Inter Faculty Department of Irrigation Water Management
Mahatma Phule Krishi Vidyapeeth
Rahuri-413 722, Dist. Ahmednagar (MS)

Doctoral Programme in Irrigation Water Management

Course Layout

Minimum Credit Requirements

Sr. No.	Subject	Minimum credit(s)
1.	Major	15
2.	Minor	08
3.	Supporting	05
4.	Seminar	02
5.	Research	45
	Total Credits	**75**
	Compulsory Non Credit Courses	06

Sr. No.	Course Number	Course Title	Credits
A) Major Subjects (Min.15 credits)			
1.	IWM - 611	Advances in Farm Irrigation System Design	2+1=3
2.	IWM - 612	Drought Climatology	2+1=3
3.	IWM - 613	Advances in Soil Physics	2+1=3
4.	IWM - 621	Diagnostic Analysis & Performance	2+1=3
5.	IWM - 631	Management of Saline, Sodic and Acidic Soils	2+1=3
B) Minor Subjects (Min. 08 credits)			
1.	IWM 614	Watershed Management and Modeling	2+1=3
2.	IWM 615	On Farm Water Management	1+1=2
3.	IWM-626	Soil, Water and Air Pollution	2+1=3
C) Supporting Subjects (Min. 06 credits)			
1.	SOILS-602	Advances in Soil Fertility	2+0=2
2.	IWM- 635	Remote Sensing and GIS Application in Agriculture	2+1=3

D) Seminar (02 credits)			
	IWM -691	Doctoral Seminar-I	0+1=1
	IWM -692	Doctoral Seminar-II	0+1=1
E) Doctoral Research (45 credits)			
		Doctoral Research	0+45=45
F) Non Credit Compulsory Courses (6 credits)			
1.	PGS-501	Library and Information Services	0+1=1
2.	PGS-502	Technical Writing and Communications Skills	0+1=1
3.	PGS-503	Intellectual Property and its Management in Agriculture	1+0 =1
4.	PGS-504	Basic Concepts in Laboratory Techniques	0+1=1
5.	PGS-505	Agriculture Research, Research Ethics and Rural Development Programmes	1+0 = 1
6.	PGS-506	Disaster Management	1+0=1

Course Contents

A) Major Courses

Course Title: ADVANCES IN FARM IRRIGATION SYSTEM DESIGN
Course No. IWM-611 2+1=3

Syllabus:

Resources inventory of irrigation in world and India. Surface irrigation; Evaluation of border, basin and furrow irrigation methods, Evaluation objectives. inflow-outflow, advance and recession opportunity time, surface storage, infiltration, different irrigation efficiencies. Design Objectives, data collection, Design of border, basin and furrow irrigation methods based on volume balance approach. Advances in surface irrigation systems- surge irrigation: effect of surging on surface flow hydraulics, cablegation: water supply management.

Sprinkler irrigation systems: planning factors, sprinkler uniformity and efficiency, pipe line hydraulics and economics. Lateral design, mainline design. Pressure requirement. Pump and power unit selection criteria. Evaluation of sprinklers, Atomization in sprinkler irrigation, modern sprinkler systems like micro, mini and gun sprinkler.

Design of rain gun sprinklers. Micro sprinklers and spray jet methods of irrigation and their utility. Trickle irrigation: hydraulics of drip irrigation, design of filters, emitter selection, lateral design and selection. Manifold and main line design. Evaluation of trickle irrigation. Automization in micro irrigation. Selection of proper irrigation system. Special uses of micro irrigation like Fertigation. Comparison of different fertigation methods. Cost estimation Evaluation. Concepts of some latest technologies like porous pipe irrigation

Suggested Readings:

1. Irrigation Theory and Practices (1978) by A.M. Michael
2. Land and Water Management Engineering by V.V.N. Murthi.
3. Trickle Irrigation for Crop Production: Design, Operation and Management by F.S. Nakayama and D.A. Bucks.
4. Sprinkle and Trickle Irrigation by Jack Keller and R.D. Bliesner
5. Trickle Irrigation design by Jack Keller and D. Karmeli.
6. Drip Irrigation by R.K. Sivanappan, O.Padmakumari and V. Kumar.
7. Design, Operation and Maintenance of Drip Irrigation, MPKV Pub. No.55
8. Sprinkler Irrigation by R.K. Sivanappan 1987.
9. Design of trickle irrigation by D. Karmeli and J. Keller.
10. Pillsbury AF. 1972. *Sprinkler Irrigation*. FAO Agricultural Development Paper No. 88, FAO.
11. Rydzewski 1987. *Irrigation Development Planning*. John Wiley & Sons.
12. FAO. 1982. *Mechanized Sprinkler Irrigation.* FAO Irrigation & Drainage Paper 35.
13. Surface Irrigation : Systems and Practice by Melvyn kay

Course Title: ADVANCES IN FARM IRRIGATION SYSTEM DESIGN

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1	Irrigation resources inventory in world and India	5
2-3	Evaluation of surface irrigation methods	10
4 & 6	Design concepts of surface irrigation methods	15
7	Effect of surging on surface flow hydraulics, cablegation	5
8 & 10	Sprinkler irrigation systems	15
11 & 13	Evaluation of sprinklers, modern sprinkler systems like micro, mini and gun sprinkler	15
14 & 15	hydraulics of drip irrigation, design of filters	15
16	Automization in micro irrigation. Selection of proper irrigation system.	10
17	Comparison of different fertigation methods	5
18	Cost estimation of PIS	5

Practical:

1	Basin irrigation evaluation
2	Border irrigation evaluation
3	Furrow irrigation evaluation
4	Estimation of seepage losses through unlined channel
5	Use of gated pipe for furrow and border irrigation
6	Sprinkler irrigation system components functions and testing.
7	Nozzle discharge measurement with pressure variation in system for different types of sprinklers.
8	Uniformity coefficient determination.
9.	Computation of head losses in system by different formulae.
10.	Case study on Design & layout of sprinkler system.
11.	Drip irrigation system components: functions and testing.
12.	Pressure-discharge relationship and emission uniformity measurement.
13.	Study of filtration capacity of drip irrigation.
14	Computation of head losses in the system.
15	Fertilizer application through ventury and fertilizer tank.
16	Design case study on drip irrigation.
17	Evaluation of drip irrigation system.

Course Title: DROUGHT CLIMATOLOGY

Course No. IWM-612 **2+1=3**

Syllabus:

UNIT I

Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation.

UNIT II

Definitions; causes, climatology of Draught. EL Nino and La Nina

UNIT III

Synoptic weather systems during droughts, drought indices and characteristics, significant drought in India, Agronomic practices during drought. Forest fire and drought, drought impact and assessment, Drought monitoring. Drought mitigation and advisory services, Drought prediction, appraisal and drought policy

UNIT IV

Crop weather forecasting, modification of microclimate through heat evasion and trapping, modification of weather through solar radiation management, case studies of successful micrometeorological applications.

Suggested Readings:

1. Michael Collier and Robert H. Webb 2002. Floods, droughts and climate change. University of Arizona Press
2. G. Satyanarayana 2018. Droughts, Drylands and Water Management in India New Century Publications
3. Deshpande Ajinkya, Gonjari Vikas and Surwase Atul (2015) Meteorological Drought Analysis. LAP Lambert Academic Publishing

IWM-613 ADVANCES IN SOIL PHYSICS 2+1=3

Syllabus:

UNIT I

Colloidal properties of soil clays, DDL, flocculation, non-ionic adsorption, Forces and energy in water-van der walls forces, London forces. Theory of flow of water through saturated soils, water movement-Steady state and isothermal moisture flow-Darcy's law, Laplace equation and boundary value problems

