COURSE SYLLABUS
for
M. Tech. (Agril. Engg.)
in
Irrigation and Drainage 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 Irrigation and Drainage Engineering

Major Courses (Requirement: 20 Credits)		
Course Code	Course Title	Credit Hours
IDE 501	Design of Surface Irrigation Systems	2+1
IDE 502*	Design of Farm Drainage Systems	2+1
IDE 503	Command Area Management	2+1
IDE 504	Water and Nutrient Management Under Protected	2+1
IDE 505*	Design of Drip and Sprinkler Irrigation Systems	2+1
IDE 506*	Ground Water Engineering	2+1
SWCE 507/IDE 507	Remote Sensing and GIS for Land and Water Resource Management	2+1
IDE 508	Waste Water Management and Utilization in Agriculture	2+1
IDE 509	Water Conveyance and Distribution	2+1
IDE 510	Minor Irrigation	2+1
IDE 511	Design of Pumps for Irrigation and Drainage	2+0
IDE 512	Crop Environmental Engineering	2+0
IDE 513	Water Resources Systems Engineering	2+1
IDE 514	Irrigation Economics, Planning and Management	2+0
IDE 515	Sensing and Automation in Irrigation Systems	3+0
IDE 516	Open Channel Flow	3+0
IDE 517	Applied Watershed Hydrology	2+1

*Compulsory course

Minor Courses (Requirement: 08 Credits)

Course Code	Course Title	Credit Hours
SWCE 501	Advanced Soil and Water Conservation Engineering	2+1
SWCE 503	Soil and Water Conservation Structures	2+1
SWCE 506	Flow Through Porous Media	2+0
SWCE 508	Climate Change and Water Resources	3+0
SWCE 510	Dryland Water Management Technologies	2+0
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	3+0
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	Credits
*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	Credits
IDE 591	Seminar	0+1
IDE 599	Research for Thesis	0+30

SEMESTER WISE COURSE DISTRIBUTION

M.Tech (Agril. Engg.) Irrigation & Drainage Engineering

Sl. No.	Course Title	Course No.	Major	Minor	Supporting	Common courses
SEMESTER-I						
1	Applied Instrumentation	EE 501			2+1	
2	Open Channel Flow	IDE 516	3+0			
3	Design of Farm Drainage Systems	IDE 502*	2+1			
4	Water and Nutrient Management Under Protected Cultivation	IDE 504	2+1			
5	Waste Water Management and Utilisation in Agriculture	IDE 508	2+1			
6	Water Conveyance and Distribution	IDE 509	2+1			
7	Water Resources Systems Engineering	IDE 513	2+1			
8	Advanced Soil and Water Conservation Engineering	SWCE 501		2+1		
9	Flow Through Porous Media	SWCE 506		2+0		
10	Climate Change and Water Resources	SWCE 508		3+0		
11	Testing and Evaluation of Agricultural Equipment	FMPE 502		2+1		
12	Finite Element Methods	MATH 501		2+1		
13	Artificial Intelligence	CSE 502		2+0		
	Statistical Methods for Research Works	STAT 501*			2+1	
14	Library and Information Service	PGS 501*				1+0
15	Basic Concepts in Laboratory Techniques	PGS 504*				0+1
SEMESTER-II						
1	Design of Surface Irrigation Systems	IDE 501	2+1			
2	Command Area Management	IDE 503	2+1			
3	Ground Water Engineering	IDE 506*	2+1			
4	Remote Sensing and GIS for Land and Water Resource Management	IDE 507/ SWCE 507	2+1			
5	Design of Pumps for Irrigation and Drainage	IDE 511	2+0			
6	Crop Environmental Engineering	IDE 512	2+0			
7	Sensing and Automation in Irrigation Systems					
8	Watershed Management and Modelling	SWCE 505		2+1		
9	Soil and Water Conservation Structures	SWCE 503		2+1		
10	Stochastic Hydrology	SWCE 504		2+1		
11	Dimensional Analysis and Similitude	ASCE 501		2+1		
12	Numerical Methods for Engineers	MATH 502		2+1		
13	Wind Energy Conversion & Utilisation	REE 505		2+1		
14	Agro Energy Audit and Management	REE 513		2+1		
15	Big Data analysis	CSE 501		2+0		
16	Mechatronics and Robotics in Agriculture	ME 501		2+0		
18	Technical Writing and Communication Skills	PGS 502*				0+1
19	Agricultural Research, Research Ethics and Rural Development Programmes	PGS 505*				1+0
20	Thesis Research	IDE 599 (0+5)				
SEMESTER-III						
1	Applied Watershed Hydrology	IDE 517	2+1			
2	Design of Drip and Sprinkler Irrigation Systems	IDE 505*	2+1			
3	Minor Irrigation	IDE 510	2+1			
4	Irrigation Economics, Planning and Management	IDE 514	2+0			
5	Dryland Water Management Technologies	SWCE 510		2+0		
6	Computer Aided Design of Machinery	FMPE 515		0+2		

7	Water Quality and Pollution Control	ASCE 502		2+1		
8	Energy, Ecology and Environment	REE 513		3+0		
9	Soft Computing Techniques in Engineering	CSE 504		2+1		
10	Intellectual Property and its Management in Agriculture	PGS 503*				1+0
11	Thesis Research	IDE 599 (0+10)				
SEMESTER-IV						
1	Thesis Research	IDE 599 (0+15)				
2	Seminar	IDE 591 (0+1)				

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

NC: Non-credit course

The students, 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 Irrigation and Drainage Engineering

I. **Course Title : Design of Surface Irrigation Systems**

II. **Course Code : IDE 501**

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. **TheoryUnit 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 softwares 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

Sl. 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 system	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 : IDE 502**

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 networkin 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 systemand their approaches.

VIII. **Lecture Schedule**

S. No.	Topic	No. of Lectures
1	Waterlogging, causes of waterlogging, salt built up in waterloggedsoil, 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 growth	1
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 Practicals

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.

