COURSE SYLLABUS
for
M. Tech. (Agril. Engg.)
in
Soil and Water Conservation Engineering

(Approved by Academic Council vide resolution No. 7644, dat. 07.12.2022)

ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR-751003

Course Title with Credit Load
M.Tech. (Agril. Engg.) in Soil and Water Conservation Engineering

Major Courses (Requirement:20 Credits)		
Course Code	Course Title	Credit Hours
SWCE 501*	Advanced Soil and Water Conservation Engineering	2+1
SWCE 502*	Applied Watershed Hydrology	2+1
SWCE 503	Soil and Water Conservation Structures	2+1
SWCE 504	Stochastic Hydrology	2+1
SWCE 505*	Watershed Management and Modeling	2+1
SWCE 506	Flow Through Porous Media	2+0
SWCE 507/ IDE 507	Remote Sensing and GIS for Land and Water Resource Management	2+1
SWCE 508	Climate Change and Water Resources	3+0
SWCE 509	Numerical Methods in Hydrology	2+0
SWCE 510	Dry Land Water Management Technologies	2+0
SWCE 511	Open Channel Flow	3+0
SWCE 512	Ground Water Engineering	2+1
SWCE 513	Design of Farm Drainage Systems	2+1
SWCE 514	Design of Surface Irrigation Systems	2+1

*Compulsory course

Minor Courses (Requirement: 08 Credits)

Course Code	Course Title	Credit Hours
IDE 503	Command Area Management	2+1
IDE 505	Design of Drip and Sprinkler Irrigation Systems	2+1
IDE 510	Minor Irrigation	2+1
IDE 511	Design of Pumps for Irrigation and Drainage	2+0
IDE 513	Water Resources Systems Engineering	2+1
ASCE 501	Dimensional Analysis and Similitude	2+1
ASCE 502	Water Quality and Pollution Control	2+1
FMPE 502	Testing and Evaluation of Agricultural Equipment	2+1
FMPE 515	Computer Aided Design of Machinery	0+2
REE 505	Wind Energy Conversion & Utilization	2+1
REE 513	Agro Energy Audit and Management	2+1
CSE 501	Big Data Analytics	2+0
CSE 502	Artificial Intelligence	2+0
CSE 504	Soft Computing Techniques in Engineering	2+1
MATH 501	Finite Element Methods	3+0
MATH 502	Numerical Methods for Engineers	3+0
ME 501	Mechatronics and Robotics in Agriculture	2+1
Any other course(s) of other department can be taken as per recommendations of the student's advisory committee.		

Supporting Courses (Requirement: 06 Credits)

Course Code	Course Title	Credit Hours
STAT 501*	Statistical Methods for Research Works	2+1
EE 501	Applied Instrumentation	2+1
Courses from subject matter fields (other than major) relating to area of special interest and research problem can be taken as per recommendations of the student's advisory committee		

*Compulsory Course

Common Courses (Requirement: 05 Credits)

Course Code	Course Title	Credit Hours
PGS 501*	Library and Information Services	1+0
PGS 502*	Technical Writing and Communication Skills	0+1
PGS 503*	Intellectual Property and its management in Agriculture	1+0
PGS 504*	Basic Concepts in Laboratory Techniques	0+1
PGS 505*	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

*Detailed course outline to be developed by designated BSMA

List of other Essential Requirements

Course Code	Course Title	Credit Hours
SWCE 591	Seminar	0+1
SWCE 599	Research for Thesis	0+30

