5 Agricultural Physics

TRIMESTER WISE DISTRIBUTION OF COURSES

I TRIMESTER

		L	P
AP 500	BASIC CONCEPTS OF PHYSICS - I	4	1
AP 503/ SSAC 503	FUNDAMENTALS OF SOIL PHYSICS	3	1
AP 504	MATHEMATICS IN AGRICULTURE	3	0
AP 530/ WST 530	FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY	3	1
AP 613	ADVANCE SOIL PHYSICS II	2	1
AP 632	SATELLITE AGROMETEOROLOGY	2	1
AP 691	SEMINAR	1	0

II TRIMESTER

AP 501	BASIC CONCEPTS OF PHYSICS - II	3	1
AP 505/ SSAC 505	SOIL GENESIS, CLASSIFICATION AND SURVEY	2	2
AP 520	PRINCIPLES OF BIOPHYSICS	3	1
AP 540	PRINCIPLES OF REMOTE SENSING	3	1
AP 610	PHYSICS OF SOIL AND WATER EROSION AND THEIR CONTROL	2	1
AP 630	CROP MICROMETEOROLOGY	2	1
AP 612	ADVANCE SOIL PHYSICS I - SOIL WATER AND NUTRIENT TRANSPORT	3	1
AP 691	SEMINAR	1	0

III TRIMESTER

AP 502/ SSAC 502 /AG 502	SOIL FERTILITY AND NUTRIENT MANAGEMENT	3	1
AP 506	PRINCIPLES OF PHYSICAL TECHNIQUES IN AGRICULTURE	3	1
AP 507	PHYSICS OF RADIATION INTERACTIONS IN AGRICULTURE	3	0
AP 508	INTRODUCTION TO NANOTECHNOLOGY	2	0
AP 511/ AG 511	CROP ECOLOGY AND AGROMETEOROLOGY	3	1

AP 541	GIS AND GPS – PRINCIPLES AND APPLICATIONS	2	1
AP 611/ SSAC 611	SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH	3	1
AP 631	EVAPOTRANSPIRATION	2	1
AP 640	REMOTE SENSING IN AGRICULTURE	2	1
AP 691	SEMINAR	1	0

Core Courses

M.Sc.: AP 500, AP 501, AP 503, AP 504, AP 520, AP 530 and AP 540

AGRICULTURAL PHYSICS

Major Fields : Agricultural Physics

Minor Fields : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AP 500 BASIC CONCEPTS OF PHYSICS-I (4L+1P) I

Objective

To impart knowledge on the concepts of physics and physics laws.

Theory

UNIT I

Linear, circular, relative motions, conservation of mass, energy and momentum, forces in nature, range of their operation, action at a distance, gravitational field, potential.

UNIT II

Elasticity, stress-strain relations – moduli of elasticity, Hooke's law, molecular and structural basis of strengths of materials, hydrostatic pressure; surface tension, capillary rise, contact angle, hydrodynamics – laminar and streamline flow, Poiseuille's equation, Stoke's law.

UNIT III

Thermometry, measurement of heat, specific heat, transfer of heat - conduction, convection and radiation, Change of phase, equation of state, vapour pressure and relative humidity, laws of thermodynamics, free energy, chemical potential.

UNIT IV

Kinetic theory of gases, Brownian motion, mean free path, simple harmonic motion, concepts of phase, phase difference, interference and reflection of sound waves, ultrasonic, applications.

UNIT V

Wave theory of light, Huygen's principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; electromagnetic theory of light, geometrical optics, aberrations, resolving power, principles of optical instruments, illuminated and luminous objects and light sources; luminescence, incandescence, fluorescence, auto-fluorescence, phosphorescence, bio-luminescence, qualitative and quantitative measurement of light, colour, optical spectrometry.

UNIT VI

Electric charges, potential, field, intensity and strength of electric field, current, Coulomb's law, dielectrics, capacitance, electrostatic units, resistance, resistivity, Ohm's law, steady currents in conductors, insulators and semi conductors, magnetic materials, induced magnetism, electromagnetism, measurement of magnetic field, geomagnetism, effects of the earth's magnetic field on life, electromagnetic inductions and applications, electromagnetic units.

Practicals

Use of the instruments :Vernier/Screw Gauge/Spherometer, Sextant, Surface Tension, Viscosity, Interference Phenomenon, Optical Instruments (diffraction grating), Resistivity measurement (Potentiometer/Wheatstone bridge), Young's Modulus

Suggested Readings

Charles Kittel, Walter Knight, Malvin A. Ruderman. 1973. B*erkeley physics course: Mechanics*, Vol. 1, McGrow-Hill, Newyork.

David Halliday, Robert Resnick, Jearl Walker. 1997. *Fundamentals of Physics*, Wiley, Newyork.

