COURSE SYLLABUS
for
Ph.D (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

Ph.D. (Agril. Engg.) in Soil and Water Conservation Engineering

Major Courses (Requirement: 12 Credits)		
Course Code	Course Title	Credit Hours
SWCE 601*	Advances in Hydrology	2+1
SWCE 602*	Soil and Water Systems Simulation and Modeling	2+1
SWCE 603	Reservoir Operation and River Basin Modeling	2+1
SWCE 604	Modeling Soil Erosion Processes and Sedimentation	2+1
SWCE 605	Waste Water Treatment and Utilization	3+0
SWCE 606	Hydro-Chemical Modeling	2+0
SWCE 607	Water Resources Systems Engineering	2+1

*Compulsory course

Minor Courses (Requirement: 06 Credits)

Course Code	Course Title	Credit Hours
IDE 601	Recent Developments in Irrigation Engineering	2+1
IDE 602	Advances in Drainage Engineering	2+1
IDE 603	Hydro-Mechanics and Ground Water Modeling	3+0
IDE 604	Soil-Water-Plant-Atmospheric Modeling	2+1
IDE 605	Plant Growth Modelling and Simulation	2+0
IDE 606	Multi Criteria Decision Making System	2+0
CSE 503	Neuro-Fuzzy Application in Engineering	2+1
CSE 506	Digital Image Processing	2+1
ASCE 501	Dimensional Analysis and Similitude	2+1
FMPE 502	Testing and Evaluation of Agricultural Equipment	2+1
FMPE 503	Ergonomics and Safety in Farm Operation	2+1
REE 602	Thermo-chemical conversion of Biomass	2+1
REE 609	Energy Planning Management and Economics	3+0
PFE 604	Agril. Waste and By-Product Utilization	2+1
CSE 503	Neuro-Fuzzy Application in Engineering	2+1
CSE 506	Digital Image Processing	2+1
ME 515	Computer Aided Design	2+1
Any other course(s) of other department can be taken as per recommendations of the student’s advisory committee.		

Supporting Courses (Requirement: 05 Credits)

Course Code	Course Title	Credit Hours
CPE-RPE*	Research and Publication Ethics	1+1
ASCE 601	Environmental Engineering for Plants and Animals	3+0
STAT 601	Theory of Design and Analysis of Experiment	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		

***Course has been made compulsory by UGC for PhD students. Course code and its detailed course outline to be adopted in toto as recommended by UGC.**

Course Code	Course Title	Credit Hours
SWCE 691	Seminar-I	0+1
SWCE 692	Seminar-II	0+1
SWCE 699	Research for thesis	0+75

SEMESTER WISE COURSE DISTRIBUTION

Ph.D (Agril. Engg.) Soil & Water Conservation Engineering

Sl. No.	Course Title	Course No.	Major	Minor	Supporting
SEMESTER-I					
1	Environmental Engineering for Plants and Animals	ASCE 601			2+1
2	Reservoir Operation and River Basin Modelling	SWCE 603	2+1		
3	Modelling Soil Erosion Processes and Sedimentation	SWCE 604	2+1		
4	Water Resources Systems Engineering	SWCE 607	2+1		
5	Recent Developments in Irrigation Engineering	IDE 601		2+1	
6	Hydro-Mechanics and Ground Water Modelling	IDE 603		3+0	
7	Soil-Water-Plant-Atmospheric Modelling	IDE 604		3+0	
8	Advances in Machinery for Precision Agriculture	FMPE 602		2+1	
9	Thermo-chemical conversion of Biomass	REE 602		2+1	
10	Neuro-Fuzzy Application in Engineering	CSE 503		2+1	
11	*Library and Information Service*	*PGS 501*	*1+0 (NC)*		
12	*Basic Concepts in Laboratory Techniques*	*PGS 504*	*0+1 (NC)*		
SEMESTER-II					
1	Research and publication Ethics	CPE-RPE*			1+1
2	Theory of Design and Analysis of Experiment	STAT 601			2+1
3	Soil and Water Systems Simulation and Modelling	SWCE 602*	2+1		
4	Waste Water Treatment and Utilisation	SWCE 605	3+0		
5	Hydro-Chemical Modelling	SWCE 606	2+0		
6	Advances in Drainage Engineering	IDE 602		2+1	
7	Plant Growth Modelling and Simulation	IDE 605		2+0	
8	Energy Planning Management and Economics	REE 609		3+0	
9	Agril. Waste and By-Product Utilization	PFE 604		2+1	
10	Advances in Machinery for Precision Agriculture	FMPE 602		2+1	
11	Digital Image Processing	CSE 506		2+1	
12	Thesis Research	SWCE 699 (0+5)			
13	*Technical Writing and Communication Skills*	*PGS 502*	*0+1 (NC)*		
14	*Agricultural Research, Research Ethics and Rural Development Programmes*	*PGS 505*	*1+0 (NC)*		
SEMESTER-III					
1	Advances in Hydrology	SWCE 601*	2+1		
2	Design of Drip and Sprinkler Irrigation Systems	IDE 505		2+1	
3	Minor Irrigation	IDE 510		2+1	
4	Water Quality and Pollution Control	ASCE 502		2+1	
5	Soft Computing Techniques in Engineering	CSE 504		2+1	
6	Thesis Research	SWCE 699 (0+15)			
7	*Intellectual Property and its Management in Agriculture*	*PGS 503*	*1+0 (NC)*		
SEMESTER-IV					
1	Thesis Research	SWCE 699 (0+15)			
SEMESTER-V					
1	Thesis Research	SWCE 699 (0+20)			
2	Seminar-I	SWCE 691 (0+1)			
SEMESTER-VI					
1	Thesis Research	SWCE 699 (0+20)			
2	Seminar-II	SWCE 692 (0+1)			

