
3.	Aerial Photograph and scale determination with stereoscope	1
4.	Interpretation of satellite imagery and aerial photograph	1
5.	Determination of Parallaxes in images	1
6.	Demonstration on GPS; Provision of Ground Control by GPS in different mode	1
7.	Introduction to digital image processing software	1
8.	Introduction to GIS software	1
9.	Data input; Data editing and Topology creation -Digitization of point, line & polygon features	
10.	SRTM & CARTO DEM download from web and Georeferencing of an image	1
11.	Delineation of Watershed, DEM generation: slope, Aspect, flow direction, Flow accumulation, Drainage, network and morphometric analysis	2
12.	LULC by supervised classification and LULC by unsupervised classification	1
13.	Application of Remote Sensing data and GIS for water quality parameters	
14.	Temporal satellite data analysis for vegetation condition, crop water requirement calculation	1
15.	Erosion mapping using aerial and satellite Data	1
	Total	**17**

X. Suggested Reading

- Ian HS, Cornelius and Steve C. 2002. *An Introduction to Geographical Information Systems*. Pearson Education, New Delhi.
- James BC and Randolph HW. 2011. *Introduction to Remote Sensing*. The Guilford Press.
- Lilles TM and Kiefer RW. 2008. *Remote Sensing and Image Interpretation*. John Wiley and Sons.
- Paul Curran PJ. 1985. *Principles of Remote Sensing*. ELBS Publications.
- Rees WG. 2001. *Physical Principles of Remote Sensing*. Cambridge University Press.

I. Course Title : Climate Change and Water Resources

II. Course Code : SWCE 508

III. Credit Hours : 3+0

IV. Aim of the course

To acquaint students about the concept of climate change and its impact on surface and ground water resources. To understand adaptation and mitigation strategy under climate change scenario.

V. Theory

Unit I

The climate system: Definitions, climate, climate system, climate change. Drivers of climate change, characteristics of climate system components: Greenhouse effect,

carbon cycle, wind systems. Trade winds and the Hadley Cell, ozone hole in the stratosphere, El Nino, La Nina– ENSO, teleconnections.

Unit II

Impacts of climate change: Observed and projected, global and Indian scenario, observed changes and projected changes of IPCC: Impacts on water resources, NATCOM Report, impacts on sectoral vulnerabilities, SRES, different scenarios, climate change impacts on ET and irrigation demand.

Unit III

Tools for vulnerability assessment: Need for vulnerability assessment, steps for assessment, approaches for assessment. Models: Quantitative models, Economic models, impact matrix approach, Box models, Zero-dimensional models, Radioactive- convective models, Higher-dimension models, EMICs (Earth-system models of intermediate complexity), GCMs (global climate models or general circulation models), Sectoral models.

Unit IV

Adaptation and mitigation water: Related adaptation to climate change in the fields of ecosystems and biodiversity, agriculture and food security, land use and forestry, human health, water supply and sanitation, infrastructure and economy (insurance, tourism, industry and transportation), Adaptation, vulnerability and sustainable development.

Unit V

Sector specific mitigation: Carbon dioxide capture and storage (CCS), bio-energy crops, biomass electricity, hydropower, geothermal energy, energy use in buildings, land-use change and management, cropland management, afforestation and reforestation. Potential water resource conflicts between adaptation and mitigation. Implications for policy and sustainable development.

Case studies: Water resources assessment case studies: Ganga Damodar Project, Himalayan glacier studies, Ganga valley project. Adaptation strategies in assessment of water resources. Hydrological design practices and dam safety, operation policies for water resources projects. Flood management strategies, drought management strategies, temporal and spatial assessment of water for irrigation, land use and cropping pattern, coastal zone management strategies.

VI. Learning outcome

The students will be able to understand climate change concept particularly on surface and ground water. Students can have in depth knowledge about adaptation and mitigation strategies in respect of climate change.

