

# Irrigation and Drainage Engineering Department

## Old Syllabus of IDE Dept-

IDE 231

Fluid mechanics

3=2+1

### Syllabus:

Properties of fluids: Ideal and real fluid. Pressure and its measurement, Pascal's law, pressure forces on plane and curved surfaces, centre of pressure, buoyancy, metacentre and metacentric height, condition of floatation and stability of submerged and floating bodies; Kinematics of fluid flow: Lagrangian and Eulerian description of fluid motion, continuity equation, path lines, streak lines and stream lines, stream function, velocity potential and flow net. Types of fluid flow, translation, rotation, circulation and vorticity, Vortex motion; Dynamics of fluid flow, Bernoulli's theorem, venturimeter, orifice-meter and nozzle, siphon; Flow through notches, weirs and open channel; Laminar flow: Stress-strain relationships, flow between infinite parallel plates - both plates fixed, one plate moving, discharge, average velocity, shear stress and pressure gradient; Laminar and turbulent flow in pipes, general equation for head loss-Darcy, Equation, Moody's diagram, Minor and major hydraulic losses through pipes and fittings, flow through network of pipes, hydraulic gradient and energy gradient, power transmission through pipe; Dimensional analysis and similitude: Rayleigh's method and Buckingham's 'Pi' theorem, types of similarities, dimensional analysis, dimensionless numbers. Introduction to fluid machinery.

### Lesson plan:

Lecture No.	Topics	Article no.	Page no.	Book
1	<b>Properties of fluids:</b> Introduction, properties of fluid like mass density, specific weight, specific volume, specific gravity, viscosity, types of fluids,	1.1, 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.3, 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.5	1-8	1
2	Compressibility, surface tension, and capillarity	1.5, 1.6,	22-25	1
3.	<b>Pressure and its measurement :</b> fluid pressure at point, Pascal's law, absolute, gauge, atmospheric and vacuum pressure	2.1, 2.2, 2.4,	32-33 38-39	1
4,5,6,7	<b>Measurement of pressure:</b> <b>Simple manometers:</b> piezometer, U-tube manometer, single column manometer, <b>Differential manometers:</b> U-tube differential manometers, Inverted U-tube differential manometer, Mechanical gauges	2.5, 2.6, 2.7, 2.6	39-48 70-72	1 2
8,9,10	<b>Pressure forces on plane and curved surfaces:</b> Introduction, total pressure and center of			

Chapter Hydrostatic forces on surfaces

	pressure, vertical plane surface submerged in liquid, horizontal plane surface submerged in liquid, inclined plane surface submerged in liquid, curved surface sub-merged in liquid.	3.1, 3.2, 3.3, 3.4, 3.5, 3.6	65-67, 81-83, 90-92	1
11,12	<b>Buoyancy and Floatation:</b> Introduction, buoyancy, center of buoyancy, meta- center, metacentric height , analytical method for metacentric height	4.1, 4.2, 4.3, 4.4, 4.5, 4.6	110-111 114-117	1
13	Condition of floatation and stability of submerged and floating bodies	4.7	121-122	1
14	<b>Kinematics of fluid flow:</b> Introduction, methods of describing fluid motion, types of fluid flow, continuity equation, continuity equation in three-dimensions ,	5.1, 5.2, 5.3, 5.4, 5.5, 5.6.	139-141, 145-146	1
15	<b>Description of the flow pattern:</b> Path lines, streak lines and <u>stream lines</u> ,stream tube	6.4	245-248	2
	Rotational and irrotational flow and circulations and vorticity	6.8 6.9	266-267 269-270	2
	Velocity potential	6.10	271-272	2
	Stream function	6.11	273-275	2
	Equipotential lines and flow net	6.12	275-277	2
16	<b>Dynamics of flow :</b> Introduction, equations of motion, Euler's equation of motion. Assumptions , Bernoulli's equation for real fluid ,	6.1,6.2, 6.3,6.5, 6.6, 6.7	233-235 239	1
17	Venturimeter, Practical applications of Bernoulli's equations <u>Orifice meter</u> , Nozzle (Pitot-tube) Siphon	6.7.1 6.7.2 6.7.3 11.15	241-243, 253-255, 257-258, 528-530	1  2
18,19, 20	<b>Flow through notches, weirs:</b> Introduction, classification of notches and weirs, Discharge over a rectangular notch or weir <u>Discharge</u> over a triangular notch or weir Discharge over a trapezoidal notch or weir Discharge over a stepped notch Advantages of triangular notch or weir over rectangular notch or weir	8.1, 8.2 8.3 8.4 8.6 8.7 8.5	319-320  320 321 325-326 326 324-325	1  1 1 1 1 1
21	<b>Flow through orifices and Mouth pieces:</b> Introduction, classifications of orifices, classifications of mouthpiece Flow through an orifice Hydraulic coefficients Flow through an external cylindrical mouthpieces	7.1, 7.2, 7.12  7.3 7.4 7.13	285 & 306 285-286 286-287 306-307	1  1 1 1

22	<b>Flow in open channels:</b>			1
	Introduction, classification of flow in channels	16.1, 16.2	664-665	
	Discharge through open channel by Chezy's formula and Manning's formula	16.3 16.4.3	666-667 672	1
	Most economical section of channel	16.5, 16.5.1 16.5.2, 16.5.3	675-676 678-680 688-689	1
23,24	<b>Laminar flow:</b>			
	Introduction, relation between shear and pressure gradients in laminar flow	13.1, 13.2	605-606	2
	Laminar flow between parallel plates- both plates at rest	13.6	616-619	2
	Laminar flow between parallel plates- one plate moving and other at rest	13.7	620-623	2
25,26	<b>Turbulent flow:</b>			1
	Introduction, Reynolds experiment	10.1, 10.2, 10.3	391-394	
	Frictional loss in pipe flow			
	Shear stress in turbulent flow	10.4	395-396	1
	Velocity distribution in turbulent flow in pipes	10.5	396-397	1
27,28	<b>General equation of head loss:</b>	11.1	420	1
	Introduction, loss of energy in pipes	11.2		
	Darcy-Weisbach equation, Chezy's equation	11.3	420-421	1
	Moody's diagram	--	683-684	2
	Minor head losses	11.4	425-428	1
	Hydraulic gradient and energy line	11.5	443-444	1
29	<b>Flow through network of pipes:</b>			
	Flow through pipes in series	11.7	454-455	1
	Flow through pipes in parallel pipes	11.9	459	1
	Flow through branched pipes	11.10	474-475	1
	Power transmission through pipe	11.11	480-481	1
30, 31	<b>Dimensional analysis and similitude:</b>			1
	Introduction, secondary or derived quantities, dimensional homogeneity	12.1, 12.2, 12.3	502-504	
	Methods of dimensional analysis:	12.4	504-509	1
	Rayleigh's method	12.4.1		
	Buckingham's $\pi$ -theorem	12.4.2		
	Types of similarities (similitude)	12.6	522-523	1
	Types of forces acting in moving fluid	12.7	523-524	1
Dimensionless numbers	12.8	524-525	1	
32	<b>Introduction of fluid machinery:</b>			
	Hydraulic accumulator- simple and differential types, hydraulic intensifier, hydraulic press, hydraulic crane, hydraulic lift, hydraulic ram, air lift pump	25.1, 25.2 25.3, 25.4 25.5, 25.6 25.7, 25.9	1201- 1219	2