SEMESTER WISE COURSE DISTRIBUTION

M.Tech (Agril. Engg.) Soil & Water Conservation Engineering

Sl. No.	Course Title	Course No.	Major	Minor	Supporting	Common courses
SEMESTER-I						
1	Applied Instrumentation	EE 501			2+1	
2	Advanced Soil and Water Conservation Engineering	SWCE 501*	2+1			
3	Open Channel Flow	SWCE 511	3+0			
4	Design of Farm Drainage Systems	SWCE 513	2+1			
5	Flow Through Porous Media	SWCE 506	2+0			
6	Climate Change and Water Resources	SWCE 508	3+0			
7	Numerical Methods in Hydrology	SWCE 509	2+0			
8	Statistical Methods for Research Works	STAT 501*		2+1		
9	Water Resources Systems Engineering	IDE 513		2+1		
10	Testing and Evaluation of Agricultural Equipment	FMPE 502		2+1		
11	Finite Element Methods	MATH 501		2+1		
12	Artificial Intelligence	CSE 502		2+0		
13	Library and Information Service	PGS 501*				1+0
14	Basic Concepts in Laboratory Techniques	PGS 504*				0+1
SEMESTER-II						
1	Watershed Management and Modelling	SWCE 505*	2+1			
2	Groundwater Engineering	SWCE 512	2+1			
3	Design of Surface Irrigation Systems	SWCE 514	2+1			
4	Soil and Water Conservation Structures	SWCE 503	2+1			
5	Stochastic Hydrology	SWCE 504	2+1			
6	Remote Sensing and GIS for Land and Water Resource Management	SWCE 507/IDE 507	2+1			
7	Design of Pumps for Irrigation and Drainage	IDE 511		2+0		
8	Command Area Management	IDE 503		2+1		
9	Dimensional Analysis and Similitude	ASCE 501		2+1		
10	Numerical Methods for Engineers	MATH 502		2+1		
11	Wind Energy Conversion & Utilisation	REE 505		2+1		
12	Agro Energy Audit and Management	REE 513		2+1		
13	Big Data analysis	CSE 501		2+0		
14	Mechatronics and Robotics in Agriculture	ME 501		2+0		
15	Technical Writing and Communication Skills	PGS 502*				0+1
16	Agricultural Research, Research Ethics and Rural Development Programmes	PGS 505*				1+0
17	Thesis Research	SWCE 599 (0+5)				
SEMESTER-III						
1	Applied Watershed Hydrology	SWCE 502*	2+1			
2	Dryland Water Management Technologies	SWCE 510	2+0			
3	Design of Drip and Sprinkler Irrigation Systems	IDE 505		2+1		
4	Minor Irrigation	IDE 510		2+1		
5	Computer Aided Design of Machinery	FMPE 515		0+2		
6	Water Quality and Pollution Control	ASCE 502		2+1		
7	Soft Computing Techniques in Engineering	CSE 504		2+1		
8	Intellectual Property and its Management in Agriculture	PGS 503*				1+0
9	Thesis Research	SWCE 599 (0+10)				
SEMESTER-IV						
1	Thesis Research	SWCE 599 (0+15)				

2	Seminar	SWCE 591 (0+1)				

* The courses are compulsory for Master's and Ph.D programme respectively.
NC: Non-credit course

The students of M. Tech (Ag. Engg.) course will have to take a minimum of 65 credit hours as given below:

Type of course	Minimum credit hours
A. Course Work	
i) Major course	20
ii) Minor course	08
iii) Supporting course	06
iv) Non–credit compulsory course	--
v) Seminar	01
Sub-Total	**35**
B. Thesis	30
Grand Total	**65**

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

I. **Course Title : Advanced Soil and Water Conservation Engineering**

II. **Course Code : SWCE501**

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. Wind erosion and its control 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 softwares.

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, 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.	Wind erosion and its control	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 soil moisture 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,	4

	silt detention dams and farm ponds	
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.
- Kirk by 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 IHydrology 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

Concept of hydraulic flood routing, flood routing (Reservoir and channel routing), 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.

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.

VI. 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.

VII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Hydrology in water resources planning, rainfall, surface runoff and sub-surface runoff as components of hydrologic cycle	2
2.	Basics of watershed hydrology and processes, global and watershed perspectives	2
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 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.	Concept of hydraulic flood routing, flood routing (Reservoir and channel routing), Hydrological hazard functions	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	**15**

IX. Suggested Reading

- Haan CT. *Hydrologic Modeling of Small Watershed*.
- SinghVP.2010. *Rainfall-Runoff Modeling* (Vol. I) – Prentice Hall, New York.
- Singh VP. 2010. *Environment 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