VII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Definitions- climate, climate system, climate change; Drivers of climate change	3
2.	Climate system and its components; wind systems, carbon cycle, Greenhouse effect, Trade winds and the Hadley Cell, ozone hole in the stratosphere, El Nino, La Nina– ENSO, teleconnections	3
3.	Climate scenarios- SRES, RCP, Scenario based observed and projected climate changes in Indian and global context	3

S.No.	Topic	No. of Lectures
4.	IPCC projected climate change impacts on water resources, NATCOM Report-impacts on ET and irrigation demand	3
5.	Vulnerability assessment: Need, steps for assessment, approaches for assessment	2
6.	Models: Quantitative models, Economic models, impact matrix approach, Box models, Zero-dimensional models, Radioactive-convective models, Higher-dimension models, EMICs (Earth-system models of intermediate complexity), GCMs (global climate models or general circulation models), Sectoral models	4
7.	Adaptation to climate change in the fields of ecosystems and biodiversity, agriculture and food security, land use and forestry, human health, water supply and sanitation, infrastructure and economy (insurance, tourism, industry and transportation)	4
8.	Sector specific mitigation: Carbon dioxide capture and storage (CCS)	2
9.	Sector specific mitigation: bio-energy crops, biomass electricity, hydropower, geothermal energy, energy use in buildings	2
10.	Sector specific mitigation: land-use change and management, cropland management, afforestation and reforestation	2
11.	Potential water resource conflicts between adaptation and mitigation	2
12.	Implications for policy and sustainable development.	2
13.	Case studies- Ganga Damodar Project, Himalayan glacier studies, Ganga valley project	5
14.	Adaptation strategies in assessment of water resources- Temporal and spatial assessment of water for irrigation, land use and cropping pattern	2
15.	Adaptation strategies in assessment of water resources- Hydrological design practices and dam safety, operation policies for water resources projects	3
16.	Flood management strategies, coastal zone management strategies.	3
	Total	**45**

VIII. Suggested Reading

- Majumdar PP and Nagesh KD. *Floods in a Changing Climate: Hydrological Modelling*. Cambride University Press, New York.
- Pathak H, Agarwal PK and Singh SD. *Mitigation in Agriculture: Methodology for Assessment and Application*. Division of Environmental Sciences, IARI New Delhi.
- Rao YS, Zhang TC Ojha, Gurjar BR, Tyagi RD, Kao CM (eds). *Climate Change Modelling, Mitigation, and Adaptation*. American Society of Civil Engineers.
- Srinivasa RK and Nagesh KD. *Impact of Climate Change on Water Resources with Modelling Techniques and Case Studies*. Springer publications, New York.
- Tamim Y and Caitlin AG. *Climate Change and Water Resources*. Springer Publication.

I. Course Title : Numerical Methods in Hydrology

II. Course Code : SWCE 509

III. Credit Hours : 2+0

IV. Aim of the course

To acquaint students about the concept of linear space, triangular and quadrilateral shape functions, isoparametric elements and transformation of coordinates.

V. Theory

Unit I

Review of finite difference operators. Concept of linear space and basis functions. Approximating from finite dimensional sub spaces.

Unit II

Variational and weighted residual methods. Langrange polynomials. Triangular and quadrilateral shape functions.

Unit III

Isoparametric elements and transformation of coordinates. Basis functions in three dimensions.

Unit IV

Galerkin finite element solution of Laplace, diffusion and dispersion-convection equations.

Unit V

Method of collocation, application in surface and sub surface hydrology.

VI. Learning outcome

The students are able to understand numerical methods in hydrology by having in-depth knowledge of linear space and finite element solution in surface and sub-surface hydrology.

VII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	Review of finite difference operators	2
2	Concept of linear space and basis functions	3
3	Approximating from finite dimensional sub spaces	3
4	Variational and weighted residual methods	2
5	Langrange polynomials	2
6	Triangular and quadrilateral shape functions	3
7	Isoparametric elements and transformation of coordinates.	3
8	Basis functions in three dimensions	3
9	Galerkin finite element solution of Laplace	3
10	Diffusion and dispersion-convection equations	3
11	Method of collocation	2
12	Application in surface and sub surface hydrology	3
	Total	**32**

VIII. Suggested Reading

- Bear J and Verruijt A. 1987. *Modeling Groundwater Flow and Pollution*. 414 pp. Dordrecht, Boston.
- Carr JR. 1995. *Numerical Analysis for the Geological Sciences*. 592 pp. Prentice-Hall, Englewood Cliffs NJ.
- George H and Patricia W. 2000. *Numerical Methods in the Hydrological Sciences*. American Geophysical Union, Florida Avenue, NW.
- Gerald CF and Wheatley PO. 1999. *Applied Numerical Analysis*. 6th ed., 768 pp, Addison-Wesley, Reading, MA.
- Middleton GV. 2000. *Data Analysis in the Earth Sciences using MATLAB* 260 pp., Prentice Hall, Saddle River NJ.