UNIT II

Transient state and isothermal moisture flow, Fundamental concepts of unsaturated flow, water diffusivity. Water infiltration, simultaneous movement of water and other materials. Miscible displacement – Types of flow, mathematical models for miscible displacement,

UNIT III

Gaseous diffusion in soils: Ficks law and differential equations of gaseous diffusion. Gas transport in the soil environment, Soil air and plant response-Direct effect. Indirect effect, measurement of soil aeration,

UNIT IV

Temperature- Thermal properties of soil. Thermal conductivity, diffusivity of soil, different methods-Smith, Micklay Gemants and Johnsons methods. Mathematical equations for heat flow, Fouriers law, Non steady state, heat flow,

UNIT V

Water flow in soil.Infiltration, evaporation horizontal and vertical infiltration into soil, numerical examples, Evaporation, soil aeration mass flow, conduction, diffusion gas phase, movement in soils, numerical example, Soil water characteristics curves, hysteresis, Solute potential-problems. Soil- plant –Atmosphere relations, radiation, energy budget. Estimating evapotranspiration from climato-logical and soil data, crop coefficient, numerical examples

Suggested Readings:

1. Baver LD, Gardner WH & Gardner WR. 1972. Soil Physics. John Wiley & Sons.
2. Hanks and Ascheroft. 1980. Applied Soil Physics. Springer Verlag.
3. Hillel D. 1980. Applications of Soil Physics. Academic Press.
4. Hillel D. 1998. Environmental Soil Physics. Academic Press.
5. Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
6. Kirkham, D. & Powers, W L. 1972. Advanced Soil Physics. Wiley Interscience.
7. Lal R & Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
8. Oswal MC.1994. Soil Physics. Oxford & IBH.

IWM-613 ADVANCES IN SOIL PHYSICS 2+1=3

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1 - 2	Colloidal properties of soil clays	10
3 - 4	Theory of flow of water through soils	5
5 & 6	Laplace equation and boundary value problems	10
7 - 9	Fundamental concepts of unsaturated flow	10
10 -12	mathematical models for miscible displacement	15
13	Soil air and plant response-Direct an indirect effect	5
14 & 15	Thermal properties of soil	20
16- 17	horizontal and vertical infiltration into soil	10
18	Soil water characteristics curves,	5
19	Soil- plant –Atmosphere relations	5
20	Estimating evapotranspication from climato-logical and soil data	5

Practical:

1	Water content of soils by neutron thermalization method.
2	Water content of soils by calcium carbide method.
3	Specific surface of soil by glycol method.
4	Soil moisture and tension relationships by sintered Glass Funnel method capillary and non-capillary porosity.
5	Determination of pore size distribution and specific water capacity of soil.
6	Determination of soil water diffusivity by Bruce and Klute method.
7	Measurement of soil strength by weighing type penetroneter.
8	Measurement of permeability of soil.
9	Measurement of soil temperature by use of thermocouples thermistore.
10	Determination of oxygen diffusion rates of soil.
11	Measurement of net radiation.
12	Measurement of crop canopy temperature by infrared thermometer.
13	Determination of saturated hydraulic conductivity of soil by augar hole method.

14	Determination of leaf water potential by pressure chamber apparatus.
15 & 16	Soil moisture and tension relationship with the use of pressure plate apparatus.

Course Title: DIAGNOSTIC ANALYSIS & PERFORMANCE EVALUATION OF IRRIGATION PROJECTS

Course No. IWM-621 2+1=3

Syllabus:

UNIT I

Basic concepts of diagnostic analysis, objectives, activities. Fundamental of conceptual framework for performance evaluation of irrigation project. Study and measurement of performance parameters.

UNIT II

The development model, reconnaissance survey, physical, cropping system, economic, social and organizational system, importance of data and data base management in decision making process

UNIT III

Interaction of productivity and water use efficiency under different fertility levels. Efficient utilization of irrigation water. Operational management of irrigation networks. Participatory irrigation water management. Equitable water distribution in command area.