I. **Course Title : Command Area Management**

II. **Course Code : IDE 503**

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

IV. **Aim of the course**

To acquaint students about the concept of command area management, assessment and appraisal of water availability in command areas, water management problems in command areas and their possible remedies including socio-economic aspects of irrigation command.

V. **Theory**

Unit I

Concept of command area development as an integrated approach. Command area project formulation, major, medium and minor projects. Command areas in India, command area activities and their prioritization. Source of budget for CAD works. Structure of command area development, organization, role and responsibilities of CADA.

Unit II

Laser based land grading survey and levelling in command areas. Design of lined and unlined canals. Diversion head works and canal head regulators, cross drainage works, canal falls, canal breaches. Design of On Farm Water Distribution Network, operation and maintenance of canal.

Unit III

Assessment and appraisal of water availability in command areas. Water management problems in command areas and their possible remedies. Duty of water, its determination and factors affecting it. Methods of improving duty of canal water. Feasibility of drip irrigation in irrigated command areas.

Unit IV

Single and multi-objective command area planning for the better management and allocation of irrigation water. Conjunctive use of canal water and groundwater. Real time canal irrigation scheduling.

Unit IV

Canal performance indices. Diagnostic analysis and perform appraisal of command area projects. Water user's association–functions, problems encountered during formation of WUA and strategy and overcome the problems. Participatory irrigation management efforts and strategy for preparing PIM. Socio economic aspects of irrigation management in command areas.

VI. **Practical**

Study of canal, tank and tube well in a command area. Study of design and operational parameters of a command area. Study of water balance in a command. Study the impact of command area project on crop yield and environment. Conflict resolution through PRA eXercise. Diagnostic analysis of the problems of commandarea through PRA and field observations. Analysis of equity in water distribution. Considerations for preparation of roistering schedules. Study of the functioning of irrigation cooperatives/water user's associations. Preparation of command area development plan.The students will be able to understand the concept of command area and its management, to analyze problem diagnostics and remedies of command area andable to understand the performance evaluation procedure of command area.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Concept of command area development as an integrated approach	1
2.	Command area project formulation, major, medium and minor projects	2
3.	Command areas in India	1
4.	Command area activities and their prioritization	1
5.	Source of budget for CAD works	1
6.	Structure of command area development	1
7.	Organization, role and responsibilities of CADA	1
8.	Laser based land grading survey and levelling in command areas	1
9.	Design of lined and unlined canals	2
10.	Diversion head works and canal head regulators, cross drainage works, canal falls, canal breaches	2
11.	Design of On Farm Water Distribution	1
12.	Network, operation and maintenance of canal	1
13.	Assessment and appraisal of water availability in command areas	1
14.	Water management problems in command areas and their possible remedies	2
15.	Duty of water, its determination and factors affecting it. Methods of improving duty of canal water	2
16.	Feasibility of drip irrigation in irrigated command areas	1
17.	Single and multi-objective command area planning for the better management and allocation of irrigation water	1
18.	Conjunctive use of canal water and groundwater	1
19.	Real time canal irrigation scheduling	1
20.	Canal performance indices	1
21.	Diagnostic analysis and perform appraisal of command area projects	1
22.	Water user's association–functions, problems encountered during formation of WUA and strategy and overcome the problems	2
23.	Participatory irrigation management efforts and strategy for preparing PIM	2
24.	Socio economic aspects of irrigation management in command areas	2
Total		**32**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Study of canal, tank and tube well in a command area	1
2.	Study of design and operational parameters of a command area	2
3.	Study of water balance in a command	1
4.	Study the impact of command area project on crop yield and environment	2
5.	Study about conflict resolution through PRA exercise	2

6.	Diagnostic analysis of the problems of command area through PRA and field observations	2
7	Analysis of equity in water distribution	1
8	Considerations for preparation of roistering schedules	1
9	Study of the functioning of irrigation cooperatives/water user's associations	2
10	Preparation of command area development plan	2
Total		**16**

X. Suggested Reading

- Jos´eLiria Montanes. 2006. *Design, Construction, Regulation and Maintenance*. Taylor andFrancis Publication.
- Modi PN. *Irrigation Water Resources and Water Power Engineering*. Standard Publishers.
- Singh VP. 2014. *Entropy Theory in Hydraulic Engineering: An Introduction*. ASCE Press.
- Sharma SK. *Irrigation Water Resources and Water Power Engineering.* Standard Publishers.
- Swamee PK and Chahar BR. *Design of Canals*. Springer Publications.

I. Course Title : Water and Nutrient Management under Protected Cultivation

II. Course Code : IDE 504

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint students about the concept of soilless culture in agriculture, water and nutrient management, water potential in soilless media and automation for climate control under protected cultivation.

V. TheoryUnit I

Significance of soilless culture in agriculture. Functions of the root system. Response of root growth to local nutrient concentrations. Interactions between environmental conditions and form of N nutrition.

Unit II

Roots as source and sink for organic compounds and plant hormones. Physical and chemical properties of soilless media.

Unit III

Water content and water potential in soilless media. Water movement in soilless media. Uptake of water by plants in soilless media and water availability.

Unit IV

Production technology for vegetables under protected conditions in soil and soilless media. Automation for climate control in protected structures. Thermal modeling of greenhouse environment for protected cultivation.

VI. Practical

Filter types and its selection criteria. Design and installation of drip irrigationsystem for vegetables and orchards. Irrigation and fertigation scheduling for vegetables and horticultural. Study of different types of sensors, relay and control mechanism for controlled irrigation and fertigation. Design of automated systemfor irrigation and fertigation. Design and installation of different protected structures as per the guidelines of NHM. Design and fabrication of soilless medium for crop/ flower production. Economical evaluation of automated irrigation system and soilless medium for crop/flower production.