• Wang HF and Anderson MP. 1982. *Introduction to Groundwater Modeling: Finite Difference and Finite Element Methods*. 237 pp, W.H. Freeman and Co., San Francisco.

I. Course Title : Dryland Water Management Technologies
II. Course Code : SWCE 510
III. Credit Hours : 2+0

IV. Aim of the course

To provide detail knowledge about analysis of severity of drought assessment and various dry land water management technologies suitable for conservation, harvesting and enhancing productivity of rainfed areas.

V. Theory

Unit I

Drought severity assessment: Meteorological, hydrological and agricultural methods. Drought indices. GIS based drought information system, drought vulnerability assessment and mapping using GIS. DPAP programme, drought monitoring constraints, limiting crop production in dry land areas. Types of drought, characterization of environment for water availability, crop planning for erratic and aberrant weather conditions.

Unit II

Stress physiology and crop resistance to drought, adaptation of crop plants to drought, drought management strategies. Preparation of appropriate crop plans for dry land areas. Mid contingent plan for aberrant weather conditions.

Unit III

Land shaping and land development for soil moisture conservation. Improvement of tillage and soil management by implements and engineering practices. Soil and moisture conservation for rainfed lands through improved implements and engineering practices. Gel technology.

Ex-situ measures: Water harvesting-micro catchments. Design of small water harvesting structures: Farm Ponds, percolation tanks their types and design, recycling of runoff water for crop productivity.

Unit IV

Crops and cropping practices related to soil and moisture conservation. Fertility management in dryland farming. Planning and development of watersheds from engineering view point. Case studies.

Unit V

Application of aerial photography in surveys and planning of watersheds for rainfed agriculture.

Use of Remote Sensing in soil moisture estimation.

VI. Learning outcome

The students will be able to understand drought severity assessment techniques alongwith new and appropriate methods of rainwater conservation and harvesting technologies for rainfed areas.

S.No.	Topic	No. of Lectures
1.	Drought severity assessment: Meteorological, hydrological and agricultural methods	2
2.	Drought indices	1
3.	GIS based drought information system, drought vulnerability assessment and mapping using GIS	2
4.	DPAP programme, drought monitoring constraints, limiting crop production in dry land areas	2
5.	Types of drought: characterization of environment for water availability	1
6.	Types of drought: crop planning for erratic and aberrant weather conditions	1
7.	Stress physiology and crop resistance to drought	1
8.	Adaptation of crop plants to drought and drought management strategies	1
9.	Preparation of appropriate crop plans for dry land areas	2
10.	Mid contingent plan for aberrant weather conditions	1
11.	Land shaping and land development for soil moisture conservation	1
12.	Improvement of tillage and soil management by implements and engineering practices	2
13.	Soil and moisture conservation for rainfed lands through improved implements and engineering practices	2
14.	Introduction of Gel technology for conservation measures	1
15.	*Ex-situ* measures: Water harvesting-micro catchments	1
16.	Design of small water harvesting structures: Farm Ponds	1
17.	Design of small water harvesting structures: percolation tanks their types and design	2
18.	Recycling of runoff water for crop productivity	1
19.	Crops and cropping practices related to soil and moisture conservation	1
20.	Fertility management in dryland farming	1
21.	Planning and development of watersheds from engineering view point	2
22.	Planning and development of watersheds - Case studies	1
23.	Application of aerial photography in surveys and planning of watersheds for rainfed agriculture	1
24.	Use of Remote Sensing in soil moisture estimation	1
	Total	**32**

VIII. Suggested Reading

- Das NR. 2007. *Tillage and Crop Production*. Scientific Publishers.
- Dhopte AM. 2002. *Agro Technology for Dryland Farming*. Scientific Publ.
- Gupta US. 1995. *Production and Improvements of Crops for Drylands*. Oxford & IBH
- Singh RP. 1988. *Improved Agronomic Practices for Dryland Crops*. CRIDA.
- Singh RP. 2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.
- Singh RV. 2003. *Watershed Planning and Management*. Second Edition. Yash Publishing House, Bikaner.
- Singh SD. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publishers.

Course Contents
Ph.D. in Soil and Water Conservation Engineering

I. Course Title : **Advances in Hydrology**
II. Course Code : **SWCE 601**
III. Credit Hours : **2+1**

IV. Aim of the course

To provide comprehensive knowledge to the students about hydrologic models, flood frequency analysis and formulation of statistical models.