UNIT IV

Socioeconomic, political and organizational implication in management of irrigation systems. Irrigation behaviour and decision making, special analysis of irrigation, evaluation of environmental impacts of irrigation systems.

UNIT V

Pricing irrigation water. economics of irrigation system farm budget,
cash flow technique. Case studies

Suggested Readings:

Irrigation Theory and Practices by A.M. Micheal

Special course on " Dignostic Analysis for Trainers", WALMI, Aurangabad (May 27-July 6, 1985).
Operation and management of irrigation system WALMI Publ. No. 20, 1987.
Warabandi systems and its infrastructure. Pub. No. 157, Central Board of Irrigation and Power, New Delhi, April 1982.
On farm development works. WALMI Publ. No. 12, 1986.
Warabandi for Irrigated Agriculture in India. Pub. No. 146, Central Board of Irrigation and Power, New Delhi, June, 87.
Irrigation Engineering and hydraulics Structures by S.K. Garg.
Report on diagnosis analysis of Nirgudi. Minor irrigation scheme, WALMI, Pub. 24, Aurangabad 1984.
Special course on diagnosis analysis of minor irrigation schemes. D.A. concept and techniques WALMI, Publ. No. 11.

IWM 621 DIAGNOSTIC ANALYSIS & PERFORMANCE EVALUATION OF IRRIGATION PROJECTS 2+1=3

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1 & 2	Concepts of diagnostic analysis	5
3-4	performance evaluation of irrigation project	10
5 & 6	The development model, reconnaissance survey	5
6 - 7	physical, cropping system, economic, social and organizational system	15
8 -9	data base management in decision making process	15
10	productivity and water use efficiency under different fertility levels	5
11-12	Efficient utilization of irrigation water	10
13- 14	Equitable water distribution in command area	15
15-16	evaluation of environmental impacts of irrigation systems	10
17	economics of irrigation system farm budget	5
18	Case studies	5

Practical:

1.	Study of soils and topography of commend area

2-3	Study of cropping pattern of command area
4	Study of information/data of command area
5-6.	Study of reconnaissance survey of main irrigation system
7-8	Study of field tests and measurement of canal flow
9	Preliminary analysis and data verification of command area project
10.	Study of data analysis and synthesis
11.	Identification of values and constraints and prioritizing solutions
12.	Study of social organization in a command area
13.	Compilation and report writing of D.A.
14-15	Report presentation by individual team and evaluation

Course Title: MANAGEMENT OF SALINE, SODIC AND ACIDIC SOILS

Course No. IWM-631 2+1=3

Syllabus:

UNIT I

Processes and factors of soil formation, physical and chemical properties of soils, Texture, structure, soil reaction (pH), soil air, soil temperature, classification of soils of Maharashtra.

UNIT II

Essential plant nutrients, their functions. Organic manures, Types of fertilizers, methods of fertilizer application, fertilizer use efficiency.

UNIT III

Land use capability classification and irritability classification, soil physical environment and plant growth. Characteristics of saline, saline-sodic soils, crop tolerance to salinity and alkalinity, acid soils, Effects of salts on plant nutrient availability in problem soils, fertilizer and cultural management in saline and alkali soils, G.R., L.R. use of brackish water for irrigation. \

UNIT IV

Quality of irrigation water, use of saline water for crop production, methods and types of drainage. Methods and models for assessing the suitability of saline water for irrigation and crop production. Management principles and practices for safe use of saline water

Suggested Readings:

1. Daji, J.A., J.R. Kadam and N.D. Patil. 1999. A text book of Soil Science, Media promoters and publishers Mumbai.
2. Dakshinamurthi, C. Advances in Soil Physics, ICAR, Publication, New Delhi.
3. Ghildyal B.P. and R.P. Tripathi. Soil Physics, Wiley eastern Ltd., New Delhi.
4. Hillel, D. 1980. Application of Soil Physics, Academic Press, New York.
5. Kadam, J.R. and B.P. Ghildyal 1992. Dictionary of Soil and Water Management Nirali Prakashan Pune-2.
6. Mortvedt, J.J., Shuman, L.M., Cox, F.R. and Weich, R.M. (ed) 1991. Micronutrients in Agriculture, Soil Science Society of Americal.
7. Oswal, M.C. 1994. Soil Physics-Oxford IBH, New Delhi.
8. Rhoades, J.D., A. Kandiah and A.M. Mashali. 1992. The use of saline waters for crop production, FAO, 48.
9. Richards, L.A. 1968. Diagnosis and improvement of saline and alkali soils. Hand book No.60.
10. Singh, Dhyan, Chhonkar, P.K. and Pandey, R.N. 1999. Soil Plant Water Analysis. A methods manual I.A.R.I. New Delhi.

IWM 631 MANAGEMENT OF SALINE, SODIC AND ACIDIC SOILS 2+1=3

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1	Processes and factors of soil formation	5
2-3	physical and chemical properties of soils,	10
4	classification of soils of Maharashtra	5
5-6	Essential plant nutrients, their functions	10
7-8	Types of fertilizers, methods of fertilizer application, fertilizer use efficiency.	10
9-10	Land use capability classification and irrigability classification	10
11-12	Characteristics of saline, saline-sodic soils	10
13-15	Effects of salts on plant nutrient availability in	20

	problem soils, cultural management in saline and alkali soils	
16	Quality of irrigation water	5
17-19	Methods and models for assessing the suitability of saline water for irrigation and crop production.	15

Practical:

1.	Soil water measurement by neutron probe
2	Soil water measurement by tensiometer
3-4	Determination of soil moisture characteristic curve with the help of pressure plate and pressure membrane apparatus.
5-6	Determination of hydraulic conductivity by constant head method
7	Measurement of leaf water potential
8	Determination of canopy temperature by infrared thermometer
9	Gypsum requirement of sodic soils
10-12	Water quality parameters pH, EC, SAR and RSC.
13-14	Characterization of saline/sodic soils.

B) Minor Courses

Course Title: WATERSHED MANAGEMENT AND MODELING

Course No. IWM-614 2+1=3

Syllabus:

UNIT I

Morphological characteristics of watershed. Computation of runoff volume and peak rate of runoff.

UNIT II

Types of soil erosion and their preventive measures. Different in situ soil and water conservation measures on arable and non arable lands. Integration of in situ and ex situ rainwater harvesting structures.

UNIT II

Water storage structures- Nala bunds, farm ponds, percolation tanks. Study of water balance in the watershed. Planning of watershed development considering the water harvesting and recycling, management of excess/deficit water. India's watershed development program

UNIT III

The role of hydrology models: Objectives and concepts. Types of models. Model components. Modelling procedures: problem definition, boundary identification, data requirements, calibration and validation. Designing a conceptual model

UNIT IV

Rainfall-runoff models: conceptual models, unit hydrograph models, mechanistic catchment models. Sensitivity analysis, parameterisation, calibration, validation, and evaluation. Stanford Watershed model

Suggested Readings:

1. Isobel W Heathcote**.** 1998. Integrated Watershed Management: Principles and Practice. Wiley Publ.
2. Vijay P. Singh and Donald K. Frevert. 2005. Watershed Models. CRC Press, Taylor and Francis Group
3. Kenneth N Brooks, Peter F Ffolliott, Hans M Gregersen, Leonard F DeBano. 1991. Hydrology and the Management of Watersheds. Wiley-Blackwell
4. Singh G. and Shastri Manual of soil and water conservation works

IWM-614 WATERSHED MANAGEMENT AND MODELING 2+1=3

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1	Characteristics of watershed	5
2-3	Computation of runoff volume and peak rate of runoff.	5
4 & 5	Types of soil erosion and their preventive measures.	5
6 - 7	in situ soil and water conservation measures on arable and non arable lands	10