VII. Learning outcome

The students will able to understand the concept of soilless farming including nutrient management, water content and water potential in soilless media along with automation for climate control under protected cultivation.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Significance of soilless culture in agriculture	1
2.	Functions of the root systems	1
3.	Response of root growth to local nutrient concentrations	2
4.	Interactions between environmental conditions and form of N nutrition	2
5.	Roots as source and sink for organic compounds and plant hormones	2
6.	Physical and chemical properties of soilless media	2
7.	Water content and water potential in soilless media	2
8.	Water movement in soilless media: water retained, drainage, plant use, etc	2
9.	Uptake of water by plants in soilless media and water availability	3
10.	Production technology for vegetables under protected conditions in soil and soilless media	4
11.	Automation for climate control in protected structures	3
12.	Thermal modeling of greenhouse environment using multiple regressions	2
13.	Thermal modeling of greenhouse environment using energy and mass balance approaches	4
Total		**30**

IX. List of Practicals

S. No.	Topic	No. of Practicals
1	To study the filter types and their selection criteria	1
2	Design and installation of drip irrigation system for vegetables	1
3	Design and installation of drip irrigation system for orchards	1
4	Irrigation and fertigation scheduling for vegetables and horticultural crops	1
5	Study of different types of sensors, relay and control mechanism for controlled irrigation and fertigation	1
6	Design of automated system for irrigation and fertigation	1
7	Design and installation of different protected structures as per guidelines of NHM	6
8	Design and fabrication of soilless medium for vegetable crops	1
9	Design and fabrication of soilless medium for flower production	1
10	Economical evaluation of automated irrigation system and soilless medium for crop/flower production	1
Total		**15**

X. Suggested Reading

- Howard M Resh. *Hydroponic Food Production.* CRC Press, New York.
- Michael Raviv and Heinrich J Lieth 2014. *Soilless Culture*. CRC Press.

• Meier Schwarz. *Soilless Culture Management.* Springer publications, New York.

I. **Course Title : Design of Drip and Sprinkler Irrigation Systems**

II. **Course Code : IDE 505**

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

IV. **Aim of the course**

To provide eXposure of new cutting-edge technologies to the students in design of drip and sprinkler irrigation systems including selection of pipe and fertigation techniques.

V. **Theory**

Unit I

Suitability of sprinkler and drip irrigation systems under Indian conditions. Basic hydraulics of sprinkler and micro irrigation system.

Unit II

Pipe flow analysis. Friction losses and pressure variation. Flow in nozzles and emitters.

Unit III

Design and evaluation of sprinkler and micro irrigation systems in relation to source, soil, climate and topographical conditions.

Unit IV

Selection of pipe size, pumps and power units. Layout, distribution, efficiency and economics.

Unit V

Fertigation through sprinkler and micro irrigation systems. Fertigation techniques involved in drip and sprinkler irrigation system.

VI. **Practical**

Design of drip and sprinkler irrigation system. Calculation of total head. Determination of uniformity of sprinkler discharge at field. Numerical on hydraulics of dripper. Calculation of different types of efficiencies of installed drip system. Calculation of cost benefits of drip and sprinkler irrigation system.

VII. **Learning outcome**

Students will understand design aspects of various drip and sprinkler irrigation

VIII. **Lecture Schedule**

S.No.	Topic	No. of lectures
1	Plant-soil-atmosphere relationships	3
2	Evapotranspiration, methods for estimation of evapotranspiration, Irrigation water requirements, Irrigation principles, Numerical Problems	2
3	Drip irrigation, adaptability, limitations, components and classification of systems	2
4	Pipe flow analysis, types of friction losses in main, sub-main and lateral, pressure variation in drip irrigation system and their calculations	2
5	Design of drip irrigation system based on source of irrigation, soil, climate and topographical conditions and hydraulics of drip components with numerical problems	3
6	Selection of pipe, pump and power unit	2
7	Fertigation: advantages, limitations, methods, fertilizers solubility and their compatibility, precautions, frequency, duration and injection rate,	2

	Emitter clogging and prevention	
8	Performance evaluation of drip irrigation system	1
9	Sprinkler irrigation, adaptability, limitations, components and classification of systems	2
10	Pipe flow analysis, types of friction losses, pressure variation in sprinkler irrigation system and their calculations	2
11	Flow in nozzles, drop size distribution, spray evaporation	1
12	Hydraulic and engineering design of sprinkler irrigation system on source of irrigation, soil, climate and topographical conditions, numerical problems	3
13	Fertigation techniques in sprinkler irrigation	1
14	Selection of pipe, pump and power unit	2
15	Performance evaluation of sprinkler irrigation system	1
16	Irrigation scheduling techniques and automation in drip and sprinkler irrigation system	2
17	Benefit cost ratio of drip and sprinkler irrigation system	1
	Total	**32**

IX. List of Practicals

S.No.	**Topic**	**No. of Practicals**
1.	Study of different components of drip and sprinkler irrigation system	1
2.	Determination of physical properties of soil	1
3.	Design of drip irrigation system for orchards	1
4.	Design of micro-irrigation system for row crops	1
5.	Design of sprinkler irrigation system for vegetable crops	1
6.	Design of sprinkler irrigation system for field crops	1
7.	Estimation of total head in drip and sprinkler irrigation system	1
8.	Determination of filtration efficiency of different filters	1
9.	Evaluation of drip irrigation system	1
10.	Determination of uniformity of sprinkler discharge at field	1
11.	Study of hydraulics of drippers	1
12.	Estimation of fertigation rate in drip irrigation system	1
13.	Calculation of different types of efficiencies of installed drip system	1

14.	Study of Automation in micro-irrigation system	1
15.	Calculation of cost benefits of drip irrigation system	1
16.	Calculation of cost benefits of sprinkler irrigation system	1
	Total	**16**

X. Suggested Reading

- Jensen ME. (Editor). 1983. *Design and Operation of Farm Irrigation Systems*. ASAE, Monograph No. 3. USA.
- James LG. 1988. *Principles of Farm Irrigation System Design.* John Wiley and Sons, New York, USA.
- Michael AM. 2006. *Irrigation Theory and Practice*. Vikas Publ. New Delhi.
- Withers Bruce and Vipond Stanley. 1974. *Irrigation: Design and Practice.* B.T. Batsford Ltd, London.
- Sivanappan RK. 1987. *Sprinkler Irrigation*. OXford and IBH Publishing Co. New Delhi.