V. Theory

Unit I

Hydrologic models, processes and systems. Uncertainty in hydrological events. Statistical homogeneity.

Unit II

Probabilistic concept. Frequency analysis. Probability distribution of hydrological variables. Confidence intervals and hypothesis testing.

Unit III

Simple and multiple linear regressions, correlation, statistical optimization and reliability of linear regression models. Analysis of hydrologic time series and modeling. Auto–correlation, correlogram and cross-correlation analysis.

Unit IV

Markov processes, stochastic hydrologic models including Markov chain models. Generation of random variates. Hydrology of climate extremes. Area-duration- frequency curves. Regional flood frequency analysis.

Unit V

Formulation of various steps involved in formulation of statistical models and their application in hydrology.

VI. Practical

Parametric and non parametric test of time series data. Development of probabilistic and deterministic models for time series data of rainfall and runoff. Development of hydrologic models and frequency analysis for specified data set using SPSS and other software used in hydrologic modeling.

VII. Learning outcome

The students will be able to develop the hydrologic modeling and find out their trend as well as periodic component. To develop the stochastic and deterministic models for forecasting precipitation for prediction of floods and droughts.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Hydrologic models, processes and systems	1
2.	Uncertainty in hydrologic events risks, uncertainty	1
3.	Statistical homogeneity in hydrologic processes	1
4.	Probability, total probability theorem, Bayes theorem	2
5.	Moment generating function, statistical parameters	1
6.	Probability distribution of hydrologic variables	2
7.	Confidence interval one sided, two sided, Hypothesis testing test statistics	2
8.	Regression analysis, simple regression, confidence interval on regression coefficient, regression line, inference on regression	3
9.	Multiple linear regression	2
10.	Optimization of regression coefficients, Statistical optimization and reliability of linear regression models	3
11.	Time series analysis, components, stationarity, Auto correlation, correlograms, Cross correlation analysis	3
12.	Generating processes, Markov process- first order, higher order	2
13.	Statistical principles and techniques for time series modeling	2
14.	Markov chain models, Examples of Markov chain models in hydrology	2
15.	Autoregressive models, Autoregressive modeling of annual time series, Examples of autoregressive modeling	3
16.	Hydrology of climate extremes. Area-duration-frequency curves. Regional flood frequency analysis	2
17.	Formulation of various steps involved in formulation of statistical models and their application in hydrology	2
	Total	**34**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Study of parametric and non parametric test of time series data	4
2.	Development of probabilistic models for time series data of rainfall and runoff	2
3.	Development of deterministic models for time series data of rainfall and runoff	2
4.	Development of hydrologic models for specified data set using SPSS and other software used in hydrologic modeling	2
5.	Development of frequency analysis for specified data set using SPSS and other software used in hydrologic modeling	2
6.	Development of the stochastic models for forecasting precipitation for prediction of floods and droughts	2
7.	Development of deterministic models for forecasting precipitation for prediction of floods and droughts	2
	Total	**16**

X. Suggested Reading

- Garg SK. 1987. *Hydrology and Water Resources Engineering*. Khanna Publications.
- Hann CT. *Advanced Hydrology*. Oxford Publications House.
- Linseley RK Jr, Kohler MA and Paulhus JLH. 1975. *Applied Hydrology*. McGraw Hill.
- Mutreja KN. 1986. *Applied Hydrology*. Tata McGraw Hill.
- Singh VP. 2010. *Hydrological Modelling*. Springer, New York.

I. Course Title : **Soil and Water Systems Simulation and Modeling**

II. Course Code : **SWCE 602**

III. Credit Hours : **2+1**

IV. Aim of the course

To acquaint students about the rainfall-runoff models, sediment model, overland and channel flow simulation and decision support systems using simulation models.

V. Theory

Unit I

Models and their classification, simulation procedure. Rainfall-runoff models. Infiltration models, evapo-transpiration models, structure of a water balance model.

Unit II

Overland and channel flow simulation. Modeling approaches and parameters. Stream flow statistics. Surface water storage requirements.

Unit III

Flood control storage capacity and total reservoir capacity. Surface water allocations. Palaeo-channels. Ground water models.

Unit IV

Design of nodal network. General systems frame work. Description of the model. Irregular boundaries. Decision support system using simulation models. Monte-Carlo approach to water management.

Unit V

Stanford watershed model and input data requirements of various hydrologic modeling systems. Soil water assessment tool (SWAT). Groundwater modeling and solute transport.