8 -9	Water storage structures	10
10	ex situ rainwater harvesting structures	5
11-12	Planning of watershed development	10
13- 14	management of excess/deficit water	5
15-16	The role of hydrology models, Objectives and concepts	20
17	Designing a conceptual model	10
18	Rainfall-runoff models	5
19	Sensitivity analysis	5
20	Stanford Watershed model	5

Practical:

1.	Exercise on watershed delineation
2-3	Determination of morphological characteristics of watershed
4	Probability analysis of rainfall data
5-6	Computation of runoff volume
7	Computation of peak rate of runoff
8-9	Determination of soil loss with universal soil loss equation
10	Study of water balance in the watershed
11-12	Study of hydrology models
13-14	Study of watershed models
15-16	Visit to watershed and NGO

Course Title: ON FARM WATER MANAGEMENT

Course No. IWM-615 **1+1=2**

Syllabus:

UNIT I

Approaches and concepts of micro distribution network, survey and mapping, planning

UNIT I

Structures of field channels, estimates of O.F.D. works construction, operation and testing maintenance of O.F.D. works.

UNIT II

Land shaping, farmers involvement, development, centroid method of land leveling, laser beam land leveling. Operation control signals.

UNIT III

Irrigation scheduling, cropping system, water measuring devices, equivalence of crops, irrigation efficiencies and crop yield.

UNIT IV

Design of chalk, management of one cusec flow use of siphon tubes, irrigation equipments, evaluation of MAD values, on farm water measurement, irrigation efficiencies, water users association, role of NGOs and Govt. in Planning and execution of on farm water management

Suggested Readings:

1. Irrigation theory and practice by A.M. Michel 1978
2. Principles of Agriculture Engineering Volume II by A.M. Michel and T.P. Ojha. 1978
3. On farm development work including micro-distribution network and land shaping for irrigation WALMI Publication No. 12.

IWM-615 ON FARM WATER MANAGEMENT 1+1=2

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1 - 2	Approaches and concepts of micro distribution network,	3
3 -4	Survey and mapping, planning	3
5	Structures of field channels	2
6	Estimates of O.F.D. works	2
7- 8	Construction, operation and testing maintenance of O.F.D. works	3

9 -10	Land shaping, development, centroid method of land leveling,	3
11- 12	Laser beam land leveling. Operation control signals	2
13	Irrigation scheduling	2
14	Cropping system	1
15	Water measuring devices	2
16-17	Irrigation efficiencies and crop yield	2
18-19	Design of chalk	2
20-22	Management of one cusec flow use of siphon tubes, irrigation equipments	2
23-24	Evaluation of MAD values	2
25-26	On farm water measurement, irrigation efficiencies,	3
27-28	Water users association	3
29-30	Role of NGOs and Govt. in Planning and execution of on farm water management	3

Practical:

1.	Planning of O.F.D. structures
2	Use and working of O.F.D. structures
3-4	Land leveling by different methods : conventional and centriod
5	Irrigation scheduling-different approaches
6	Water measuring devices-Notch's, weirs, flumes, orifices etc.
7	Equivalence of crops evaluation of cropping systems
8	Design of chak
9	Management of one cusec flow using siphon tube.
10	Evaluation of MAD values
11-12	Determination of irrigation efficiencies application, storage and distribution efficiency.
13	Study of water users association role and functioning

Course Title: SOIL, WATER AND AIR POLLUTION

Course No. IWM-626 **Credit: 2+1=3**

Theory

UNIT I

Soil, water and air pollution, problems associated with agriculture, nature and extent. Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides,

acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings.

UNIT II

Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal.

UNIT III

Pesticides – their classification, behavior in soil and effect on soil microorganisms. Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health. Pollution of water resources due to leaching of nutrients and pesticides from soil

UNIT IV

Emission of greenhouse gases – carbon dioxide, methane and nitrous oxide. Remediation/amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution

Suggested Readings

1. Lal R, Kimble J, Levine E & Stewart BA. 1995. Soil Management and Greenhouse Effect. CRC Press.
2. Middlebrooks EJ. 1979. Industrial Pollution Control. Vol. I. *Agro-Industries*. John Wiley Interscience.
3. Ross SM. 1980 Toxic Metals in Soil Plant Systems. John Wiley & Sons.
4. Vesilund PA & Pierce 1983. Environmental Pollution and Control. Ann Arbor Science Publ.