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 spill way	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,	2

	hydraulic and structural design	
9	Chute Spillway-Components and their functions, hydrologic, Hydraulic and structural design	3
10	Criteria of selection of appropriate structures as per soil, and 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 Lectures
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.
- SureshR.2006.*SoilandWaterConservationEngineering*.FourthEditionStandard Publishers and Distributors, Delhi.
- SinghRajVir.2003.WatershedManagement.SecondEdition,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, stationary 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
6.	Statistics and probabilities in hydrology-Discrete and Continuous probability-Random Variable and Variate; Probability Distribution of hydrological variables; Co-relation and regression analysis.	3
7.	Introduction and examples of stochastic processes; Specification of stochastic process nature, stationarity and ergodicity, components of time series,	2
8.	Hydrologic time series analysis – trend, periodicity	1
9.	Stochastic time series analysis – Methods of analysis - Auto correlation coefficient,	1
10.	Stochastic time series analysis- moving average process, auto regressive process,	2
11.	Stochastic time series analysis - auto regressive moving average process,	2
12.	Stochastic time series analysis – auto regressive integrated moving average process.	2
13.	Spectral analysis, analysis of multivariate hydrologic series	2
14.	Thomas Fiering model, Box Jenkins model	2
15.	Model formulation: Parameter estimation, calibration and validation.	2
16.	Application to hydrologic data	2
17.	Generation and forecasting-Regional flood frequency analysis Transformations,	1
18	Hypothesis testing	1
Total		**32**

IX. Practicals

S.No.	Topic	No. of Lectures
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		**32**

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. Practical

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 : SWCE506

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. Hydrodynamic dispersion in soil-aquifer system.
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.

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**

VIII. Suggested Reading

- Bears J. 1972. *Dynamics of Fluids in Porous Media*. American Elsevier Publishing Co.Inc. New York. 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 Ground Water Flow*. 2nd Edn., Macmillan, London

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

II. Course Code : IDE 507/SWCE 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 platforms: 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. Data merging.

Unit III

Basic components of GIS. Map projections and co-ordinate system. Spatial data structure: Raster, vector. Spatial relationship. Topology. Geo database 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. Measurement in GIS: Length, perimeter and areas. Query analysis. Reclassification, Buffering and Neighborhood functions. Map overlay: Vector and raster overlay. Interpolation and network analysis. Digital elevation modelling. Analytical Hierarchy Process. Object oriented GIS, AM/FM/GIS and Web Based GIS.

Unit V

Spatial data sources. 4M GIS approach water resources system. Thematic maps. Rainfall runoff modelling, groundwater modelling and water quality modelling. Flood inundation mapping and modelling. Drought monitoring. Cropping pattern

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 preprocessing, 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
8	Spatial data structure: Raster, vector data, Spatial relationship-Topology	1
9	Geo data base models: Hierarchical, network, relational, object-oriented models. Integrated GIS database	3
10	Data quality, Common sources of error, Macro, micro and Usage level components, Metadata and Spatial data transfer standards	2
10	Measurement in GIS-Length, perimeter and areas	1
11	Query analysis. Reclassification, Buffering and Neighborhood functions	1
12	Map overlay: Vector and raster overlay	1
13	Interpolation and network analysis	1
14	Digital elevation modelling. Analytical Hierarchy Process. Object oriented GIS,AM/FM/GIS and Web Based GIS	3
15	GIS approach to Rainfall runoff modelling, Flood inundation Mapping and modelling	2
16	GIS approach to Ground water modelling and water quality modelling	2
17	Site selection for artificial recharge. Reservoir sedimentation	1
18	Drought monitoring	1
19	Performance evaluation of irrigation commands	1
20	Cropping pattern change analysis	1
Total		**32**

IX. Practical

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 & CARTODEM 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 SteveC.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, tele connections.

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 global context	3
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.
- SrinivasaRKandNageshKD.*ImpactofClimateChangeonWaterResourceswithModelling 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 : SWCE509

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 basic 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 basic functions	3
3	Approximating from finite dimensional subspaces	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 subsurface hydrology	3
	Total	**32**

VIII. Suggested Reading

- Bear J and Verruijt A. 1987. *Modeling Ground water Flow and Pollution*. 414pp. Dordrecht, Boston.
- Carr JR. 1995. *Numerical Analysis for the Geological Sciences*. 592pp. 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*. 6thed., 768pp, Addison-Wesley, Reading, MA.
- Middleton GV. 2000. *Data Analysis in the Earth Sciences using MATLAB* 260 pp., Prentice Hall, Saddle River NJ. *And Finite Element Methods*. 237pp, W.H. Freeman and Co., San Francisco.