I. Course Title : Ground Water Engineering

II. Course Code : IDE 506

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.

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

List of Practicals

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

Suggested Readings

- 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 : 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. Geodatabase models: Hierarchical, network, relational, object-oriented models. Integrated GIS database. Common sources of error. Data quality: Macro, micro and Usage level components, Meta data. Spatial data transfer standards.

Unit IV

Thematic mapping. Measurement in GIS: Length, perimeter and areas. Query analysis. Reclassification, Buffering and Neighbourhood functions. Map overlay: Vector and raster overlay. Interpolation and network analysis. Digital elevation modelling. Analytical Hierarchy Process. Object oriented GIS, AM/FM/GIS andWeb 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 change analysis. Performance evaluation of irrigation commands. Site selection forartificial

recharge. Reservoir sedimentation. Familiarization with the remote sensing instruments and satellite imagery. Aerial Photograph and scale determination with stereoscope. Interpretation of satellite imagery and aerial photograph. 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

The student will be able to use satellite remote sensing to perform image analysis and classification for developing thematic maps and also able to integrate satellite data with GIS to undertake recourse mapping and lanning studies.

VIII. Lecture Schedule

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

IX. List of Practicals

S.No.	Topic	No. of Practicals

1	Familiarization with the remote sensing instruments and satellite imagery	1
2.	Methods of establishing ground truth survey and Comparison between	2
	ground truth and remotely sensed data	1
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 and polygon features	2
10	SRTM and CARTO DEM download from web and Georeferencing of an image	1
11	Delineation of Watershed, DEM generation: slope, Aspect, flow direction, Flow accumulation, Drainage, network and morphometric analysis	1
12	LULC by supervised classification and LULC by unsupervised Classification	1
13	Application of Remote Sensing data and GIS for water quality parameters Temporal satellite data analysis for vegetation condition, crop water	1
14	Erosion mapping using aerial and satellite Data	1
Total		**17**

X. Suggested Reading

- Charles Elach and Jakob van Zyl. 2006. *Introduction to the Physics and Techniques of Remote Sensing*. John Wiley & Sons publications.
- Ian Heywood Sarah, Cornelius and Steve Carver. 2002. *An Introduction to Geographical Information Systems.* Pearson Education. New Delhi.
- James B Campbell and Randolph H Wynne. 2011. *Introduction to Remote Sensing*. TheGuilford Press.
- Lillesand TM and Kiefer RW. 2008. *Remote Sensing and Image Interpretation*. John Wiely and Sons.
- Paul Curran PJ. 1985. *Principles of Remote Sensing*. ELBS Publications.
- Rees WG. 2001. *Physical Principles of Remote Sensing*. Cambridge University Press.
- Thanappan Subash. 2011. *Geographical Information System*. Lambert Academic Publishing.

I. Course Title : Waste Water Management and Utilization in Agriculture

II. Course Code : IDE 508

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint students about status of waste water and water quality requirements, standards both for domestic and irrigation purposes and also to provide in depth knowledge of waste water treatment methods and utilization in agriculture.

V. TheoryUnit I

Status of wastewater in India. Sources of contamination and characterization of urban and rural wastewater for irrigation. Water quality: Physical, chemical and biological parameters of wastewater.

Water quality requirement: Potable water standards, wastewater effluent standards, water quality indices. Irrigation water quality standards and guidelines for their restricted and

unrestricted uses. Selection of appropriate forestry trees, fruits, vegetables, oilseeds and food grain crop for wastewater utilization.

Unit III

Control measures for preventing soil and other surface/groundwater source contamination. Different types of wastewater, pollutants and contaminants. Impactof wastewater on ecosystem, eutrophication, biomagnification, water borne diseases.

Unit IV

Wastewater treatment methods: Physical, chemical and biological. General water treatments: Wastewater recycling, constructed wetlands, reed bed system. Carbon foot prints of wastewater reuse. Environmental standards.

Unit V

Regulation and environmental impact assessment (EIA): Environmental standards - CPCB Norms for discharging industrial effluents to public sewers. Stages of EIA-Monitoring and Auditing. Environmental clearance procedure in India.

VI. Practical

Measurement of water quality indices in the lab. Field demonstration of impact of waste water on eco-system and human health. Waste water treatment methods and effect of waste water in contamination of ground water. Visit of waste water treatment plant near by area.

VII. Learning outcome

The students will be able to understand sources and treatment methods of waste water quality with standard norms of water quality for domestic and irrigation purposes and also be eXposed to waste water recycling and environmental standards.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Status of wastewater in India, Sources of contamination and characterization of urban and rural wastewater for irrigation	2
2.	Water quality: Physical, chemical and biological parameters of wastewater	2
3.	Wastewater quality requirement: Potable water standards, wastewater effluent standards, water quality indices. Irrigation water quality standards both national and global and guidelines for their restricted and unrestricted uses.	2
4.	Different types of wastewater, pollutants and contaminants.	1
5.	Impact of wastewater on ecosystem, eutrophication, biomagnification, water borne diseases.	2
6.	Key drivers of wastewater use in agriculture and eXisting approaches for regulating wastewater reuse in agriculture	2
7.	Selection of appropriate forestry trees, fruits, vegetables, oilseeds and food grain crop for wastewater utilization and practices used for irrigation	3
8.	Health Risks Associated with the Use of Wastewater for Irrigation	1
9.	Wastewater treatment methods: Physical, chemical and biological.	3
10.	Choice of (Cost-Effective) Wastewater Treatment Systems for Irrigation	2
11.	General water treatments: Wastewater recycling, constructed wetlands, reed bed system.	2