**Practicals:**

1. Study of manometers
2. Study of pressure gauges;
3. Verification of Bernoulli's theorem;
4. Determination of coefficient of discharge of venturimeter
5. Determination of coefficient of discharge of orifice meter;
6. Determination of coefficient of friction in pipeline;
7. Determination of coefficient of discharge for rectangular
8. Determination of coefficient of discharge for rectangular triangular notch;
9. Determination of coefficient of discharge, coefficient of velocity and coefficient of contraction for flow through orifice;
10. Determination of coefficient of discharge for mouth piece;
11. Determination of metacentric height;
12. Determination of efficiency of hydraulic ram;
13. Study of current meter;
14. Velocity distribution in open channels and determination of Manning's coefficient of rugosity.

**BOOKS :**

**Text book/books**

Sl.no.	Title	Author	Publication
1	A text book of fluid mechanics and hydraulic machines ( Eighth edition )	Dr. R.K. Bansal	Laxmi Publications (p) Ltd. New Delhi
2	Hydraulics and fluid mechanics (including hydraulic machines) (Thirteenth edition)	Dr. P.N. Modi Dr. S.M. Seth	Standard Book House, Delhi-6

**Reference book/books**

Sl.no.	Title	Author	Publication
1	Fluid mechanics	Dr. Jagdish Lal	Metropolitan books Cl. Pvt. Ltd. New Delhi

*(S. Kadam)*  
 Course Coordinator  
 Professor and Head  
 Deptt. of Irrigation and  
 Drainage Engineering,  
 Dr. BSKKV, Dapoli

*(S. S. Pawar)*  
 Associate Professor  
 Deptt. of Irrigation and  
 Drainage Engineering,  
 MPKV, Rahuri

*(S. B. Wadathar)*  
 Assistant Professor  
 Deptt. of Irrigation and  
 Drainage Engineering,  
 Dr. PDKV, Akola

*(R. G. Bhagwanant)*  
 Assistant Professor  
 Deptt. of Irrigation and  
 Drainage Engineering,  
 MAU, Prabhani

*(S. B. Jadhav)*  
 Assistant Professor  
 Deptt. of Irrigation and  
 Drainage Engineering,  
 MAU, Prabhani

*(P. M. Jogle)*  
 Assistant Professor  
 Deptt. of Irrigation and  
 Drainage Engineering,  
 Dr. BSKKV, Dapoli

**Theory**

Irrigation Engineering: Irrigation, impact of irrigation on Human Environment, some major and medium irrigation schemes of India, purpose of irrigation, sources of irrigation water, present status of development and utilization of different water resources of the country; Measurement of irrigation water, weir, notches, flumes and orifices and other methods; water conveyance, design of irrigation field channels, underground pipe conveyance system, irrigation structures, channel lining; land grading, different design methods and estimation of earth work and cost; soil water plant relationship, soil water movement, infiltration and its equations, evapotranspiration, soil moisture constants, depth of irrigation, frequency of irrigation, irrigation efficiencies; surface irrigation methods of water application, border, check basin, furrow and contour irrigation.

**Practical**

Measurement of soil moisture by different soil moisture measuring instruments; Measurement of irrigation water; Measurement of infiltration characteristics; Determination of bulk density, field capacity and wilting point; Estimation of evapotranspiration; Land grading exercises; Design of under ground pipeline system; Estimation of irrigation efficiency; Study of advance, recession and computation of opportunity time; Infiltration by in flow outflow method; Evaluation of border Irrigation method; Evaluation of furrow irrigation method; Evaluation of check basin irrigation method

**Lesson Plan:**

Lect. No.	Topics	Article No.	Page No.	Book
1	Irrigation: Impact of irrigation on human environment	1.1,1.4, 1.5	1-2,7-15	2
2	Some major and medium irrigation schemes of India	2.2.3	37-44	2
3	Sources of irrigation water: Surface water sources Ground water resources	-- 1.6	23-44 15-16	1 2
4	Present status of development and utilization of different	1.13	48-52	1

	water resources of the country			
5,6	Measurement of irrigation water	Chapter 4	285-315	1
7,8	Water conveyance system: Open Channel: Design of open channel Lined channels Irrigation structures for open channel	5.1, 5.2 5.3, 5.4 5.5, 5.6	316-350	1
9,10	Under ground pipe conveyance System: Pipes for underground water distribution system, Design capacity of pipeline, installation of concrete Pipeline, structures of underground pipelines, Design of underground pip line irrigation system, common troubles of underground pipelines	5.9, 5.10 5.11,5.12 5.13,5.14	356-391	1
11,12, 13	Land grading: Introduction, Criteria for land grading, Land clearing, Land leveling design methods (plane method) Earthwork quantities Equipment for land grading and field layout	6.1 6.2 6.5 6.6 6.9	392-412, 416-420, 6.5 6.6 6.9	1
14,15, 16	<b>Soil-plant-water relationship:</b> Soil physical properties influencing irrigation such as soil texture, soil structure, bulk density, capillary and non-capillary pores, soil consistency, Volume and mass relationships of soil constituents, kinks of soil water.	7.1 7.3	448-458 462-464	1
17,18, 19	<b>Infiltration:</b> Movement of water into soils: Infiltration, factors affecting infiltration rate, Measurement of infiltration, infiltration equation $Y = at^a + b$	7.4	464-472	
20,21	<b>Soil moisture constants:</b> Saturation capacity, field capacity, moisture equivalent,	--	478-482	1

	permanent wilting percentage, available water, soil moisture characteristics curves			
22	<b>Evapotranspiration:</b> Evaporation, transpiration and consumptive use	7.8	512-517	1
23	<b>Measurement of evapotranspiration:</b> Lysimeter experiment, field experimental plots, soil moisture depletion studies, water balance method.	-	518-520	1
24,25	<b>Estimation of evapotranspiration from climatological data:</b> Blaney-Criddle method Thornthwaite formula Modified Panman formula Selection crop coefficient for estimating ET (crop)	-	522-537	5
	Panman-Monteith Jensen-Haise, Hargraves-Samani		17-78	1
26	<b>Depth of irrigation:</b> Net irrigation requirement Gross irrigation requirement		542-544	1
	Irrigation frequency Irrigation period		544-545	1
27	<b>Irrigation efficiencies:</b>	7.10	546-549	1
28	<b>Irrigation methods:</b> Surface irrigation methods: Introduction and classification		585	1
29,30	<b>Border irrigation:</b> Introduction, types, specifications, hydraulic of border irrigation, Design of border irrigation	8.1 8.2 8.3	585-603	1
31	<b>Check basin irrigation:</b> Introduction, types, specifications, hydraulic of check basin irrigation, Design of check basin irrigation	8.4 8.5 8.6	603-610	1
32	<b>Furrow irrigation:</b>	8.7	610-622	1