I. Course Title : Dry land 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 dry land 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 along with new and appropriate methods of rainwater conservation and harvesting technologies for rainfed areas.

VII. Lecture Schedule

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	2

	assessment and mapping using GIS	
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 dry land 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 Dry land Farming*. Scientific Publ.
- GuptaUS.1995.*ProductionandImprovementsofCropsforDrylands.*OXford&IBH

- SinghRP.1988.*ImprovedAgronomicPracticesforDrylandCrops*.CRIDA.
- SinghRP.2005.*SustainableDevelopmentofDrylandAgricultureinIndia*.ScientificPubl.
- SinghRV.2003.*Watershed Planning and Management*. Second Edition. Yash Publishing House, Bikaner.
- Singh SD. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publishers.

I. Course Title : Open Channel Flow

II. Course Code : SWCE 511

III. Credit Hours : 3+0

IV. Aim of the course

To acquaint and equip with the hydraulics of surface water flow phenomenon in open channels.

V. Theory

Unit I

Open channel and their properties, energy and momentum, critical flow computation and application.

Unit II

Uniform flow, gradually varied flow theory and analysis, methods of computation.

Unit III

Practical problems such as design of transitions, flow passing islands etc., spatially varied flow, rapidly varied flow.

Unit IV

Hydraulic jump and its use as energy dissipater, flow through channel of non-linear alignment and flow through non-prismatic channel sections.

Unit V

Unsteady flow, gradually varied unsteady flow and rapidly varied unsteady flow.

VI. Learning outcome

The students are able to understand flow in open channels by having in-depth knowledge of flow hydraulics.

VII. Lecture Schedule

S.No.	Topic	No.of Lectures
1	Open channel flow and its classifications	2
2	Open channels and their properties	4
3	Velocity distribution in a channel section	2
4	Energy and momentum principles: energy in open channel flow, specific energy. Interpretation of local phenomenon, momentum in open channel flow	10

5	Critical flow: its computation and application	4
6	Uniform flow: best hydraulic section, grassed waterway	4
7	Practical problems such as design of transitions, flow passing islands etc.,	2
8	Hydraulic jump and its use as energy dissipator, types of jump, efficiency, height of jump, length of jump, jump as energy dissipator, control of jump by sills,	5
9	Flow through channel of non-linear alignment and flow through non-prismatic channel sections	2
10	Rapidly varied flow	2
11	Gradually varied flow theory and analysis, methods of computation	4
12	Spatially varied flow	4
13	Unsteady flow, gradually varied unsteady flow and rapidly varied unsteady flow	3
Total		**48**

VIII. Suggested Reading

- Chaudhry M H.1993. Open Channel Flow. Prentice Hall.
- Chow V T.1973. Open Channel Hydraulics, Mc-Graw Hill.
- Henederson F M.1966. Open Channel Flow. Macmillan.
- Modi P N and Seth S M.2000. Hydraulics and Fluid Mechanics. Standard Book House.
- Subramanya K.2019. Flow in Open Channels. Mc-Graw Hill

I. Course Title : Ground Water Engineering

II. Course Code : SWCE 512

III. Credit Hours : 2+1

IV. Aim of the course

To provide comprehensive knowledge to the students in aquifers, groundwater flow, artificial groundwater recharge techniques, well hydraulics and groundwater models.

V. Theory

Unit I

Water resources of India. Occurrence, storage and movement of groundwater in alluvial and hard rock formations. Principles of groundwater flow. Interaction between surface water and groundwater.

Unit II

Natural and artificial groundwater recharge. Conjunctive use of surface and groundwater. Groundwater balance. Fluctuation of water table beneath a recharge site. Delineation of groundwater potential zones using RS and GIS, MODFLOW equation.