12.	Carbon foot prints of wastewater reuse. Environmental standards.	2
13.	Management of health and environmental risks of wastewater irrigation	1
14.	Regulation and environmental impact assessment (EIA): Environmental standards-CPCB Norms for discharging industrial effluents to public sewers. Valuation of environmental impacts.	3
15.	Impact on groundwater resources and soil health, EIA process, Stages of EIA-monitoring and auditing. Environmental clearance procedure in India	3
16.	Economics of wastewater irrigation	1
Total		**32**

IX. 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**

X. Suggested Reading

- Charis Michel Galanakis. *Sustainable Water and Wastewater Processing.* Elsevier Publication, Amsterdam.
- Sean X Liu. 2014. *Food and Agricultural Wastewater Utilization and Treatment*. Wileu Blackwell New York.
- Shirish H, Sonawane Y, Pydi Setty T, Bala Narsaiah and S Srinu Naik. 2017. *Innovative Technologies for the Treatment of Industrial Wastewater: A Sustainable Approach*. CRC Press.
- Stuetz Richard. *Principles of Water and Wastewater Treatment Processes* (*Water and Wastewater Process Technologies*). IWA Publishing.
- Syed R Qasim and Guang Zhu. 2018. *Wastewater Treatment and Reuse: Theory and Design Examples*. CRC Press.

I. Course Title : Water Conveyance and Distribution

II. Course Code : IDE 509

III. Credit Hours : 2+1

IV. Aim of the course

To develop the common understanding of different conveyance structure in irrigation

network and provide knowledge of various flow and their computations including sediment transport in channels.

V. Theory

Unit I

Channel characteristics. Prismatic and non-prismatic channel. Steady, unsteady, uniform and non-uniform flow. Open channel and their properties. Energy and momentum, critical flow computation and application. Basic Concepts of free surface flow, classification of flow, velocity and pressure distribution.

Unit II

Uniform flow, conservation laws and specific energy. Application of momentum and energy equation. Channel transition. Study of critical flow, uniform flow, gradually varied flow, rapid varied flow, spatially varied flow and unsteady flow and their computations.

Unit III

Energy dissipation. Flow control structures and flow measurement. Theories and methods of open channel design.

Unit IV

Sediment transport in channels. Regime flow theories. Tractive force theory. Design of stable channels.

Unit V

Basic principles of pipe flow, pipe flow problems and equivalent pipe. Principles of network synthesis. Pipe network analysis. Water transmission lines. Cost considerations: Single-Input source. Branched systems: Single-Input source. Looped Systems: Multi-Input source. Branched systems: Multi-Input source, Looped systems. Decomposition of a large water system and optimal zone size.

VI. Practical

Computation and use of geometrical and hydraulic elements of open channel. Use of flow measuring devices and methods and their limitations. EXamination of velocity distribution and calculation of energy and momentum coefficients. Solution of channel design problems. Appraisal of flow control and distribution structures. Analysis and computation of flow profiles.

VII. Learning outcome

The student will be able to infuse the knowledge about different types of channel flow and their behavior and also able to gain the knowledge of appraisal of flow control and distribution structures including design of stable channel.

S. No.	Topic	No. of Lectures
1	Channel characteristics. Prismatic and non-prismatic channel	1
2	Steady, unsteady, uniform and non-uniform flow	1
3	Open channel and their properties	2
4	Energy and momentum, critical flow computation and application	2
5	Basic Concepts of free surface flow, classification of flow, velocity and pressure distribution	2
6	Uniform flow, conservation laws and specific energy	2
7	Application of momentum and energy equation	1
8	Channel transition	1
9	Study of critical flow, uniform flow, gradually varied flow, rapid varied flow	2

10	Spatially varied flow and unsteady flow and their computations	2
11	Energy dissipation	1
12	Flow control structures and flow measurement	1
13	Theories and methods of open channel design	2
14	Sediment transport in channels	1
15	Regime flow theories	1
16	Tractive force theory	1
17	Design of stable channels	1
18	Basic principles of pipe flow, pipe flow problems and equivalent pipe	1
19	Principles of network synthesis. Pipe network analysis	1
20	Water transmission lines. Cost considerations: Single-Input source. Branched systems: Single-Input source	2
21	Looped Systems: Multi-Input source. Branched systems: Multi-Input source, Looped systems	2
22	Analysis and computation of flow profiles	2
Total		**32**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Computation and use of geometrical and hydraulic elements of open channel	2
2.	Study of Flow measuring devices,methods and their limitations	2
3.	EXamination of velocity distribution	2
4.	Calculation of energy and momentum coefficients	2
5.	Channel design: problems and its solution	3
6.	Appraisal of flow control and distribution structures	2
7.	Analysis and computation of flow profiles	3
Total		**16**

X. Suggested Reading

- Chaudhry MH. 1993. *Open Channel Flow*. Prentice-Hall, NJ.
- Chow VT. 1979. *Open Channel Hydraulics*. McGraw Hill Inc. N York.
- French RH. 1986. *Open Channel Hydraulics*. McGraw Hill Pub Co., N York
- Henderson FM. 1966. *Open Channel Flow*. Macmillan Co. New York.
- Prabhata K Swamee and Ashok K Sharma. *Design of Water Supply Pipe Networks*. John Wiley New York.
- Subramanya K. 2008. *Flow in Open Channels*. Tata McGraw Hill Pub.
- Terry Sturm. 2011. *Open Channel Hydraulics.* Tata McGraw Hill Pub.

I. Course Title : Minor Irrigation

II. Course Code : IDE 510

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint students about the need and scope of minor irrigation in India. To provide in-depth knowledge in design and operation of surface and groundwater- based irrigation practices.

Unit I

Definition, scope, historical background and progress in minor irrigation works in India, Assessment of surface water resource. Design and operation of surface water storage structures.