Edward M. Purcell. 1985. *Berkeley physics course: Electricity and Magnetism* Vol. II. McGrow-Hill, Newyork.

Frank S. Crawford, Jr. 1968. *Berkeley physics course: Waves*. Vol. III. McGrow-Hill, Newyork.

Hugh D. Young, Roger A. Freedman. 2003. *University Physics with Modern Physics*, Menlo Park, California.

Krishna, Ram. 1960. *General Properties of Matter*, Kitab Mahal, Allahabad.

Mathur, D.S. 1956. *Elements of Properties of Matter*, S Chand & Co, New Delhi.

Richard P. Feynman, Robert B. Leighton and Matthew Sands. 1969. *The Feynman Lectures on Physics*. Addison-Wesley.

Sengupta, P.C. and Kohli, B.S. 1967. *Text Book of Physics*, Vol I, II, Kitab Ghar, New Delhi.

Any Graduate level Text book of Physics, Lecture notes/hand-outs given in selected classes.

AP 501 BASIC CONCEPTS OF PHYSICS- II (3L+1P) II

Objective

To impart knowledge on the modern concepts of physics and physics laws.

Theory

UNIT I

Maxwell's theory of electromagnetism, atomic structure, avogadro hypothesis and molecules, atomic and molecular weights, atomic sizes, quantum mechanics: uncertainty principle, De-Broglie hypothesis, wave function, Eigen state, Schrodinger equation.

UNIT II

Spectroscopy: atomic and molecular spectra, cathode rays; positive rays; radio activity; alpha-, beta-, and gamma- rays; detection and measurement of radiation; Rutherford's theory of the scattering of alpha particles; X-rays, nature and properties; scattering of X-rays by atoms; diffraction of X-rays and Bragg's law; characteristic X-ray spectra.

UNIT III

Planck's quantum theory of thermal radiation; quantum theory and photo-electric effect; elements of special theory of relativity, atomic nucleus and its constitution, angular momentum of the nucleus; nuclear transmutation of elements; proton-neutron hypothesis; cosmic rays; elementary particles.

UNIT IV

Natural radioactivity, types of radiations, their interaction with matter and decay; isotopes; isotopic masses and abundances; mass spectrograph and mass spectrometers; stable isotopes; atomic masses,

packing fractions and binding energies, theory of radioactive disintegration; half life and mean life; Mass spectrometer.

UNIT V

Nuclear fission, fusion, nuclear reactions, neutron moderation, nuclear energy, atomic power; production of artificial isotope.

UNIT VI

Physical principles of radiation detection; types of radiation detectors; efficiency of detectors; uses of radiation detectors, Elements of radioactive sources, handling, radiation protection and cardinal principles of radiation safety.

Practicals

Safe Handling of radioisotopes, Characteristics of GM counters, half life of a radioactive isotope, dead time of GM counter, Estimation of linear absorption coefficient of a material, Characteristics and Calibration of scintillation counter using CS-137 source, Determination of strength of gamma sources using multichannel analyzer

Suggested Readings

Burcham, E. 1995. *Nuclear Physics*, ELBS/Longman.

Chandrasekharan, H. and Gupta, Navindu. 2006. Fundamentals of Nuclear Science: Application in Agriculture, Northern Book Centre, New Delhi.

David Halliday, Robert Resnick, Jearl Walker. 1997. Fundamentals of Physics, Wiley, Newyork.

Eyvind H. Wichmann. 1971. Berkeley physics course: Quantum physics. Vol IV. McGraw Hill, New York.

Hugh D. Young, Roger A. Freedman. 2003. University Physics with Modern Physics, Menlo Park, California.

Kapoor, S.S. and Ramamurthy, V.S. 1986. Nuclear Radiation Detectors, Wiley Eastern Ltd, New Delhi.

Pochin.E. 1983. Nuclear Radiation: Risks and Benefits, Clarendon Press, Oxford.

Rajam, J.B. 2000. Atomic Physics, S Chand and Co, New Delhi.

Richard P. Feynman, Robert B. Leighton and Matthew Sands. 1969. The Feynman Lectures on Physics. Addison-Wesley.

Slater, John C. 1960. Quantum Theory of Atomic Structure, Vol.1, McGraw Hill, New York.

Any Graduate level Text book of Physics, Lecture notes/hand-outs given in selected classes

AP 502/ SSAC 502/ AG 502 SOIL FERTILITY AND NUTRIENT MANAGEMENT (3L+1P) III

Objective

To teach basics of soil fertility evaluation, techniques of soil fertility evaluation, plant nutrients, integrated approach of plant nutrition, and environmental quality.

Theory

UNIT I

Historical aspects of soil fertility, essential plant nutrients: criteria of essentiality, classification, functions, deficiency and toxicity symptoms, beneficial elements.