	Introduction, types, specifications, hydraulic of furrow irrigation, Design of furrow irrigation, contour irrigation	8.8 8.9	613-614	
--	--	------------	---------	--

**Practical:**

1. Measurement of soil moisture by gravimetric method.
2. Measurement of soil moisture by tensiometer, gypsum block, pressure plate apparatus.
3. Determination of bulk density.
4. Measurement of irrigation water using weir, notch, orifices, flumes and siphon tubes.
5. Measurement of infiltration using double ring infiltrometer.
6. Determination of field capacity, wilting point.
7. Estimation of evapotranspiration based on climatological data.
8. Study of Land grading and leveling.
9. Design of irrigation open channel.
10. Design of under ground pipeline system
11. Estimation of irrigation efficiencies.
12. Study of advance, recession and computation of opportunity time
13. Evaluation of border Irrigation method.
14. Evaluation of furrow irrigation method.
15. Evaluation of check basin irrigation method.

**Books:**

**Text book/ books**

Sr. No.	Title	Author	Publication
1	Irrigation: theory and practice	A.M. Michael	Vikas publishing house Pvt. Ltd. New Delhi
2	Irrigation Water Management Principles and Practice	Dilip Kumar Majumda	Prentice-Hall of India Pvt. Limited. New Delhi
3	Land and Water Management Engineering	V.V.N. Murthy	Kalyani publishers, New Delhi
4	Irrigation Principles and Practice	Israelsen & Hunson	
5	Crop evapotranspiration (Guidelines for computing crop water requirements) FAO-56	R.G. Allen, L.S. Pereira, D. Raes, M. Smith	FAO, Rome
6	Design and Operation of Irrigation System	Ed. M.E. Jenson	ASCE.



**Theory**

Occurrence and movement of ground water, aquifer and its types, classification of wells, steady and transient flow into partially, fully and non-penetrating and open wells, familiarization of various types of bore wells common in the state, design of open well, groundwater exploration techniques, methods of drilling of wells, percussion, rotary, reverse rotary, design of assembly and gravel pack, installation of well screen, completion and development of well, groundwater hydraulics-determination of aquifer parameters by different method such as Theis, Jacob and Chow's etc. Theis recovery method, well interference, multiple well systems, surface and subsurface exploitation and estimation of ground water potential, quality of ground water, artificial groundwater recharge planning, modelling, ground water project formulation. Pumping Systems: Water lifting devices; different types of pumping machinery, classification of pumps, component parts of centrifugal pumps; pump selection, installation and trouble shooting; design of centrifugal pumps, performance curves, effect of speed on head capacity, power capacity and efficiency curves, effect of change of impeller dimensions on performance characteristics; hydraulic ram, propeller pumps, mixed flow pumps and their performance characteristics; priming, self priming devices, rotodynamic pumps for special purposes such as deep well turbine pump and submersible pump.

**Practicals**

Verification of Darcy's Law; Study of different drilling equipments; Sieve analysis for gravel and well screens design; Estimation of specific yield and specific retention; Testing of well screen; Estimation of aquifer parameters by Theis method, Coopers-Jacob method, Chow method; Theis Recovery method; Well design under confined and unconfined conditions; Well losses and well efficiency; Estimating ground water balance; Study of artificial ground water recharge structures; Study of radial flow and mixed flow centrifugal pumps, multistage centrifugal pumps, turbine, propeller and other pumps; Installation of centrifugal pump; Testing of centrifugal pump and study of cavitations; Study of hydraulic ram; Study and testing of submersible pump

### Lesson Plan

Lecture No.	Topics	Article No.	Page No.	Book
(A)	<b>Ground water and wells</b>			
1	<b>Occurrence and movement of ground water:</b> Origin and age of groundwater, rock properties affecting groundwater, Important definitions, hydraulic conductivity, transmissibility, coefficient of storage, specific yield, hydraulic resistance, leakage factor.	---  2.2	23-28, 6-8  59-63	2,3  1
2	<b>Aquifer and its types</b>	1.2	7-9	1
3	<b>Classification of wells</b>	1.10	25-28	1
4	<b>Steady and transient flow into partially, fully and non penetrating and open wells:</b> Steady state flow to wells in unconfined aquifers Steady state flow to wells in confined aquifers Unsteady state flow to wells in unconfined aquifers Unsteady state flow to wells in confined aquifers	  2.3 2.4	  63-71 74-76	  1
5	<b>Ground water exploration techniques</b> Surface investigations of groundwater, sub surface investigations of groundwater	1.11  Chapter 9 Chapter 10	33-39  219-232 235-249	1  2 2
6	<b>Design of open well</b>	3.2	99-114	1
7	<b>Methods of drilling of wells:</b> Drilling equipment and methods, Percussion drilling Rotary drilling Reverse rotary drilling	5.2 5.3 5.4 5.6 5.7 5.10 5.11 5.12	222-265	1
8	<b>Design of assembly and gravel pack:</b> Design of tube well, analysis of particle-size	4.9 4.10	192-197	1

	distribution of the aquifer, design of housing pipe and well casing, bore size and well depth, selection of strata to be screened	<b>4.11</b> <b>4.12</b>		
<b>9</b>	<b>Installation of well screen:</b> Design of well screen, slot opening, percent open area, diameter of the screen.	<b>4.13</b>	<b>198-202</b>	<b>1</b>
<b>10</b>	<b>Design of gravel pack:</b> Design criteria for gravel pack, Gravel pack material, screening of gravel	<b>4.14</b>	<b>202-210</b>	<b>1</b>
<b>11</b>	<b>Completion and development of well</b>	<b>6.1,</b> <b>6.2,</b> <b>6.3</b> <b>6.3.5</b>	<b>310-329</b>  <b>177-180</b>	<b>1</b>  <b>3</b>
<b>12</b>	<b>Aquifer parameters determination:</b> Theis method Cooper-Jacob method Chow method Recovery method (Theis)	<b>2.4</b>	<b>75-84</b>	<b>1</b>
<b>13</b>	<b>Well interference</b>	<b>2.6</b>	<b>88-91</b>	<b>1</b>
<b>14</b>	<b>Multiple well systems</b>	<b>4.5</b>	<b>179-180</b>	<b>1</b>
<b>15</b>	<b>Ground water quality</b>	<b>1.13</b> <b>10.4</b> <b>10.5</b>	<b>42-45</b> <b>344-357</b> <b>358-366</b>	<b>1</b> <b>3</b> <b>3</b>
<b>16</b>	<b>Artificial recharge of ground water:</b> Concept of artificial recharge, Recharge methods	<b>1.12</b>	<b>39-42</b>	<b>1</b>
<b>17</b>	<b>Ground water modeling:</b>	<b>7.1,7.2,7.3,</b> <b>7.4, 7.5</b>	<b>2000-231</b>	<b>3</b>
<b>(B)</b>	<b>Pumps</b>			
<b>18</b>	<b>Pumping systems and machinery:</b> Principles of lifting and moving of water, water lifting devices: scoop, swing basket, Archimedian screw, counterpoise bucket lift, Persian wheel	<b>10.1</b> <b>10.2</b> <b>10.3</b>	<b>486-513</b>	<b>1</b>