VI. Practical

Rainfall-runoff models. Infiltration models. Stanford watershed model (SWM). Channel flow simulation problems. Stream flow statistics. Model parameters and input data requirements of various software's of surface hydrology and groundwater. Hydrologic modeling system. Soil water management model. Soil water assessment tool (SWAT). Catchments simulation hydrology model. Stream flow model and use of dimensionless unit hydrograph. Generalized groundwater models.

VII. Learning outcome

The students will be able to develop the model for overland and channel flow simulation, which can be used for watershed management and planning and also able to simulate the ground water and surface water by developing the ground water model and runoff models.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	Models and their classification, simulation procedure	2
2	Rainfall-runoff models	3
3	Infiltration models, evapo-transpiration models, structure of a water balance model	2

S.No.	Topic	No. of Lectures
4	Overland and channel flow simulation	2
5	Modeling approaches and parameters. Stream flow statistics	2
6	Surface water storage requirements	1
7	Flood control storage capacity and total reservoir capacity	2
8	Surface water allocations	1
9	Palaeo-channels	1
10	Ground water models	2
11	Design of nodal network	1
12	General systems frame work	1
13	Description of the model	1
14	Irregular boundaries	1
15	Decision support system using simulation models	2
16	Monte-Carlo approach to water management	2
17	Stanford watershed model and input data requirements of various hydrologic modeling systems	2
18	Soil water assessment tool (SWAT)	2
19	Groundwater modeling and solute transport	2
	Total	**32**

IX. List of Practicals

S. No.	Topic	No. of Practicals
1.	Rainfall-runoff models	2
2.	Infiltration models	1
3.	Stanford watershed model (SWM)	1
4.	Channel flow simulation problems	1
5.	Stream flow statistics	2
6.	Model parameters and input data requirements of various software's of surface hydrology and groundwater	2
7.	Hydrologic modeling system. Soil water management model	2
8.	Soil water assessment tool (SWAT). Catchments simulation hydrology model	2
9.	Stream flow model and use of dimensionless unit hydrograph	1
10.	Generalized groundwater models	2
	Total	**16**

X. Suggested Reading

- Biswas AK. 1976. *Systems Approach to Water Management*. McGraw Hill.
- Cox DR and Mille HD. 1965. *The Theory of Stochastic Processes*. John Wiley & Sons.
- Eagleson PS. 1970. *Dynamic Hydrology*. Mc Graw Hill.
- Himmel Blau DM and Bischoff KB. 1968. *Process Analysis and Simulation Deterministic Systems*. John Wiley & Sons.
- Linsley RK, Kohler MA and Paulhus JLH. 1949. *Applied Hydrology*. McGraw Hill.
- Schwar RS and Friedland B. 1965. *Linear Systems*. McGraw Hill.
- Ven Te Chow, David R Maidment and Mays LW. 1998. *Applied Hydrology*. McGraw Hill.

I. Course Title : Reservoir Operation and River Basin Modeling

II. Course Code : SWCE 603

III. Credit Hours : 2+1

IV. Aim of the course

To provide comprehensive knowledge to the students about water management

plans, demand analysis and water resources planning in river basins including stochastic and deterministic modeling.

V. Theory

Unit I

Water resources system analysis: Techniques, concept, objectives and applications.

Unit II

Identification and evaluation of water management plans. Demand analysis, policy formulation. Water resources planning objectives. Water resources planning under uncertainty.

Unit III

Definition of terminologies and basic concepts. Theories and principles of IRBM processes/phases in integrated river basin management. River basins, river functions. Human interventions and impacts. River basins in India, related case studies. Water resources planning in river basins. Operational management, tools and methods. Monitoring, acquisition and processing of water resource data.

Unit IV

Statistical methods. Decision support systems. Deterministic river basin modeling. Stream flow estimation, estimating reservoir storage, mass diagram analysis, sequent peak analysis, single and multi-reservoir operation models. Economics and finance.

Unit V

Stochastic river basin modeling: Single reservoir design and operation, multisite river basin models, stochastic linear programming operation models.

VI. Practical

Development of regression models, stochastic models and deterministic models for river basin based on stream flow data. Estimation of reservoir storage and preparation of operation models.