Unit III

Derivation of hydraulics of fully and partially penetrating wells in confined, leaky and

unconfined aquifers. Flow net analysis. Partial penetrating wells

Unit IV

Analysis of multi aquifers. Flow analysis in interfering wells. Pumping tests for estimation of aquifer parameters. Wells near recharge and impermeable boundaries. Skimming well technology. Design of tube wells, construction and development of tube wells.

Unit V

Design of well field. Safe yield and basin wide groundwater development, techniques for groundwater recharge, Salt water intrusion in inland and coastal aquifers. Application of groundwater models for groundwater management. Calibration and validation of models.

VI. Practical

Water table contour maps and determination of groundwater flow. Estimation of aquifer characteristics. Problems on non-leaky and leaky aquifers. Analysis of pumping test data. Computation of interference of wells. Groundwater computer simulation models.

VII. Learning outcome

The student will be able to analyze storage, movement and flow characteristics of different aquifers and also model ground water and plan for ground water recharge including delineation of potential groundwater recharge zones.

VIII. Lecture Schedule

S. No.	Topic	No. of Lectures
1	Water Resources of India. Occurrence, movement of groundwater and storage of groundwater in geological formation	2
2	Study of hydro geological formation in India	1
3	Principal of Groundwater flow. Interaction between surface water and groundwater	
4	Natural and artificial groundwater recharge. Conjunctive use of surface and groundwater	1
5	Groundwater balance and fluctuation of water table beneath recharge sites	2
6	Delineation of groundwater potential zones using RS and GIS	2
7	Study of MODFLOW and its application	2
8	Hydraulics of wells, Steady state flow to fully penetrating well in unconfined, confined and leaky aquifer, partially penetrating wells, well interference	3
9	Flow net analysis for groundwater flow	1
10	Steady and Unsteady flow in Multi aquifers	1
11	Flow analysis in interfering multiple wells	1
12	Pumping tests for estimation of aquifer parameters	1
13	Design of tube well	2
14	Construction and development of tube well	1
15	Safe yield and basin wide groundwater development	1
16	techniques for groundwater recharge	1
17	Flow to wells near recharge and impermeable boundaries	2
18	Design of well field and skimming well technology (multiple well point system)	1

19	Salt water intrusion in inland and coastal aquifers	1
20	Groundwater modelling approaches	1
21	Study of various groundwater models	1
22	Application of groundwater models for groundwater management	2
23	Calibration and validation of models	2
Total		32

IX. List of Practical

S. No.	Topic	No. of Practicals
1	Delineation of water table contour maps.	2
2	Determination of groundwater flow using contour maps	1
3	Estimation of aquifer characteristics by Theis and Cooper-Jacob method	2
4	Estimation of aquifer characteristics by Chow's and Theis recovery method	2
5	Hand on exercise for analysis groundwater flow through well in leaky aquifers.	2
6	Hand on exercise for analysis groundwater flow through well in non-leaky aquifers	2
7	Analysis of pumping test data for estimation of aquifer parameters.	1
8	Computation of drawdown and discharge under interference of wells	2
9	Simulation of groundwater flow using various computer models (MODFLOW, etc)	2
Total		16

X. Suggested Reading

- Boonstra J and de Ridder NA. 1981. *Numerical Modeling of Groundwater Basins*. ILRI.
- Demenico PA. 1972. *Concept and Models in Groundwater Hydrology*. McGraw Hill.
- Huisman L 1972. *Ground Water Recovery*. Mac Millan.
- Jat ML and SR Bhakar 2008. *Ground Water Hydrology*. Agro-tech Publishing Academy. Udaipur.
- Polubarinova Kochina P Ya. 1962. *Theory of Ground Water Movement*. Princeton Univ. Press.
- Raghunath HM 1992. *Ground Water*. Wiley Eastern.
- Todd DK 1997. *Ground Water Hydrology*. Wiley Eastern.

I. Course Title : Design of Surface Irrigation Systems

II. Course Code : SWCE 513

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint students for design and evaluation of various surface irrigation methods, design optimum layout, conveyance network for efficient use of water in surface irrigation system.

V. Theory

Unit I

Climate and irrigation water requirement. Irrigation principles, losses, conveyance, distribution, application and water budgeting. Estimation techniques of effective rainfall. Irrigation softwares: CROPWAT, AQUACROP.