		<b>10.4</b>		
<b>19</b>	<b>Classification of pumps</b>		<b>487</b>	<b>1</b>
<b>20</b>	<b>Centrifugal pump:</b> Classification of variable displacement pumps, principles of operation of centrifugal pumps, parts of centrifugal pump, classification of centrifugal pump	<b>12.1</b> <b>12.2</b> <b>12.3</b>	<b>619-630</b>	<b>1</b>
<b>21</b>	<b>Power requirements in pumping</b>	<b>12.8</b>	<b>640-644</b>	
<b>22</b>	<b>Pump characteristic curves</b>	<b>12.9</b>	<b>645-648</b>	
<b>23</b>	<b>Pump performance:</b> Effect of change of speed on head, capacity, power and efficiency Effect of change of impeller diameter on head, capacity, power and efficiency System head curve	--	<b>650-652</b>	<b>1</b>
<b>24</b>	<b>Selection of centrifugal pump</b>	<b>12.11</b>	<b>652-657</b>	<b>1</b>
<b>25</b>	<b>Design of centrifugal pumps</b>	<b>13.1</b>	<b>676-683</b>	
<b>26</b>	<b>Centrifugal pump installation and trouble shooting:</b> Location, pump foundation, installation of centrifugal pump in shallow/deep open well and in tube well Trouble-shooting in centrifugal pumps	<b>14.1</b> <b>14.2</b> <b>14.3</b> <b>14.4</b> <b>14.5</b> <b>14.11</b>	<b>708-711</b> <b>716-727</b> <b>741-745</b>	<b>1</b>
<b>27</b>	<b>Hydraulic ram:</b> Application construction, Principle of operation, advantages and limitations, efficiency of hydraulic ram	<b>11.13</b> <b>11.14</b> <b>11.15</b>	<b>574-583</b>	
<b>28</b>	<b>Propeller pumps:</b> Introduction, principles of operation, construction, operating characteristics, installation	<b>16.1</b> <b>16.2</b> <b>16.3</b> <b>16.4</b>	<b>797-806</b>	
<b>29</b>	<b>Mixed flow pumps:</b> Principles of operation, Operating characteristics and installation, selection of mixed flow pump	<b>16.8</b> <b>16.9</b> <b>16.10</b>	<b>812-815</b>	<b>1</b>
<b>30</b>	<b>Priming and self priming</b>	<b>3.6</b>	<b>225-226</b>	<b>4</b>

<b>31</b>	<b>Rotodynamic pumps:</b>			
	<b>Deep well turbine pump:</b>	<b>15.1</b>	<b>747-755</b>	<b>1</b>
	Introduction, principle of operation, construction,	<b>15.2</b>		
	characteristics of pump, selection of pump	<b>15.3</b>		
	<b>15.4</b>			
<b>32</b>	<b>Submersible pumps:</b>	<b>15.11</b>	<b>780-795</b>	<b>1</b>
	Introduction, construction, installation, operation of	<b>15.12</b>		
	pump, common troubles in operation and remedies.	<b>15.14</b>		
		<b>15.16</b>		

### Practical:

1. Verification of Darcy's Law;
2. Study of different drilling equipments;
3. Sieve analysis for gravel and well screens design;
4. Estimation of specific yield and specific retention'
5. Estimation of aquifer parameters by Theis method, Coopers-Jcob method, Chow method,
6. Theis Recovery method;
7. Well design under confined and unconfined conditions,
8. Well losses and well efficiency;
9. Estimating ground water balance;
10. Study of artificial ground water recharge structures;
11. Study of radial flow and mixed flow centrifugal pumps, multistage centrifugal pumps, turbine, propeller and other pumps;
12. Installation of centrifugal pumps;
13. Testing of centrifugal pump and study of cavitations;
14. Study and testing of submersible pump.

### BOOKS:

#### Text Book/books

Sr.No.	Title	Author	Publication
1	Water well and pump engineering (9 <sup>th</sup> Edition, 2005)	A.M. Michael and S.D. Khepar	Tata McGraw-Hill publishing Company Ltd. New Delhi
2	Groundwater hydrology (2 <sup>nd</sup> Edition)	David Keith Todd	John Wiley and sons, New York (International Book Disturbing Co. Lucknow)
3	Groundwater hydrology (International student Edition)	Herman Bouwer	McGraow-Hill publishing Company Ltd. New York.
4	Irrigation: Theory and Practices	A.M. Michael	Vikas publishing house Pvt. Ltd. New Delhi.

5	Groundwater Assessment and Management (11 <sup>th</sup> Edition, 2007)	K.R. Karanth	Tata McGraw-Hill publishing Company Ltd. New Delhi.
6	Irrigation Engineering and Hydraulic Structures (14 <sup>th</sup> Edition, 1999)	S.K. Garg	Khanna Publisher 2-13 Nath Market Naisaraf, Delhi-06

**Theory**

Drainage, objectives of drainage, familiarization with the drainage problems of the state, Surface drainage, drainage coefficient, types of surface drainage, design of open channel, sub-surface drainage purpose and benefits, investigations of design parameters, hydraulic conductivity, drainable porosity, water table etc., drainage criteria, types and use of subsurface drainage system, Design of surface drains, interceptor and relief drains. Derivation of ellipse (Hooghoudt's) and Ernst's drain spacing equations. Steady and unsteady state groundwater condition, dynamic equilibrium concept, Design of subsurface drainage system. Drainage materials, drainage pipes, drain envelope. Layout, construction and installation of drains. Drainage structures. Vertical drainage. Bio-drainage. Tile Drains. Drainage of irrigated and humid areas. Salt balance, reclamation of saline and alkaline soils. Leaching requirements, conjunctive use of fresh and saline waters. Economic aspects of drainage.

**Practicals**

*In-situ* measurement of hydraulic conductivity by single auger hole method; *In-situ* measurement of hydraulic conductivity by inverse auger hole method; Determination of drainage coefficients; Installation of piezometer and observation well; Preparation of iso-bath and isobar maps; Determination of drainable porosity by sand tank model; Determination of drainable porosity by using field method; Design of surface drainage systems; Design of gravel envelop; Design of subsurface drainage systems; Determination of chemical properties of soil and water; Study of drainage tiles; Determination of gypsum requirement for land reclamation; Installation of sub-surface drainage system; Cost analysis of surface and sub-surface drainage system.