VII. Learning outcome

The students will be able to develop the model for effective water resources planning for river basins, identification and evaluation of water management plans as well as in-depth knowledge of stochastic and deterministic modeling.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Introduction–Concepts of Systems and Systems Analysis; Techniques, objectives and applications	2
	Applications of Water resources system analysis	1
2.	Identification and evaluation of water management plans-water demand analysis, Water resources planning objectives	2
3.	Water resource planning and management approaches-Top-Down Planning and Management; Bottom-Up Planning and Management Integrated Water Resources Management	1
4.	Water resource management policy formulation, Water resources planning under uncertainty	1

S.No.	Topic	No. of Lectures
5.	River basins, river functions, Theories and principles of IRBM processes/phases in integrated river basin management	1
6.	Human interventions and impacts in in integrated river basin management	1
7.	River basins in India- related case studies	1
8.	Water resources planning in river basins- Operational management, tools and methods	2
9.	Water resources planning in river basins - Monitoring, acquisition and processing of water resource data	2
10.	Economic Considerations in Water Resources Planning	1
10.	Deterministic river basin modeling-Stream flow estimation, estimating reservoir storage, mass diagram analysis, sequent peak analysis	2
11.	Deterministic river basin modeling- Reservoir Sizing; Reservoir Operation – standard operating policy, optimal operating policy; multi-reservoir systems,	6
12.	Concept of Reliability	1
13.	Stochastic river basin modeling: Basic probability theory,	2
14.	Single reservoir design and operation-Chance constrained Linear Programming for reservoir operation and design	3
15.	Stochastic river basin modeling: multisite river basin models, Model Formulations and Case Studies- Conjunctive use of ground and surface water; Crop yield optimization, Multi-basin and multi-reservoir systems	1 3
	Total	**33**

IX. List of Practicals

S. No.	Topic	No. of Practicals
1.	Development of regression models	1
2.	Regression analysis	1
3.	Correlation analysis	1
4.	Simple Linear Regression and coefficient of determination	1
5.	Discrete and Continuous probability - Random Variable and Variate	1
6.	Deterministic models for river basin based on stream flow data	1
7.	Stochastic models for river basin based on stream flow data	1
8.	Stochastic river basin modeling	1
9.	Stochastic linear programming operation models	1
10.	Single and multi-reservoir operation models	1
11.	Evaluation of water management plans	1
12.	Evaluation of demand analysis	1
13.	Stream flow estimation	1
14.	Estimation of reservoir storage	1
15.	Preparation of operation models	1
16.	Deterministic river basin planning model	1
	Total	**16**

X. Suggested Reading

- Chaturvedi MC 1984. *System Approach to Water Resources Planning and Management.*
- Loucks DP *et al.* 1980. *Water Resources System Planning and Analysis.* Prentice Hall, NJ.
- Major DC and Lenton RL. 1979. *Applied Water Resources System Planning.* Prentice Hall Inc., New Jersey.

I. Course Title : **Modeling Soil Erosion Processes and Sedimentation**

II. Course Code : **SWCE 604**

III. Credit Hours : **2+1**

IV. Aim of the course

To acquaint students about the concept of modeling upland erosion, reservoir sedimentation and sediment yield models for estimation of soil erosion.

V. Theory

Unit I

Mechanics of soil erosion. Erosion-sedimentation systems of small watersheds. Overland flow theory and simulation. Basic theory of particle and sediment transport. Sediment deposition processes.

Unit II

Modeling upland erosion and component processes. Modes of transport and transport capacity concept and computation. Channel erosion. Erosion and sediment yield measurement and estimates.

Unit III

Reservoir sedimentation surveys and computation. Classification of models, structure and mathematical bases of sediment yield models. Nature and properties of sediment: Individual and group of particles. Critical tractive force, lift and drag forces. Shield's analysis.

Unit IV

Calibration and testing of models. Universal soil loss equation, its modification and revisions. Stochastic and dynamic sediment yield models.

Unit V

Evaluation of erosion control measures. Computer models used for hydrologic and/ or watershed modeling.

VI. Practical

Computation of soil erosion index. Estimation of soil erodibility factor. Design of erosion control structures. Computation of suspended load and sediment load using empirical formulae. Application of sediment yield models. Prediction of sediment loss. Computation of reservoir sedimentation, sounding method.