Unit II

Farm irrigation systems. Irrigation efficiencies. Economic feasibility. Irrigation water quality and salinity management techniques. Design of water conveyance, control and distribution systems.

Unit III

Hydraulics: Design and operation of border, check basin, furrow, sprinkler and trickle irrigation systems. Flow dynamics, drop size distribution and spray losses in sprinklers. Cablegation, surge and bubbler irrigation. Automation of irrigation system.

Unit IV

Underground water conveyance systems, evaluation of irrigation systems and practices

Unit V

Basic water management concepts and objectives. Alternative irrigation scheduling techniques. Integrated approach to irrigation water management.

VI. Practical

Design and evaluation of border, furrow, check basin, sprinkler and micro-irrigation. Computation of frictional losses. Design of underground water conveyance systems. Economics of irrigation methods. Visit to mechanized farms.

VII. Learning outcome

The students will be able to plan and design various surface irrigation systems and irrigation scheduling techniques for efficient use of water. They will also be exposed to irrigation software used for design purpose.

VIII. Lecture Schedule

Sl. No	Topic	No. of Lectures
1.	Climate and irrigation water requirement	1
2.	Irrigation principles, losses, conveyance, distribution, application and water budgeting	2
3.	Estimation techniques of effective rainfall	2
4.	Irrigation softwares; CROPWAT, AQUACROP	2
5.	Farm irrigation systems. Irrigation efficiencies, Economic feasibility	2
6.	Irrigation water quality and salinity management techniques	2
7.	Design of water conveyance, control and distribution systems	2
8.	Hydraulics; Design and operation of border, check basin and furrow irrigation systems.	3
9.	Hydraulics: Design and operation of sprinkler and trickle irrigation systems	4
10.	Flow dynamics, drop size distribution and spray losses in sprinklers	2

11.	Cablegation, surge and bubbler irrigation	1
12.	Underground water conveyance systems, evaluation of irrigation systems and practices	2
13.	Automation of irrigation system	2
14.	Basic water management concepts and objectives	2
15.	Alternative irrigation scheduling techniques	1
16.	Integrated approach to irrigation water management	2
Total		**32**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Estimation of different techniques of effective rainfall	1
2.	Design of irrigation methods using irrigation software's: CROPWAT, AQUACROP	3
3.	Design of water conveyance, control and distribution systems.	1
4.	Design and evaluation of border irrigation method	1
5.	Design and evaluation of furrow irrigation method	1
6.	Design and evaluation of check basin method	1
7.	Design and evaluation of sprinkler irrigation method	1
8.	Design and evaluation of trickle irrigation method	1
9.	Study of automation of irrigation system	1
10.	Design of underground water conveyance systems	1
11.	Study of economics of irrigation methods	2
12.	Visit to mechanized farms	1
Total		**15**

X. Suggested Reading

- Finkel HJ. 1983. *Handbook of Irrigation Technology*. Vols. I-II, CRC Press.
- James LG. 1988. *Principles of Farm Irrigation System Design*. John Wiley and Sons, NewYork, USA.
- Karmeli D, Peri G and Todes M. 1985. *Irrigation Systems: Design and Operation*. Oxford University Press.
- Michael AM. 2008. *Irrigation Theory and Practices*. Vikas Publishing House Pvt. Ltd, NewDelhi.
- Pillsbury AF. 1972. *Sprinkler Irrigation*. FAO Agricultural Development Paper No. 88, FAO.
- Rydzewski. 1987. *Irrigation Development Planning*. John Wiley and Sons.
- Sivanappan RK 1987. *Sprinkler Irrigation.* OXford and IBH.
- Sivanappan RK, Padmakumari O and Kumar V. 1987. *Drip Irrigation*. Keerthy Publ, House.

I. Course Title : Design of Farm Drainage Systems

II. Course Code : SWCE 514

III. Credit Hours : 2+1

IV. Aim of the course

To provide in depth knowledge of water logging and salt affected areas, surface and sub-surface drainage systems, design and reclamation of salt affected waterlogged areas.