Unit II

Evaporation and seepage control. Groundwater development methods and their scope. Groundwater eXtraction devices and methods. Aquifer characteristic and their evaluation. Wells in alluvial and rocky aquifers.

Unit III

Well interference, spacing and multiple well point system for controlled groundwater pumping. Safe yield from wells. Augmentation of well yield through pumping and recovery time management.

Unit IV

Well design, drilling and construction. Tube well strainers, gravel packing and resistance to flow. Pumps and prime movers for groundwater lifting. Diagnosis of sick and failed wells and their remediation.

Unit V

Conjunctive use of surface and groundwater. Legislation for groundwater development and management. Groundwater recharge and its use.

V. Practical

Measurement of seepage loss from reservoirs. Estimation of inflow to surface reservoir. Measurement of evaporation loss from surface reservoirs. Pumping test and determination of aquifer parameters. Establishment of draw down-discharge characteristic. Well log analysis and deciding on length and placement of strainers. Computation of well interference and deciding on well spacing. Estimation of irrigation for given discharge from well. Estimating pumping cost for irrigation. Analysis of ground water quality. Problems on well design.

VI. Learning outcome

The students will be able to understand minor irrigation practices and their importance in Indian agriculture. They will also eXpose to conjunctive use of surface and groundwater and able to perform groundwater development legislation, recharge and utilization practices.

VII. Lecture Schedule

S. No.	Topic	No. of Lectures
1	Definition and scope of minor irrigation works in India	1
2	Historical background and progress in minor irrigation works in India	2
3	Assessment of surface water resource	1
4	Design and operation of surface water storage structures	2
5	Evaporation and seepage control	1
6	Groundwater development methods and their scope	2
7	Groundwater extraction devices and methods	1
8	Aquifer characteristic and their evaluation	2
9	Wells in alluvial and rocky aquifers	1
10	Well interference	2
11	Spacing and multiple well point system for controlled groundwater pumping	2
12	Safe yield from wells	1
13	Augmentation of well yield through pumping and recovery time management	2
14	Well design, drilling and construction	2
15	Tube well strainers	1

16	Gravel packing and resistance to flow	2
17	Pumps and prime movers for groundwater lifting	2
18	Diagnosis of sick and failed wells and their remediation	1
19	Conjunctive use of surface and groundwater	1
20	Legislation for groundwater development and management	1
21	Groundwater recharge and its use	2
Total		**32**

VIII. List of Practicals

S.No.	Topic	No. of Practicals
1.	Measurement of seepage loss from reservoirs	1
2.	Estimation of inflow to surface reservoir	2
3.	Measurement of evaporation loss from surface reservoirs	1
4.	Pumping test and determination of aquifer parameters	2
5.	Establishment of draw down-discharge characteristic	2
6.	Well log analysis and deciding on length and placement of strainers	2
7.	Computation of well interference and deciding on well spacing	2
8.	Estimation of irrigation for given discharge from well	1
9.	Estimating pumping cost for irrigation	1
10.	Analysis of ground water quality	1
11.	Problems on well design	1
Total		**16**

IX. Suggested Reading

- Garg SK. 1987. *Irrigation Engineering and Hydraulic Structures*. Khanna Publisher, Delhi.
- Garg SK. 1987. *Hydrology and Water Resource Engineering.* Khanna Publishers, Delhi.
- Michael AM. 2006. *Irrigation Theory and Practice*. Vikas Publications, New Delhi.
- Sharma RK. 1987. *Hydrology and Water Resources Engineering*. Dhanpat Rai and Sons, New Delhi.
- Subramanian K. 1993. *Engineering Hydrology*. Tata Mc-Graw-Hill Co. New Delhi.

I. Course Title : Design of Pumps for Irrigation and Drainage

II. Course Code : IDE 511

III. Credit Hours : 2+0

IV. Aim of the course

To acquaint students about basic hydraulic design of various pumps, energy requirement in pumping, solar photovoltaic system and solar pump including design of pumping station.

V. Theory

Unit I

Basic hydraulic design of centrifugal pump. Net positive suction head and cavitation, vapour pressure, water hammering problem in centrifugal pump.

Unit II

Principles and design of pumping systems for agricultural drainage. Selection and performance of characteristics of centrifugal pump, vertical turbine pump, submersible pump and axial flow pump.

Unit III

Multiple well point system and their design. Energy requirement in groundwater pumping.

Unit IV

Non-conventional energy sources for pumping, wind mills, micro turbines, solar pumps. Hydraulic ram: Selection and design criteria. Solar photovoltaic system.

Unit V

Design of pumping station. Techno-economic evaluation. Efficient pumping system operation, flow control strategies and conservation measures for pumping systems.

VI. Learning outcome

The students will be able to select the pump for desired discharge to be pumped from particular water source by developing pump characteristics curve, able to analyze the flow in different types of pump and also able to design the pumping station for managing the irrigation and drainage system.

VII. Lecture Schedule

S. No.	Topic	No. of Lectures
1	Different types of pumps used under different conditions	1
2	Principal and working of centrifugal pump	1
3	Basic hydraulic design of centrifugal pump	1
4	Net positive suction head and cavitation, vapour pressure, water hammering problem in centrifugal pump	3
5	Use of pumpsets for agricultural drainage under different conditions.	1
6	Principles and design of pumping systems for agricultural drainage.	2
7	Selection and performance of characteristics of centrifugal and vertical turbine pump	2
8	Flow pattern in turbine pumps	1
9	Selection and performance of characteristics of vertical submersible pump	2
10	Flow pattern in submersible pumps	1
11	Visit to Pumping Industry	5
12	Use of Multiple well point/skimming well point system under different conditions and its design	1
13	Energy requirement and efficiency for Multiple well point/skimming well point system	1
14	Introduction and use of Non-conventional energy sources for pumping	1
15	Selection and design criteria for Solar photovoltaic system	2
16	Selection and design criteria for wind mills, micro turbines, solar pumps. Hydraulic ram	3
17	Introduction to pumping station and its components & design	1
18	Techno-economic design evaluation in pumping sets	1
19	Energy conservation measures under different pumping units under different flow conditions	2
Total		**32**

VIII. Suggested Reading

- Bansal RK. 1990. *A Text Book of Fluid Mechanics and Hydraulic Machines*. LaXmi Publications, New Delhi.
- Church AH and Jagdish Lal. 1973. *Centrifugal Pumps and Blowers*. Metropolitan Book Co. Pvt. Ltd. Delhi.