VII. Learning outcome

The students will be able to estimate the sediment from the particular watershed by using various instruments. Development of the common understanding of mechanics of sediment transportation process and remedies to reduce sedimentation of watersheds

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Mechanics of soil erosion	1
2.	Erosion-sedimentation systems of small watersheds	1
3.	Overland flow theory and simulation	2
4.	Basic theory of particle and sediment transport. Sediment deposition processes	2

S.No.	Topic	No. of Lectures
5.	Modeling upland erosion and component processes	2
6.	Modes of transport and transport capacity concept and computation	2
7.	Channel erosion	1
8.	Erosion and sediment yield measurement and estimates	1
9.	Reservoir sedimentation surveys and computation	2
10.	Classification of models, structure and mathematical bases of sediment yield models	2
11.	Nature and properties of sediment: Individual and group of particles	2
12.	Critical tractive force, lift and drag forces	2
13.	Shield's analysis	2
14.	Calibration and testing of models	2
15.	Universal soil loss equation, its modification and revisions	2
16.	Stochastic and dynamic sediment yield models	2
17.	Evaluation of erosion control measures	2
18.	Computer models used for hydrologic and/or watershed modeling	2
	Total	**32**

IX. List of Practicals

S. No.	Topic	No. of Practicals
1.	Computation of soil erosion index	2
2.	Estimation of soil erodibility factor	2
3.	Design of erosion control structures	4
4.	Computation of suspended load and sediment load using empirical formulae	2
5.	Application of sediment yield models	2
6.	Prediction of sediment loss	2
7.	Computation of reservoir sedimentation, sounding method	2
	Total	**16**

X. Suggested Reading

- Garde RJ and Ranga Raju KG. 1977. *Mechanics of Sediment Transport and Alluvial Stream Problems*.Wiley Eastern Ltd.
- Morgan RPC (Ed. D A Davison). 1986. *Soil Erosion and Conservation*. ELBS.
- Longman USDA. 1969. *A Manual on Conservation of Soil and Water*. Oxford & IBH.
- Tripathi RP and Singh HP. 1993. *Soil Erosion and Conservation*. Publisher- New Age International, New Delhi.

I. Course Title : Waste Water Treatment and Utilization

II. Course Code : SWCE 605

III. Credit Hours : 3+0

IV. Aim of the course

To acquaint students about types of waste water and the various treatment measures alongwith the utilization of waste water in agriculture and other sectors.

V. Theory

Unit I

Types of waste water, causes of pollution, analysis of pollutants in the waste effluents, Biological wastewater treatment, biological sludge treatment. Biological

systems: Fundamentals of microbiology and biochemistry, bioenergetics and metabolism, kinetics of biological growth. Process analysis: Reaction rates, effect of temperature on reaction rate, enzyme reaction and kinetics, effect of temperature on reaction rate. Reactor analysis, residence time distribution.

Unit II

Sewerage system: Domestic wastewater characteristics, flow equalization, population equivalent, treatment flow chart. Primary, secondary and tertiary treatment of domestic wastewater. Downstream wastewater treatment for reuse and recycle. Need for downstream processing. Guidelines for wastewater recycling. Small and package plants for wastewater treatment.

Unit III

Activated sludge process: Substrate utilization and biomass growth, Monod's kinetics, estimation of kinetic parameters. Process Description and its Modification, Process design, process performance evaluation, trouble shooting. Nitrogen removal-Biological nitrification and denitrification.

Unit IV

Activated sludge process design for nutrient removal. Process operation: (F/M), mean cell residence time, oxygen requirement. Biological and chemical phosphorus removal, Sedimentation of activated sludge. Advanced activated sludge process-Sequencing Batch reactor, Oxidation ditch and membrane bioreactors.

Unit V

Biofilm process: Trickling filter, biotower, rotational biological contactor, integrated activated sludge and biofilm processes. Stabilization ponds and aerated lagoons: Types and their description, design, operation and maintenance. Anaerobic processes: Process description, process design, operation and maintenance, sludge digestion. Sludge treatment-thickening, dewatering-mechanical and sludge drying beds. Utilization of waste water in agriculture and other sectors.

VI. Learning outcome

Students will be able to have in-depth knowledge about waste water treatment methods, sewerage system, activated sludge process, biofilm process. The student will also expose to use of waste water in agriculture and other sectors.