V. Theory

Unit I

Salt affected waterlogged areas in India. Water quality criteria and brackish water use for agriculture. Drainage requirements and crop growth under salt affected waterlogged soil.

Unit II

Concept of critical water table depth for waterlogged soil and crop growth. Drainage investigations and drainage characteristics of various soils. Methods of drainage system and drainage coefficient.

Unit III

Theories and applications of surface and subsurface drainage. Planning, design and installation of surface and subsurface drainage systems for waterlogged and saline soils. Theories and design of vertical drainage, horizontal subsurface drainage and multiple well point system. Drainage materials.

Unit IV

Steady and unsteady state drainage equations for layered and non-layered soils. Principle and applications of Hooghoudt, Kirkham, Earnst, Glover Dumm, Kraijenhoff-van-deleur equations. Drainage for salinity control.

Unit V

Salt balance, leaching requirement and management practices under drained conditions. Disposal of drainage effluents. Case study for reclamation of salt affected waterlogged areas.

VI. Practical

Measurement of in-situ hydraulic conductivity. Estimation of drainage coefficient and leaching requirements. Delineation of waterlogged areas through isobar, isobath and topographic maps. Design of surface and subsurface drainage systems. Design of filter and envelop materials.

VII. Learning outcome

The students will able to develop surface as well as subsurface drainage networking the agriculture field, install and laying of the drainage pipe with fitting of all accessories at their place and derive equation for different flow in drainage system and their approaches.

VIII. Lecture Schedule

S. No.	Topic	No. of Lectures
1	Waterlogging, causes of waterlogging, salt built up in waterlogged soil, solute transport in salt affected soil. Recent salt affected areas in different states and country as whole	2
2	Technology and approach for reclamation of salt affect waterlogged areas	2
3	Drainage requirement and crop growth under salt affected waterlogged soil. Drainage water/ brackish water quality and it's criteria for use in agriculture	2
4	Concept of critical water table depth for waterlogged soil and crop	1

	growth	
5	Drainage investigations and drainage characteristics of various soils.	2
6	Methods of drainage system: surface, sub surface, well drainage and bio-drainage and drainage coefficient	1
7	Theories and applications of surface and subsurface drainage	3
8	Planning, design and installation of surface and subsurface drainage systems for waterlogged and saline soils	3
9	Theories of vertical and horizontal subsurface drainage systems	2
10	Theory, design and application of multiple well point system	1
11	Drainage materials. Design of filter and envelop for drainage system with different materials	2
12	Steady state drainage equations for layered and non- layer soils	2
13	Unsteady state drainage equations for layered and non- layer soils	3
14	Principle and application, Hooghoudt and Khirkham equation	3
15	Principles and application of Ernst, Glover Dumm, Kraijenhoff-van-deleur equation	2
16	Drainage for salinity control, salt balance equation, leaching requirement and management practices under drained conditions, Disposal of drainage effluents	3
17	Case study: Integrated planning, design and installation of drainage system for reclamation of salt affected waterlogged areas	2
Total		36

IX. List of Practical

S.No.	Topic	No. of Practicals
1.	Delineation of waterlogged areas through isobar, isobath and topographic maps	3
2.	Measurement of in-situ hydraulic conductivity	1
3.	Estimation of drainage coefficient from rainfall data	2
4.	Determination of leaching requirements for reclamation of salt affected land	2
5.	Design of surface drainage systems	2
6.	Design of subsurface drainage systems	2
7.	Design of filter and envelop materials	2
8.	Visit to drainage installation site/Institute	2
Total		**16**

X. Suggested Reading

- Bhattacharaya AK and Michael AM. 2003. *Land Drainage.* Vikas Publ.
- Clande Ayres and Daniel Scoates AE. 1989. *Level Drainage and Reclamation*. Mc.GrawHill.
- Luthin JN. 1978. *Drainage Engineering*. Wiley Eastern.
- Ritzema HP (Ed.) 1994. *Drainage Principles and Applications*. ILRI
- Roe CE. 1966. *Engineering for Agricultural Drainage*. McGraw Hill.
- Schilfgaarde Jan Van (Editor). 1974. *Drainage for Agriculture*. Monograph No. 17. AmericanSociety of Agronomy Madison, Wisconsin, USA.