- Luthin JN. 1966. *Drainage Engineering*. Wiley and Sons. New York, USA.
- Michael AM and Khepar SD. 1989. *Water Wells and Pump Engineering*. Tata McGraw Hill Publishing Co., New Delhi.

I. Course Title : Crop Environmental Engineering

II. Course Code : IDE 512

III. Credit Hours : 2+0

IV. Aim of the course

To develop the common understanding aerial and edaphic environments for plant growth, energy and mass transfer which help to maximizing the crop yield. To understand the basic interface of soil and root and its characteristics.

V. Theory

Unit I

Principles of heat, mass and momentum transport. Transport of radiant energy, radiation environment, micro climatology of radiation. Micrometeorology: Turbulent transfer profiles and fluxes. Interpretation of flux measurement. Laws of electromagnetic radiation, its measurement and estimation.

Unit II

Profile balance of heat, mass and momentum in and above crop communities. Climatic changes and plant response to environmental stresses. Measurement and estimation of potential evapotranspiration on point and regional scale.

Unit III

Root anatomy, water flow in roots and root density models (microscopic and macroscopic). Stem anatomy and pressure volume curves. Methods of measuring water status in plants. Estimating ET using three temperature model and MODIS algorithm. Soil–Plant–Atmosphere system: Basic properties. Dynamics of water movement. ET-yield relations.

Unit IV

Principles of optimal scheduling of irrigation and seasonal allocation of limiting water supplies using LP and DP. Seasonal and dated production functions. Crop yield modelling and condition assessment. Instrumentation and techniques for monitoring plant environments. Design and operation of controlled environment facilities and their instrumentation. Climatic changes and plant response to environmental stresses. Evapotranspiration models.

VI. Learning outcome

The students will be able to identify climatic changes on plant and how plant responds to environmental stresses and evapotranspiration. The students will be exposed for design and operation of controlled environment facilities and crop yield modeling.

VII. Lecture Schedule

S. No.	Topic	No. of Lectures
1	Principles of heat, mass and momentum transport	2
2	Transport of radiant energy radiation environment, micro climatology of radiation	2
3	Micrometeorology: Turbulent transfer profiles and fluxes. Interpretation of flux measurement	1
4	Laws of electromagnetic radiation, its measurement and estimation	1
5	Profile balance of heat, mass and momentum in and above crop Communities	1
6	Climatic changes and plant response to environmental stresses	1

7	Measurement and estimation of potential evapotranspiration on point and regional scale	1
8	Root anatomy, water flow in roots and root density models (microscopic and macroscopic)	1
9	Stem anatomy and pressure volume curves	1
10	Methods of measuring water status in plants	1
11	Estimating ET using three temperature model and MODIS algorithm	2
12	Soil–Plant–Atmosphere system: Basic properties	1
13	Dynamics of water movement	1
14	ET-yield relations	2
15	Principles of optimal scheduling of irrigation	1
16	Seasonal allocation of limiting water supplies using LP and DP	2
17	Seasonal and dated production functions	2
18	Crop yield modelling and condition assessment	2
19	Instrumentation and techniques for monitoring plant environments	2
20	Design and operation of controlled environment facilities and their Instrumentation	2
21	Climatic changes and plant response to environmental stresses	1
21	Evapotranspiration models	2
Total		**32**

VIII. Suggested Reading

- Abtew W and Melese A. 2017. *Evaporation and Evapotranspiration: Measurements and Estimations*. Springer Publications.
- Campbell GS and Norman JM. *An Introduction to Environmental Biophysics*. Springer Publication New York.
- Ghildyal BP and Tripathy RP. 1987. *Fundamental of Soil Physics.* Wiley Eastern.
- Monteith JL and Unsworth MH. *Principles of Environmental Physics*. Elsevier, Amsterdam.
- Slatyor O P 1967. *Plant Water Relationship*. Academic Press.
- Yang Y. *Evapotranspiration over Heterogeneous surfaces: Models and Applications.* Springer Publications.

I. Course Title : Water Resources Systems Engineering

II. Course Code : IDE 513

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 programming	5
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*.

I. Course Title : Irrigation Economics Planning and Management

II. Course Code : IDE 514

III. Credit Hours : 2+0

IV. Aim of the course

To impart knowledge of various public and government policy on regulation and allocation of irrigation water, cost and benefit analysis including project evaluation, decision making process and risk analysis.

V. Theory Unit I

Economic analysis. Problems in project selection. Methods and approaches to water pricing. Criteria for investment and pricing in irrigation projects. Social benefits, problems and causes of under-utilization. Mathematics of economic analysis. Cost allocation, separable and non-separable costs. Discounting factors and techniques. Determination of benefits, cost and benefit analysis. Project evaluation. Limitations of benefit-cost analysis. Dynamics of project analysis.

Unit II

Role of financial analysis. Distinctions from economic analysis. Financial feasibilityand analysis. Impact of public policies on regulation and allocation of irrigation water. Relative economic efficiency of alternative irrigation water management models. Irrigation system improvement by simulation and optimization to enhance irrigation water use efficiency.

Unit III

Indian agriculture, main problems, population, government policies, systems, organizing agriculture production. Farm Management: Definition, importance, scope, relation with other sciences and its characteristics.