**Lesson Plan**

Lect. No.	Topics	Articles No.	Page No.	Book
1	Drainage: Introduction, definition, Drainage problem of the state and country, causes and effect of waterlogging, prevention and control of waterlogging.	1.1 1.2 1.3 1.4,1.5	1-17	1
2	Objectives of drainage:	1.6	18-23	1

	Need of drainage, purpose of drainage Effect of poor drainage, benefits of drainage Drainage requirement of various crops	1.7 & Circulated notes		
<b>3</b>	Interrelationship of irrigation and drainage	2.1,2.2,2.3,2.3.1 ,2.3.2	27-40	1
<b>4&amp;5</b>	Surface drainage: Introduction, surface drainage system and components, factors affecting drainage, types of lands requiring drainage Drainage coefficient.	6.1 6.2 6.3 6.6	261-271	1
<b>6</b>	Types of surface drainage: Surface drainage for flat areas Surface drainage for sloping areas Interceptor drain	6.10 6.11 6.12	261-271	1
<b>7,8,9</b>	Design of surface drainage system: Design consideration, design of surface drainage system, hydraulic design of open channel (drain)	6.4 6.9	230-234 255-261	1
<b>10</b>	Subsurface Drainage			
<b>11</b>	Drainage properties-Structure and texture	--	480-481	2
	Drainable porosity	--	80-82	3
	Hydraulic conductivity	--	87-97	2
<b>12</b>	Subsurface drainage system: Introduction, general considerations, Components of subsurface drainage system and different layouts of Subsurface drainage system	8.1 27.1 27.4.4	352-353 3-4 30-31	1 5 5
<b>13,14,</b>	Derivation of ellipse (Hooghoudt's)	--	149-156	3
<b>15</b>	*Ernst's drain spacing equations.	8.4.3	366-369	1
	Unsteady state equation (Glover-Dum)	11.4.2	155-160	4
<b>16,17</b>	Dynamic equilibrium concept	11.4.4	160-162	4
<b>18</b>	Drainage criteria for steady and unsteady state	11.1 11.2 11.2.2	133-138	4
<b>19</b>	Design of subsurface drainage system-problems	-	-	-
<b>20,21</b>	Drainage materials: Drainage pipes, drain envelop	27.5	33-41	5



	and drainage structures **Design of gravel envelope	8.11.1	410	1
<b>22,23</b>	Installation of subsurface drainage system	8.12.3, 8.12.4, 8.12.5, 8.12.6, 8.12.7,8.12.8	418-426	1
<b>24</b>	Subsurface system design: Procedure, Hydraulic design of subsurface system.	8.3 8.8	355-358 391-400	1
<b>25</b>	Mole drainage Bio-drainage Vertical drainage	27.3 8.16.3 --	9-14 460-466 579-580	5 1 2
<b>26</b>	Types of salt affected soil Chemical properties of soil Classification of soil	7.3 7.10	313-315	1
<b>27,28</b>	Reclamation of saline and alkali soils Leaching requirement and methods Gypsum requirement	7.12.2, 7.12.4,7.12.6 7.13	320-323 323-333 334-343	1
<b>29</b>	Salt balance	9.2	62-67	4
<b>30</b>	Economic aspects of drainage: Problem	8.10	438-466	1
<b>31</b>	Tile drain: Selection of tile, characteristics of good drain tile, concrete tile, clay tile	8.9	400-401	1
<b>32</b>	Drainage for humid and irrigated areas Conjunctive use of fresh and saline water	Notes to be circulated later on	--	--

**Book****Text book/books**

<b>Sr. No.</b>	<b>Title</b>	<b>Author</b>	<b>Publisher</b>
1	Agricultural Drainage: Principles & Practices (1 <sup>st</sup> Edition)	U.S. Kadam, R.T. Thokal, Sunil Gorantiwar, A.G. Powar	Westville Publishing House, New Delhi

**Reference book/books**

<b>Sr. No.</b>	<b>Title</b>	<b>Author</b>	<b>Publisher</b>
2	Principles of Agricultural Engineering Vol. II (1 <sup>st</sup> Edition)	A.M. Michael and T.P. Ojha	Jain Brothers Jodhpur
3	Drainage Engineering	J.N. Luthin	Wiley Eastern Pvt. Ltd. New Delhi
4	Drainage Principles and Application	--	ILRI Publications, Netherlands Vol.2
5	Drainage Principles and Applications	--	ILRI Publications, Netherlands Vol.4

**Theory**

Past, present and future need of micro-irrigation systems, Role of Govt. for the promotion of micro-irrigation in India, Merits and demerits of micro-irrigation system, Types and components of micro-irrigation system, Basic variables involved in design of irrigation methods.

Sprinkler Irrigation: system types, planning for design, uniformity and efficiency, layout of set sprinkler system, lateral, manifold and main delivery system. Pressure requirement and pump power unit selection. Economical pipe selection and system economics. Rain-gun irrigation system.

Trickle Irrigation: Different types of trickle, components of trickle system, planning the trickle system and design strategy Selection and design criteria for emitters. Lateral/ manifold and main pipe system design. Clogging, filtration, fertigation and chemigation. Maintenance and upkeep of trickle Irrigation. Cost economics of the system.

**Practicals-**

Study of different components of sprinkler irrigation system; Design of the sprinkler irrigation system.; Installation of sprinkler irrigation system; Determination of precipitation pattern, discharge and uniformity coefficient; Study of different components of trickle irrigation; Design of trickle irrigation system; Installation of trickle irrigation system; Determination of pressure discharge relationship and emission uniformity for given emitter; Study of different types of filters and determination of filtration efficiency; Determination of rate of injection and calibration for chemigation/fertigation; Field evaluation of drip system; Cost economics of drip irrigation system; Cost economics of sprinkler irrigation system