UNIT II

Carbon cycle in nature, carbon stocks, sequestration, greenhouse effects, different carbon pools in soil and their role in maintaining soil quality and productivity; soil organisms and their role in soil fertility.

UNIT III

Transformations and dynamics of major- and micro-nutrients in soils and their availability to plants.

UNIT IV

Nutrient interactions in soils and plants: Concept, different types of interaction, interaction among essential plant nutrients, law of minimum and maximum.

UNIT V

Commercial fertilizers, new fertilizer material and principles of their evaluation, crop response to fertilizer application and use efficiency, economics of fertilizer use, nutrient requirements of crops and cropping systems in sustainable agriculture and quality of the produce, foliar nutrition of crop plants.

UNIT VI

Soil fertility evaluation: Different approaches, soil and plant tests, biological tests, hidden hunger, critical nutrient concentration- concept and determination (graphical and statistical procedures), critical nutrient range, diagnosis recommendation and integrated system (DRIS)

UNIT VII

Integrated nutrient management (INM): Concept, objectives and components; organic farming: principles, practice and its impact on soil processes; precision farming: concept and practices. Organic manures including compost, farmyard manure, green manure and crop residues.

UNIT VIII

Fertilizer x water interactions, crop production under fertilizer / water constraints, site-specific nutrient management: concept and practices; summary of long-term fertilizer experiments

Practicals

Soil and plant sampling and processing for chemical analysis; determination of soil pH, total and organic carbon in soil; chemical analysis of soil for total and available nutrients (major and micronutrients); analysis of plants for essential elements (major and micronutrients)

Suggested Readings

Brady, N.C. and Weil, R.R. 2002. *The Nature and Properties of Soils*. 13th Edition. Pearson Education, New Delhi. .

Epstein, E. and Bloom, A. 2005. *Mineral Nutrition of Plants: Principles and Perspective*s. Second edition. Sinauer Associates.

Fageria, N.K., Baligar, V.C. and Jones, C.A. 1991. *Growth and Mineral Nutrition of Field Crops*. Marcel Dekker.

Goswami, N.N., Rattan, R.K., Dev, G., Narayanasamy, G., Das, D.K., Sanyal, S.K., Pal, D.K. and Rao, D.L.N. 2009. *Fundamentals of Soil Science*. Second Edition. Indian Society of Soil Science, New Delhi.

Havlin, J. L., Beaton, J. D., Tisdale, S. L. and Nelson W. L. 2006. *Soil Fertility and Fertilizers* (7th Edn.) Prentice Hall, New Delhi.

Khasawneh, F.E., Sample, E.C. and Kamprath, E.J. (Editors) 1980. *The Role of Phosphorus in Agriculture*. Soil Science Society of America, Madison, Wisconsin, USA.

Marschner, H. 1995. *Mineral Nutrition of Higher Plants*. Second Edition. Academic Press, London.

Mortvedt, J.J., Cox, F.R., Shuman, L.M. and Welch, R.M. (Editors) 1991. *Micronutrients in Agriculture*, Second Edition. Soil Science Society of America, Madison, Wisconsin, USA.

Pierzynski, G.W., Sims, J.T. and Vance, G.F. 2002. *Soils and Environmental Quality*, Second Edition. CRC Press, Boca Raton.

Prasad, R. and Power, J.F. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press, Boca Raton.

Srivastava, P.C. and Gupta, U.C. 1996. *Trace Elements in Crop Production*. Oxford and IBH, New Delhi.

Stevenson, F.J. (Editor) 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison, Wisconsin, USA.

Stevenson, F.J. 1986. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulfur and Micronutrients*. John Wiley and Sons, New York.

Sumner, A.M.E. (Editor) 2000. *Handbook of Soil Science*. CRC Press, Boca Raton, USA.

Tandon, H.L.S. (Editor) 1995. *Management of Nutrient Interactions in Agriculture*. FDCO, New Delhi.

AP 503/ SSAC 503 FUNDAMENTALS OF SOIL PHYSICS (3L+1P) I

Objective

To impart knowledge (both theoretical and practical) about the mechanism governing the behaviour of soil and its role in the biosphere for its proper management.

Theory

UNIT I

Basic principles of physics applied to soils viz. viscosity, surface tension, capillarity, stress-strain relations, gaseous diffusion, heat transport, thermodynamic principles; Properties of water in relation to porous media.

UNIT II

Physical characterization of soil; Soil as a polyphase system; Mass-volume relationships

UNIT III

Particle size distribution; soil texture; mechanical analysis; specific surface; clay-a colloidal surface; hydration of clays.

UNIT IV

Soil structure and aggregation: genesis, classification and evaluation; soil structural stability and indices; soil tilth; soil conditioners.