VII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Status of wastewater in India, Sources of contamination and characterization of urban and rural wastewater for irrigation	2
2.	Water quality: Physical, chemical and biological parameters of wastewater	2
3.	Wastewater quality requirement: Potable water standards, wastewater effluent standards, water quality indices. Irrigation water quality standards both national and global and guidelines for their restricted and unrestricted uses.	2
4.	Different types of wastewater, pollutants and contaminants.	1
5.	Impact of wastewater on ecosystem, eutrophication, biomagnification, water borne diseases.	2
6.	Key drivers of wastewater use in agriculture and existing approaches for regulating wastewater reuse in agriculture	2

S.No.	Topic	No. of Lectures
7.	Selection of appropriate forestry trees, fruits, vegetables, oilseeds and food grain crop for wastewater utilization and practices used for irrigation	3
8.	Health Risks Associated with the Use of Wastewater for Irrigation	1
9.	Wastewater treatment methods: Physical, chemical and biological.	3
10.	Choice of (Cost-Effective) Wastewater Treatment Systems for Irrigation	2
11.	General water treatments: Wastewater recycling, constructed wetlands, reed bed system.	2
12.	Carbon foot prints of wastewater reuse. Environmental standards.	2
13.	Management of health and environmental risks of wastewater irrigation	1
14.	Regulation and environmental impact assessment (EIA): Environmental standards-CPCB Norms for discharging industrial effluents to public sewers. Valuation of environmental impacts.	3
15.	Impact on groundwater resources and soil health, EIA process, Stages of EIA-monitoring and auditing. Environmental clearance procedure in India	3
16.	Economics of wastewater irrigation	1
	Total	**32**

VIII. List of Practicals

S. No.	Topic	No. of Practicals
1.	Study on physical, chemical and biological parameters of wastewater	1
2.	Determination of EC and pH of wastewater	1
3.	Determination of BOD of wastewater	1
4.	Determination of COD of wastewater	1
5.	Determination of TSS and TDS of wastewater	1
6.	Determination RSC of wastewater	1
7.	Determination of e-coli in the wastewater	1
8.	On field demonstration of wastewater use for the irrigation	1
9.	Determination of nutrient (N, P and K) concentration in wastewater	2
10.	Field demonstration of impact of waste water on eco-system and human health.	1
11.	Study on various wastewater treatment methods	2
12.	Study on effect of wastewater on contamination of ground water	1
13.	Visit of village pond treatment nearby area	1
14.	Visit of sewerage treatment plant nearby area	1
	Total	**16**

IX. Suggested Reading

- Droste RL. 1997. *Theory and Practice of Water and Wastewater Treatment*. John Wiley.
- Metcalf and Eddy. 2003. *Wastewater Engineering*. 4th Ed., McGraw Hill.
- Qasim SR. 1999. *Wastewater Treatment Plants – Planning, Design and Operation*. CRC Press, Florida.
- Ramalho RS. *Wastewater Treatment*. Wiley.

I. Course Title : **Hydro-Chemical Modeling**

II. Course Code : **SWCE 606**

III. Credit Hours : **2+0**

IV. Aim of the course

To provide comprehensive knowledge to the students about hydrodynamics of flow through porous media and development of analytical, statistical and numerical models.

V. Theory

Unit I

Review of hydrodynamics in flow through porous media. Miscible displacement, physical processes.

Unit II

Breakthrough curves and mathematical models for miscible displacement. Hydrodynamic dispersion convection equations and its solutions.

Unit III

Statistical models for dispersion. Gaseous (CO_2 and O_2) diffusion equation.

Unit IV

Heat flow through soil by conduction. Concept of adsorption in solute transport.

Unit V

Analytical and numerical models of contaminant transport in unsaturated soil profile and groundwater aquifers.

VI. Learning outcome

Students will be able to demonstrate understanding of hydrodynamics of fluid transport through modeling and will be able to do water quality analysis of lakes and reservoir based physical and chemical characteristics. Develop water reclamation and water reuse plans for irrigation and industries.

VII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Review of hydrodynamics in flow through porous media	7
2.	Miscible displacement, physical processes, breakthrough curves	2
3.	Mathematical models for miscible displacement	5
4.	Hydrodynamic dispersion convection equation and its solutions	4
5.	Heat flow through soil by conduction	2
6.	Concept of adsorption in solute transport	2
7.	Analytical and numerical models of contaminant transport in unsaturated soil profile and groundwater aquifers.	6
8.	Statistical models for dispersion	3
9.	Gaseous (CO_2 and O_2) diffusion equation.	3
	Total	**34**

VIII. Suggested Reading

- Larry W Mays 1996. *Water Resources Handbook*. Mc Graw Hill.
- Metcalf and Eddey 1994. *Wastewater Treatment Engineering and Reuse*. John Wiley.
- Soli J Arceivala 1998. *Wastewater Treatment for Pollution Control*. Tata Mc Graw-Hill.