**Lesson plan:**

Lecture	Topics	Article	Page	Book
---------	--------	---------	------	------

No.		no.	no.	
1	Past, present and future need of micro-irrigation systems, role of Govt. for the promotion of micro-irrigation in India (Statistics to be continuously updated)	1.1,	1 - 4	3
		1.1.1,		
		1.1.1 a to c,		
		1.6, 1.7	4, 10 - 11	6
		-	1 - 8	5
		-	9 - 15	7
		-	1 - 6	8
2	Merits and demerits of micro-irrigation system	1.1.4a, 1.1.4b	16 - 19	3
3	Types and components of micro-irrigation system,  Basic variables involved in design of irrigation methods.	1.1.2	5 - 11	3
		1.1.3	11 - 15	3
		-	4 - 5	4
4	<b>Sprinkler Irrigation:</b> Introduction, adaptability, limitations, types of systems Components of the sprinkler system	8.11	624-628	1
		8.12	629-634	
		8.13	636-639	
5	<b>Uniformity and efficiency:</b> Moisture distribution patterns and uniformity of coverage, uniformity coefficient	8.14	639-645	1
6	<b>Design of Sprinkler irrigation system:</b> Inventory of resources, layout of sprinkler system, sprinkler selection and spacing, capacity of the sprinkler system	8.15	645-650	1
7	<b>Hydraulic design of sprinkler systems:</b> Design of sprinkler laterals, main line pipe size	8.15	651-655	1
8	<b>Pressure requirement and power units</b>	3.5	216 to 220	1
9	<b>Economical pipe selection and system economics</b>	3.24	279 to 282	1
10	<b>Rain-gun irrigation system</b>	Notes to be circulated		
11	<b>Trickle irrigation:</b> Introduction, benefits of trickle irrigation, components of trickle system,	-	6 - 9,	2
		-	622 - 642	1b
12	<b>Selection and design criteria for emitters</b>	-	12 - 26	2

13	<b>Design of lateral</b>	-	60 -67, 72 -77	2
14	<b>Design of sub main, main and pump</b>	-	80 -91	2
15	<b>Clogging and filtration</b>	-	100-104	2
16	<b>Fertigation and chemigation</b>	-	104-109	2
17	<b>Maintenance and upkeep of trickle irrigation</b>	-	643-645	1b
18	<b>Cost economics of the system</b>	To be prepared by the concerned Teacher		
19	<b>Evaluation of trickle irrigation system</b>	-	50 -55	2

**Practical:**

1. Study of different components of sprinkler irrigation system.
2. Design of the sprinkler irrigation system a case study.
3. Installation of sprinkler irrigation system
4. Determination of precipitation pattern, discharge and uniformity coefficient.
5. Study of different components of trickle irrigation.
6. Design of trickle irrigation system a case study.
7. Installation of trickle irrigation system
8. Determination of pressure discharge relationship.
9. Determination of emission uniformity of trickle irrigation system.
10. Study of different types of filters and determination of filtration efficiency.
11. Determination of rate of injection and calibration for chemigation/fertigation.
12. Field evaluation of drip system.
13. Cost economics of drip irrigation system
14. Cost economics of sprinkler irrigation system

**BOOKS:**

**Text book/books**

S. N.	Title	Author	Publication
1	a Irrigation Theory and Practice First Edition, 1978 reprint 2002	A.M.Michael	Vikas Pub. House Pvt. Ltd. New Delhi
	b Irrigation Theory and Practice Second Edition, 2008	A.M.Michael	Vikas Pub. House Pvt. Ltd. New Delhi.
2	Trickle Irrigation Design	Jack Keller and David Karmeli	Rain Bird Sprinkler Manufacturing Co. Clendora, California, USA
3	Trickle Irrigation for Crop	F.S.Nakayama &	Elsevier

	Production, Design, Operation & Management	D.A.Bucks	
--	--	-----------	--

**Reference book/books**

S. N.	Title	Author	Publication
4	Design and evaluation of irrigation methods (IARI monograph No. 1)	A.M.Michael, Shri Mohan, K.R. Swaminthan	Water Technology Centre, New Delhi
5	Micro-irrigation for cash crops	M.L.Choudhary, U.S.Kadam	Westvile Publishing house, New Delhi
6	Principles of Drip Irrigation System	M.S.Mane, B.L.Ayare, S.S.Magar	Jain Brothers, New Delhi
7	Centrally Sponsored Scheme on Micro Irrigation (Drip & Sprinkler Irrigation) Guidelines	Anonymous	Ministry of Agriculture, Dept. of Agril. & Co-operation, New Delhi.2006.
8	Subsurface Porous Pipe Irrigation System	R.S.Dhotre, S.D.Gorantiwar, S.B.Gadge, N.N.Firke	MPKV/RES/PUB/N.16/08 Dept. of Irrigation & Drainage Engineering, M.P.K.V., Rahuri.

<b>(U. S. Kadam)</b>	<b>(R. S. Dhotre)</b>	<b>(S.D.Gorantiwar)</b>	<b>(M. S. Mane)</b>
Course Coordinator	Head,	Associate Professor,	Associate Professor,
Professor and Head,	Deptt. of Irrigation and	Deptt. of Irrigation and	Deptt. of Irrigation and
Deptt. of Irrigation	Drainage Engineering,	Drainage Engineering,	Drainage Engineering,
and Drainage	MPKV, Rahuri.	MPKV, Rahuri.	Dr. BSKKV, Dapoli
Engineering, Dr.			
BSKKV, Dapoli			

<b>(S. R. Kale)</b>	<b>(S. B. Gadge)</b>	<b>(P. M. Ingle)</b>
Associate Professor,	Assistant Professor,	Assistant Professor,
Deptt. of Irrigation	Deptt. of Irrigation and	Deptt. of Irrigation and
and Drainage	Drainage Engineering,	Drainage Engineering,
Engineering, Dr.	MPKV, Rahuri	Dr. BSKKV, Dapoli
BSKKV, Dapoli		

**MINOR IRRIGATION AND COMMAND AREA DEVELOPMENT****Syllabus:**

Major, medium, and minor irrigation projects their comparative performance; development and utilization of water resources. Basic concepts of command area - definition, need and scope: historical perspective, command area development authorities; Interaction/collaboration of irrigation water use efficiency and agricultural production. Farmers participation in command area development.

Description of components of irrigation canal system, their functions, planning and layout of canal irrigation system, preliminary design procedure for irrigation project and command area, crop water requirement, duty and delta, specific discharge of canal, design of canal by Kennedy and Lacey's theory and tractive force approach, Canal seepage and lining of canal, design of lined canal and economics.

Diversion head works and canal head regulators, hydraulic jump and its usefulness in the design of irrigation structures, theories of seepage, cross drainage works, canal falls, irrigation structures on distributory and minor, regulator and modules, operation and maintenance of canal.