Unit IV

Socio-economic survey. Importance of such survey in planning, implementation and evaluation of project performance. Planning of socio-economic survey, types ofdata sets to be collected, preparing the questionnaires form, schedules sampling, editing and scrutinizing of secondary data, classification and analysis of data.

Unit V

Role of farm management principles in decision making for irrigated agriculture. Decision making process, assessing risk and uncertainty in planning.

VI. Learning outcome

The students will be able to estimate the cost benefit analysis, pricing and investment criteria on irrigation project evaluation and finding their problems.

The students will also expose to conduct socio-economic survey and analyse secondary data

VII. Lecture Schedule

S. No.	Topic	No. of Lectures
1	Economic analysis, problems in project selection	1

2	Methods and approaches to water pricing	1
3	Criteria for investment and pricing in irrigation projects	1
4	Social benefits, problems and causes of under-utilization	1
5	Mathematics of economic analysis	1
6	Cost allocation, separable and non-separable costs	1
7	Cost allocation, separable and non-separable costs	1
8	Determination of benefits and limitations of cost-benefit analysis	1
9	Project evaluation	1
10	Dynamics of project analysis	1
11	Role of financial analysis	1
12	Distinctions from economic analysis	1
13	Financial feasibility and analysis	1
14	Impact of public policies on regulation and allocation of irrigation water	1
15	Relative economic efficiency of alternative irrigation water management models	2
16	Irrigation system improvement by simulation and optimization to enhance irrigation water use efficiency	2
17	Indian agriculture, main problems, population, government policies, systems, organizing agriculture production	2
18	Farm Management: Definition, importance, scope, relation with other sciences and its characteristics	2
19	Socio-economic survey: Importance of survey in planning, implementation and evaluation of project performance	**2**
20	Planning of socio-economic survey, types of data sets to be collected, preparing the questionnaires form, schedules sampling, editing and scrutinizing of secondary data	2
21	Classification and analysis of data	1
22	Role of farm management principles in decision making for irrigated agriculture	2
23	Decision making process	1
24	Assessing risk and uncertainty in planning	2
Total		**32**

VIII. Suggested Reading

- Heady, Early Orel, HeXem R and Roger W. 1978. Water Production Functions for Irrigated Agriculture.
- James Douglas and Lee Rober R. 1995. Economics of Water Resource Planning. Tata Mcgraw-Hill Publication Company Ltd, Bombay, New Delhi.
- Joshi SS and TR Kapoor. 2001. Fundamentals of Farm Business Management. Kalyani Publishers, Ludhiana.
- Management of Water Project-Decision Making and Investment Appraisal. OXford Publication Co.
- Sharma VK. 1985. Water Resource Planning and Management. Himalaya Publication House, New Delhi.

I. **Course Title : Sensing and Automation in Irrigation Systems**

II. **Course Code : IDE 515**

III. **Credit Hours : 3+0**

IV. **Aim of the course**

To acquaint students about the concept of sensing and automation in irrigation system, wireless sensor network and digital signal processor. To provide knowledge of surface irrigation automation.

V. **Theory**

Unit I

Sensing and sensors. Sensor classifications. Wireless sensor networks. History of wireless sensor networks (WSN). Communication in a WSN. Important design constraints of a WSN like Energy, self management, wireless networking, decentralized management, design constraints, security etc.

Unit II

Node architecture. Sensing subsystem. Analog-to-Digital converter. The processor subsystem, architectural overview, microcontroller, digital signal processor, application-specific integrated circuit, field programmable gate array (FPGA). Communication interfaces, serial peripheral interface, inter-integrated circuit, the IMote node architecture, The XYZ node architecture, the Hogthrob node architecture.

Unit -IV

Applications in surface irrigation automation, automation based on volume, time, fertigation scheduling, water logging, salinity, oxygen diffusion systems, etc.

VI. **Learning outcome**

The students will be able to understand concept of automation in irrigation system which is quite important to enhance water use efficiency and also able to understand Node architecture and other routing protocols.

VII. **Lecture Schedule**

S. No.	Topic	No. of Lectures
1	Sensing and sensors	2
2	Sensor classifications	2
3	History of wireless sensor networks (WSN) and Wireless sensor networks	3
4	Communication in a WSN	1
5	Important design constraints of a WSN like Energy, self-management, wireless networking, decentralized management, design constraints, security etc	3
6	Node architecture	1
7	Sensing subsystem	1
8	Analog-to-Digital converter	2
9	The processor subsystem	1
10	Architectural overview	1
11	Microcontroller	2
12	Digital signal processor	2
13	Application-specific integrated circuit	2
14	Field programmable gate array (FPGA)	2
15	Communication interfaces	2

16	Serial peripheral interface	3
17	Inter-integrated circuit	2
18	The IMote node architecture	2
19	The XYZ node architecture	2
20	The Hogthrob node architecture	2
21	Applications in surface irrigation automation	3
22	Automation based on volume, time, fertigation scheduling, water logging, salinity, oxygen diffusion systems, etc	4
Total		**45**

VIII. Suggested Reading

- Cauligi S Raghavendra, Krishna M Sivalingam and Taieb Znati. *Wireless Sensor Networks.* Springer.
- Edgar H, Callaway Jr. and Edgar H Callaway. *Wireless Sensor Networks: Architectures and Protocols.*
- Holger Karl and Andreas Willig. *Protocols and Architectures for Wireless Sensor Networks.* John Wiley & Sons.
- Waltenegus Dargie and Christian Poellabauer. *Fundamentals of Wireless Sensor Networks:* Theory and Practice. A John Wiley and Sons, Ltd, Publication.

I. Course Title : Open Channel Flow

II. Course Code : IDE 516

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 phenophenon, 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**

VI. 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 : Applied Watershed Hydrology

II. Course Code : IDE 517

III. Credit Hours : 2+1

IV. Aim of the course

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

V. Theory Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

VI. Practical

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

VII. Learning outcome

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

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Hydrology in water resources planning, 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. *Environmental Hydrology*. Springer, New York.