IWM-626 SOIL, WATER AND AIR POLLUTION 2+1=3

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1 - 2	Soil, water and air pollution	5
3	problems associated with agriculture	5
4-5	agricultural, industrial, urban wastes	5
6-8	fertilizers and pesticides, acid rains, oil spills etc.; air,	10

	water and soil pollutants - their CPC standards and effect on plants, animals and human beings. Nature and sources of pollutants	
9-10	Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal	10
11-13	Pesticides – their classification, behavior in soil and effect on soil microorganisms. Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.	10
14-15	Pollution of water resources due to leaching of nutrients and pesticides from soil	5
16-17	Toxic elements – their sources	5
18-19	Pollution of water resources	5
20-21	Emission of greenhouse gases – carbon dioxide, methane and nitrous oxide	10
22-23	Remediation/amelioration of contaminated soil and water	5
24-25	Monitoring and management of soil and water pollution.	5

Practical:

1-2	Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants
3-4	Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD)
5-6	Determination of nitrate and ammoniacal nitrogen
7	Determination of phosphorus content in effluents
8-9	Heavy metals in contaminated soils and plants
10	Management of contaminants in soil and plants to safeguard food safety
11-12	Air sampling and determination of particulate matter and oxides of sulphur
13-16	Visit to various industrial sites to study the impact of pollutants on soil and plants

Course Title: REMOTE SENSING AND GIS APPLICATIONS IN AGRICULTURE

Course No. IWM-635 **Credit: 2+1=3**

Theory

UNIT I

Basic principles of remote sensing. components of remote sensing : signals, sensors and sensing systems : active and passive remote sensing ; Electromagnetic spectrum, characteristics of electromagnetic radiation, Energy interaction with matter; spectral features of earth's surface features; imaging and non imaging systems; framing and scanning systems;

UNIT II

Resolution of sensors; sensors platforms, their launching and maintenance; data acquisition system, data preprocessing, storage and dissemination

UNIT III

Digital image processing and information extraction; microwave remote sensing; visual and digital image interpretation; introduction to Geographical Information System (GIS) and GPS. Digital techniques for crop discrimination and identification; crop stress detection

UNIT IV

GIS and remote sensing for land and water resources data collection, inventory of ground water and satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation; soil resource inventory; land use/land cover mapping and planning; Integrated watershed development; crop yield modeling and crop production forecasting

Suggested Readings

1. Curan, P.J. Principles of Remote sensing, ELBS/Longman.
2. Jain, A.K. 1989. Fundamentals of Digital Image Processing, Prentice Hall of India,
3. Saddle river, NJ. Kamat, D.S. and Sinha, S.K. (eds)1984. Proceedings of the Seminar on Crop Growth Condition and Remote Sensing, June 22-23, ICAR & ISRO.
4. Lillesand T.M. and Kiffer, R.W. Remote Sensing and image interpretation, John Wiley & sons.
5. Sabins, F.F. 1997. Remote Sensing-Principles and Interpretation, 3rd ed. WH Freeman
6. Panda B.C. 2005 Remote sensing Principles and applications viva books private limited

IWM-635 REMOTE SENSING AND GIS APPLICATIONS IN AGRICULTURE 2+1=3

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1- 2	Basics of Remote Sensing	5
3-4	Characteristics of Electromagnetic Radiation	5
5	Interaction of EMR with matter, Earth's Surface	5
6-7	Remote sensor in Visible, Infrared and Micro-wave Regions	5
8-9	Imaging and Non imaging Systems, Framing and Scanning System	5
10-11	Resolution of Sensor, sensor platforms	5
12-13	Digital Image Processing	10
14-15	Microwave Remote Sensing	5
16-17	Visual and Digital Image Interpretation	10
18-19	Introduction to GIS and GPS	5
20-21	Crop Identification, crop stress detection	5
22-23	Crop Stress Detection	5
24-25	Soil Moisture & Temperature Assessments, Inventory of Ground Water	5
26-30	Soil resources inventory, Integrated Watershed Development	5