**Practicals-**

Preparation of command area development layout plan; Irrigation water requirement of crops; Preparation of irrigation schedules; Design of lined irrigation canal; Planning and layout of water conveyance system; Hydraulic design of canal outlets; Hydraulics design of straight Glacis fall; Hydraulic design of aqueduct; Hydraulic design of siphon; Design of irrigation systems; Conjunctive water use planning; Determination of operation schedule for canal outlets based on rotational water supply; Technical feasibility and economic viability of a command area project; Study tour to minor irrigation and command area development projects

**MINOR IRRIGATION AND COMMAND AREA DEVELOPMENT**

Lesson plan:

Lecture No.	Topic	Article no.	Page no.	Book
1	Major, medium and minor irrigation projects their comparative performance		721 -723	4
2	Development of utilization of water resources	-	57 – 70	4
3	Basic concept of command area: Definition, need and scope, historical perspective	-	14 1 – 5	4 2
4	Command area development authorities, administrative structure	Notes to be circulated		
5	Command area development authority's interaction/collaboration with water use Societies/Association	Notes to be circulated		
6	Farmers participation in command area development	Notes to be circulated		
7	Components of irrigation canal system:			
	Distribution system for canal irrigation	3.4	66-68	1
	Silt control devices	9.3.8	622-623	1
	Fish ladder	9.3.6	612-615	1
8	Planning and layout of canal irrigation system,	3.1 3.2 3.3	63-66	1
	preliminary design procedure for irrigation project	12.2 -12.6	251 -255	2
9	Preliminary design procedure for command area	5.1 – 6.0	3 - 21	3



10, 11	<p><b>Crop water requirement:</b> Introduction, crop period and base period, duty and delta of a crop, certain important definitions</p>	<p>2.1 2.2 2.3 2.5</p>	<p>25-31 32-35</p>	1
12	<p><b>Specific discharge of canal:</b>  Certain important definitions,  Determination of required channel capacity</p>	<p>3.6 3.7</p>	<p>69-70 70-84</p>	1
13, 14, 15 & 16	<p><b>Design of canal:</b> i. Kennedy's theory ii. Lacey's theory iii. Tractive force approach Comparison of Kennedy's and Lacey's theory</p>	<p>4.7.3 4.7.4 4.1 – 4.4 4.7.5</p>	<p>108 -116 116 – 122 90 -94 122- 123</p>	<p>1 1 1 1</p>
17	<p><b>Canal seepage:</b> Causes of failure, Blight's creep theory, Lane's weighted creep theory</p>	<p>11.1 11.2 11.3</p>	643-647	1
18	<p><b>Lining of canal:</b> Advantages of lining, financial justification &amp; economics of canal lining</p>	<p>5.1 5.2 5.3</p>	184- 194	1

19	<b>Design of lined irrigation channel</b>	5.5 5.6	195 – 200	1
20, 21	<b>Diversion head works:</b> Weir and barrage, gravity and non gravity weirs, layout of a diversion head works and components, certain important definitions	9.1 9.2 9.3.1 9.3.2	600-608	1
22	<b>Canal head regulators</b>	9.3.7	615-621	1
23,24	<b>Hydraulic jump and its usefulness in the design of irrigation structure:</b>  Types of jump, momentum formula	10.1 10.2 10.3	633-639	1
25, 26	<b>Cross drainage works:</b> Types of cross drainage works, selection of drainage work, Types of cross drainage works	14.1 14.2 14.3	841-848	1
27	<b>Canal falls:</b> Definition, location, types of falls	12.1 12.2	734-744	1
28,29	<b>Canal regulator:</b> Canal regulator works, alignment of the off-taking channel, Distributary head regulator and cross	13.1 13.2 13.3 13.4	797-800	1

	regulator			
<b>30, 31</b>	<b>Canal outlet or modules:</b> Requirements of good modules, types of modules. Criteria for judging the performance of modules, certain important definitions	<b>13.8</b> <b>13.9</b> <b>13.10</b> <b>13.11</b> <b>13.12</b> <b>13.13</b>	<b>817 - 836</b>	<b>1</b>
<b>32</b>	<b>Operation and maintenance of canal:</b> i. Maintenance of irrigation canal ii. Operation of irrigation canal: water distribution methods & criteria of canal operation	<b>4.13</b> <b>-</b>	<b>175-179</b> <b>1 - 16</b>	<b>1</b> <b>5</b>

**Practical :**

1. Preparation of command area development layout plan
2. Irrigation water requirement of crops based on duty, delta concept
3. Preparation of irrigation schedules
4. Design of lined irrigation canal
5. Planning and layout of water conveyance system
6. Hydraulic design of canal outlets
7. Hydraulics design of straight Glacis fall
8. Hydraulic design of aqueduct
9. Hydraulic design of siphon
10. Conjunctive water use planning
11. Determination of operation schedule for canal outlets based on rotational water supply
12. Technical feasibility and economic viability of a command area project
13. Study tours to minor irrigation and command area development projects

**Book :****Text book/books**

Sl. No.	Title	Author	Publisher
1	Irrigation Engineering and Hydraulic Structures ( 12 <sup>th</sup> Revised ed <sup>n</sup> )	Santosh Kumar Garg	Khanna Publishers, New Delhi
2	Irrigation Engineering and Hydraulic structures	S.R. Sahastrabudhe	--

**Reference book/books**

Sl. No.	Title	Author	Publisher
3	Operation and management of irrigation system in Maharashtra State, Second Edition, Pub No. 20	-	WALMI Publications, Aurangabad
4.	Irrigation Theory and Practice	A.M. Michael	Vikas Publishing house Pvt. Ltd, New Delhi
5	Water distribution practices in Maharashtra State, Pub No. 22	-	WALMI Publications, Aurangabad

<b>(U. S. Kadam)</b> Course Coordinator Professor and Head, Deptt. of Irrigation and Drainage Engineering, Dr. BSKKV, Dapoli	<b>(R. S. Dhotre)</b> Head, Deptt. of Irrigation and Drainage Engineering, MPKV, Rahuri.	<b>(S.D.Gorantiwar)</b> Associate Professor, Deptt. of Irrigation and Drainage Engineering, MPKV, Rahuri.	<b>(M. S. Mane)</b> Associate Professor, Deptt. of Irrigation and Drainage Engineering, Dr. BSKKV, Dapoli
--	--	---	---

<p><b>(S. R. Kale)</b> Associate Professor, Deptt. of Irrigation and Drainage Engineering, Dr. BSKKV, Dapoli</p>	<p><b>(S. B. Gadge)</b> Assistant Professor, Deptt. of Irrigation and Drainage Engineering, MPKV, Rahuri</p>	<p><b>(P. M. Ingle)</b> Assistant Professor, Deptt. of Irrigation and Drainage Engineering, Dr. BSKKV, Dapoli</p>
--	--	---

**CAE-IDE-471 MICRO-IRRIGATION SYSTEMS DESIGN 3(2+1)**

History and scope of micro-irrigation system, merits and demerits of micro-irrigation system, sprinkler irrigation – crop suitability, types, components, design-design synthesis, pumps and pressure unit selection, uniformity and efficiency, planning and layout, operation and maintenance, drip irrigation – potential, crop suitability, types, components, design, design synthesis, pumps and pressure unit selection, uniformity and efficiency, installation, operation and maintenance, fertigation, fertilizer application criteria, suitability of fertilizer compounds, injection duration, rate and frequency, capacity of fertilizer tank, quality of irrigation water, cost estimation of micro-irrigation.