* The courses are compulsory for Master’s and Ph.D programme respectively.

NC: Non-credit (*italic*) courses are exempted if undergone during Master's programme.

Type of course	Minimum credit hours
A. Course Work	
i) Major course	12
ii) Minor course	06
iii) Supporting course	05
iv) Non–credit compulsory course	--
v) Seminar	02
Sub-Total	**25**
B. Thesis	75
Grand Total	**100**

Course Contents

Ph.D. (Agril. Engg.) 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 modelling.

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.	Confidence interval one sided, two sided, Hypothesis testing test statistics	2
7.	Probability distribution of hydrologic variables	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	2

	rainfall and runoff	
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
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	2

	various hydrologic modeling systems	
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**

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
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;	1
16.	Crop yield optimization, Multi-basin and multi-reservoir systems	3
Total		**33**

VIII. 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**

IX. 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
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.

XI.

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 along with 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, bio magnification, water borne diseases.	2
6.	Key drivers of wastewater use in agriculture and existing approaches for regulating wastewater reuse in agriculture	2
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	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.

I. **Course Title : Water Resources Systems Engineering**

II. **Course Code : SWCE 607**

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

IV. **Aim of the course**

To acquaint students about the concept of optimization and its application in water resources management, mathematical programming techniques and multi objective water resources planning.

V. **Theory**

Unit I

Concepts and significance of optimization in water resources management. Model development in water management. Objective functions, deterministic and stochastic inputs.

Unit II

Soil plant atmosphere system. Problem formulation. Mathematical programming techniques: Linear programming, simplex method.

Unit III

Non-linear programming, quadratic programming, integer programming. Transportation problem and solution procedure. Geometric programming and dynamic programming.

Unit IV

Application of optimization techniques for water resources planning. Conjunctive use of water resources. Crop production functions and irrigation optimization.

Unit V

Multi objective water resources planning. Critical path method. Programme evaluation and review technique. Economic models. Project evaluation and discounting methods.

VI. **Practical**

Assessment of water resources. Problems related to water allocation in agriculture under single and multiple cropping system. Use of computer software for linear and dynamic programming. Introduction to the use of other programming methods. Sensitivity analysis of different alternatives of water resources development and allocation. Analysis of water demand and supply. Analysis of Competitive demands for water by various sectors of development. Benefits and cost of water resources development.

VII. **Learning outcome**

The students will be able to identify objective function and components in water resource planning problems and also able to formulate and solve various mathematical programming models of water resource system as well as to develop conjunctive use and crop production function optimization models.

VIII. **Lecture Schedule**

S. No.	**Topic**	**No. of Lectures**
1	Concepts and significance of optimization in water resources management	1
2	Model development in water management	1
3	Objective functions, deterministic and stochastic input	1
4	Soil plant atmosphere system. Problem formulation. Mathematical programming techniques	1
5	Linear programming, simplex method	5
6	Non-linear programming, quadratic programming, integer	5

	programming	
7	Transportation problem and solution procedure	3
8	Geometric programming	3
9	Dynamic programming	4
10	Application of optimization techniques for water resources planning	2
11	Conjunctive use of water resources	1
12	Crop production functions and irrigation optimization	2
13	Multi objective water resources planning. Critical path method	2
14	Programme evaluation and review technique	1
15	Economic models	2
16	Project evaluation and discounting methods	1
Total		**35**

IX. **List of Practicals**

S. No.	**Topic**	**No. of Practicals**
1	Assessment of water resources of the region	1
2	Problems on water allocation in agriculture under single and multiple cropping system	2
3	Familiarization with computer software for linear programming	3
4	Hands on exercise for non-linear programming on computer	3
5	Hands on exercise for dynamic programming on computer	3
6	Sensitivity analysis of different alternatives of water resources development and allocation	2
7	Analysis of water demand and supply	2
8	Benefits and cost of water resources development	1
Total		**17**

X. **Suggested Reading**

- Larry WM. 1996. *Water Resources Handbook.* Mc-Graw-Hill.
- Loucks DP *et al*. 1981. *Water Resources System Planning and Analysis.* Prentice Hall.
- Rao SS. 1978. *Optimization Theory and Application*. Wiley Eastern.
- Wallander WW and Bos M. 1990. *Water Resource System Planning and Management*