Practical:

1-2	Interpretation of Arial photographs for mapping
3-4	Interpretation of satellite image for mapping
5-6	Study of ERDAS, image processing software
7-8	Study of image enhancement; image classification methods
9-10	Familiarization with remote sensing and GIS hardware, software and their principle of working
11-12	Comparison between ground truth and remotely sensed data
13-14	Study of ArcView/ArcGIS package
15-16	Use of ArcView/ArcGIS package for Crop acreage estimations
17-18	Use of ArcView/ArcGIS package for water resources assessment

C) Supporting Courses

Course Title: ADVANCES IN SOIL FERTILITY

Course No.SOILS-602 **Credit: 2+0=2**

Theory

UNIT I

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices. Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants

UNIT II

Models for transformation and movement of major micronutrients in soils. Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils.

UNIT III

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting. Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

UNIT IV

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use

Suggested Readings

1. Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.
2. Barker V Allen & Pilbeam David J. 2007. *Handbook of Plant Nutrition*.CRC / Taylor & Francis.
3. Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed.Pearson Educ.
4. Cooke GW. 1979. *The Control of Soil Fertility*. Crossby Lockwood &Sons.
5. Epstein E. 1978. *Mineral Nutrition of Plants - Principles and Perspectives*.Wiley Eastern, New Delhi.
6. Kabata- Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC /Taylor & Francis.
7. Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
8. Mortvedt JJ, Shuman LM, Cox FR & Welch RM. (Eds.). 1991.*Micronutrients in Agriculture*. 2nd Ed. Soil Science Society ofAmerica, Madison.
9. Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
10. Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen,Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
11. Stevenson FJ. (Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.101
12. Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1990. *Soil Fertility and Fertilizers*. 5th Ed. Macmillan Publ.
13. Wild A. (Ed.). 1988. *Russell's Soil Conditions and Plant Growth*. 11th Ed.Longman.

SOILS-602 ADVANCES IN SOIL FERTILITY 2+0=2

Theory:

Lecture No.	Topics to be covered	Weightage in Marks
1- 2	Modern concepts of nutrient availability;	5
3-4	Soil solution and plant growth; nutrient response functions and availability indices.	10
5-6	Nutrient movement in soils; nutrient absorption by plants;	5
7-8	mechanistic approach to nutrient supply and uptake by plants	5
9-10	Models for transformation and movement of major micronutrients in soils.	5

11-12	Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils	5
13-14	Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.	10
15-16	Modern concepts in fertilizer application; soil fertility evaluation techniques;	5
17-18	Role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture	10
19-20	Monitoring physical, chemical and biological changes in soils	5
21-22	Permanent manurial trials and long-term fertilizer experiments	5
23-24	Soil productivity under long-term intensive cropping;	5
25-26	Direct residual and cumulative effect of fertilizer use	5

F) Seminar (02 credits)			
	IWM -691	Doctoral Seminar-I	0+1=1
	IWM -692	Doctoral Seminar-II	0+1=1
G) Doctoral Research (45 credits)			
		Doctoral Research	0+45=45
F) Non Credit Compulsory Courses (6 credits)			
1.	PGS-501	Library and Information Services	0+1=1
2.	PGS-502	Technical Writing and Communications Skills	0+1=1
3.	PGS-503	Intellectual Property and its Management in Agriculture	1+0 =1
4.	PGS-504	Basic Concepts in Laboratory Techniques	0+1=1
5.	PGS-505	Agriculture Research, Research Ethics and Rural Development Programmes	1+0 = 1
6.	PGS-506	Disaster Management	1+0=1