**Lesson plan:**

<b>Lecture No.</b>	<b>Topics</b>	<b>Article no.</b>	<b>Page no.</b>	<b>Book</b>
1	Micro-irrigation system-importance, status, types, merits and demerits		1-11	3
2	Sprinkler irrigation and their components		23-45	1
3	Drip irrigation and their components		15-20	2
4	Design criteria and procedure for sprinkler nozzle		49-58	1
5	Distribution of moisture under sprinkler irrigation and overlapping of sprinklers		113-115	1
6	Computation of system capacity		59-65	1

			71-75	
7,8	Design of sprinkler irrigation pipe network on flat and sloping land		65-71	1
9	Design of system under windy condition		590	
10	Design of pump unit		75-91	1
11	Evaluation of sprinkler irrigation system, uniformity, pressure- discharge etc.		116-122	1
12	Drip irrigation emitters, design requirements, characteristics and types		12-18	3
13	Design of orifice type and long flow path type of emitters,		18-23	3
14	Pressure-discharge relationship of an emitters		24-26	3
15	Distribution of moisture and salts in drip irrigation system, spacing between emitters and number of emitters per plant etc.		100-107, 125-127	4 4
16	Computation of water requirement and system capacity, determination of number of subunits/values		27-44 92-95	3
17	Design of drip irrigation laterals on flat and sloping lands		60-79	3
18	Design of manifold under different scenario-slope, field size etc, design of main		80-91	3
19	Power requirement and pump selection			
20	Filtration system		131-139	2
21	Design of screen filter			
22	Design of sand filter			
23	Fertigation systems and devices		109-118	2
24	Types of fertilizers and computation of fertilizer requirement		118-125	2
25	Maintenance of drip irrigation system-		76-78	2

	acidification and requirement			
26	Chlorinification and requirement		78-84	2
27	Evaluation of drip irrigation system manufacturing coefficient of variation, absolute and field emission uniformity		48-55	3
28	Automation of micro-irrigation system - Time based, Volume based - Sensor based		98-105	5
29	Optimization of pipe network in drip and sprinkler irrigation system		244-255	6
30	Economic feasibility of sprinkler irrigation system			
31	Economic feasibility of drip irrigation system		60-61	2
32	Government policies on micro-irrigation system			

**Practical :**

1. Estimation of water requirement of different crops under micro-irrigation system
2. Hydraulic design of lateral ;
3. Hydraulic design of main and sub-main
4. Determination of fertilizer injection rate;
5. Determination of capacity of fertilizer tank;
6. Design of water filtration unit;
7. Design and layout of drip irrigation system for and orchard;
8. Design and layout of drip irrigation system for row crops;
9. Design and layout of sprinkler irrigation system;
10. Estimations for acid treatment and chlorination;
11. Study of components of automation in micro-irrigation systems;
12. Field visit of micro-irrigation system;

**BOOKS :****Text book/books**

<b>S.N</b>	<b>Title</b>	<b>Author</b>	<b>Publication</b>
1	Principles of sprinkler irrigation	M.S.Mane, B.L.Ayare,	Jain Brothers, New Delhi
2	Principles of drip irrigation	M.S.Mane, B.L.Ayare, S.S.Magar	Jain Brothers, New Delhi
3	Trickle irrigation design	Jack Keller, David Karmelli	Rainbird Sprinkler Manufacturing Corporation,California, USA
4	Trickle irrigation for crop production – design, operation and management	F.S.Nakayama, D.A.Bucks	Elsevier Publication
5	Irrigation system; design and operation	D.Karmelli, G.Peri, M.Todes	Oxford University Press, Capetown 1985
6	Irrigation Engineering: Sprinkler, trickle and surface irrigation	A. Benami and A. Ofen	Irrigation Engineering Scientific Publication Technion Israel Institute of Technology, Haifa, Israel



**CAF-IDE-474 LIFT IRRIGATION SYSTEM DESIGN AND 3(2+1)  
MANAGEMENT**

Site selection for lift irrigation and reconnaissance survey, survey and mapping of field, cropping pattern and computing water requirement, selection of site for intake and jack well, computing total head and power requirement, design of intake chambers, inlet pipe and pump house, selection of pump, pump layout and connection. Design and layout of rising main, distribution system and delivery chamber, working out water rates.

**Lesson plan:**

<b>Lecture No.</b>	<b>Topics</b>	<b>Article no./ Page no.</b>	<b>Book No.</b>
1	Introduction to lift irrigation, necessity and role of lift irrigation schemes in irrigation development	249-250	1, 2
2	Assessment of feasibility of lift irrigation project	250-251	1
3,4	Selection of site and reconnaissance survey for lift irrigation scheme	257-260	1,2
5,6	Survey and leveling procedure i) Chain and Compass Survey ii) Plain Table Survey iii) Dumpy / Automatic level	159-161 293-298 371-379	3
7	Water availability	251,255,256	1
8	Computation of water requirement and capacity of project	25-35	4
9	Components of lift irrigation scheme i) Intake well – function, type, constructional details	260-262	1
10	Sump well	268-269	1
11	Jack well	270-271	1
12,13	Intake pipe and rising main	278-280 263-264	1 2
14	Pumps	487	5
15	Pump house	271-275	1
16	Delivery / distribution chamber	282-283	1

17	Electrical equipments and accessories	275-276	1
18	Valves and Water Hammer Contral Devices	633-635 281-282	1
19	Design of intake well	262-263	1
20	Design of intake pipe	264-267	1
21	Design of sump well	269-270	1
22	Specification of jack well	274-275	1
23	Pump house structure	272-273	1
24	Layout of rising main	280-281	1
25	Design of rising main	420-421	6
26-27	Computation of power requirement	209-213 238-241	1
28-29	Operation of lift irrigation scheme (Pump)	277-278	1
30-31	Economics of lift irrigation project	697-704	1
32	Norms for fixing economic water rate	283-285	1

**Practicals :**

1. Selection of site for lift irrigation scheme and reconnaissance survey,
- 2.3. Survey and mapping of field, including 'L' section
4. Estimation of water availability and computing water requirement
5. Design of intake well
6. Design of intake pipe
7. Design of sump well
8. Design of jack well
9. Computation of total head and power requirement
10. Selection of pump
- 11,12. Economic of lift irrigation project
13. Field visit to lift irrigation project

**BOOKS:****Text book/books**

<b>S.N</b>	<b>Title</b>	<b>Author</b>	<b>Publication</b>
1	Irrigation Theory and Practices (IInd edition 2008)	A.M.Michael	Vikas Publishing House Pvt. Ltd.
2	Technical Aspects of Agricultural Projects, Volume – 1		NABARD Publication, November 1989
3	Surveying & Leveling- I	T.P.Kanetkar & S.V.Kulkarni	Pune Vidyarthi Griha Prakashan - Pune
4	Irrigation Engineering and Hydraulic Structures	S.K.Garg	Khanna Publishers, Delhi
5	Water, Well and Pumps	A.M.Michael & S.D.Khepar	Tata McGraw Hill Publication Co. Ltd. New Delhi
6	A Text Book of Fluid Mechanics and Hydraulic Machines (Eighth edition)	R.K.Bansal	Laxmi Publications (p) Ltd. New Delhi