UNIT V

Geometry of pore space and pore size distribution; inter- and intra-aggregate pores; Soil consistency and its limits; consistency and deformation of cohesive soils; compaction and crusting in soils; soil strength and its measurement;

UNIT VI

Geometry of water phase; energy state of soil water; water content and potential and their measurement; different components of soil water potential; Soil water characteristic, hysteresis and available water;

UNIT VII

Flow of water in soil; Darcy's law, hydraulic conductivity and water diffusivity; saturated and unsaturated flow and equations; Methods for saturated and unsaturated hydraulic conductivity measurement-both *in situ* and in laboratory; Capillary movement of water, contact angle.

UNIT VIII

Entry of water into soil and its redistribution; permeability; evaporation from bare soil; modification of soil surface affecting infiltration and evaporation; field water balance;

UNIT IX

Gaseous phase in soil, content and composition; renewal of soil air and gaseous diffusion measurement of soil aeration; factors affecting soil aeration.

UNIT X

Energy balance in bare soil; soil heat flux, heat capacity, specific heat and thermal diffusivity; soil temperature and its measurement, factors affecting; thermal regime in soil profile.

Practicals

Particle size analysis of soil, Determination of bulk density, particle density and mass-volume relationships of soil, Soil aggregate analysis, Measurement of soil moisture content and soil moisture potential, Determination of soil-moisture characteristic curve, Determination of saturated and unsaturated hydraulic conductivity of soil, Determination of Atterberg constants, Measurement of soil strength, Determination of infiltration characteristics of soil, Soil temperature measurement

Suggested Readings

Baruah, T.C. and Barthakur, H.P. 2001. *Textbook of Soil Analysis*. Vikas Publishing House Pvt. Ltd, New Delhi.

Ghildyal, B.P. and Tripathi, R.P. 1987. *Soil Physics*. Wiley Eastern and New Age International, New Delhi.

Hillel, D. 1980. *Applications of Soil Physics*. Academic Press, New York.

Hillel, D. 1998. *Environmental Physics*, Academic Press, New York.

Jury, W.A., Gardner, W. and Horton, R. 2004. *Soil Physics*. John Wiley and Sons, New York.

Klute A. (Edited) 2006. *Methods of Soil Analysis*. **Part 1**. *Physical and Minerological Methods* (SSSA Book Series No. 5), ASA and SSSA, Madison, Wisconsin..

Lal, R. and Shukla, M.K. 2004. *Principles of Soil Physics*, Marcel Dekker, New York.

Warwick, A.W. (Edited) 2002. *Soil Physics Companion*, CRC Press, Boca Raton.

AP 504 MATHEMATICS IN AGRICULTURE (3L+0P) I

Objective

To educate about the basic mathematical techniques which are used in agricultural physics studies.

Theory

UNIT I

Functions, limits, continuity, linear equations, non-linear equations, polynomials, infinite series and Taylor series.

UNIT II

Vectors, matrices and determinants, inversion of matrices, Eigen values and Eigen vectors, Orthogonality, Grahm-Schmidt processes, least square problems.

UNIT III

Differentiation, integration, areas, partial differential equations, applications, solutions to differential and integral equations.

UNIT IV

Systems of coordinates, cartesian, cylindrical, spherical and polar coordinates, three dimensional geometry, relative motion of frame of reference.

UNIT V

Probability, probability distributions and applications, Curve fitting, regression and correlation, linear and non-linear.

UNIT VI

Geo-statistics, averaging and scaling methods, Fourier analysis, numerical approximations, numerical analysis, finite element method, Monte Carlo analysis, stochastic methods, iterative and optimal techniques.

Suggested Readings

Advanced Engineering Mathematics by C. Ray Wylie

Advanced Mathematics for Engineers by H.W. Reddick

Any book on Mathematics for graduates

Mathematical Statistics by M. Ray & H.S. Sharma

Statistics for Geoscientists- Techniques and Applications by S.K. Pal

AP 505 / SSAC 505 SOIL GENESIS, CLASSIFICATION AND SURVEY (2L+2P) II

Objective

To teach the students concept of pedon, Pedology as a core discipline of Soil Science, factors and processes of soil formation, soil classifications systems, survey and cartography. Main emphasis is on enabling the students to conduct soil survey and interpret soil survey reports for sustainable land use and planning.

Theory

UNIT I

Historical developments in Pedology; characterization and classification of rocks and minerals; weathering of rocks and minerals, weathering sequences of minerals with special reference to Indian soils; soil forming processes and factors of soil formation.

UNIT II

Concept of soil as an individual entity; soil classification – principles and historical development; soil classification systems - historical developments and modern systems of soil classification with special emphasis on soil taxonomy.

UNIT III

Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps; landform – soil relationships; application of remote sensing and GIS in soil survey and mapping; major soil groups of India.

UNIT IV

Land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystems.

Practicals

Morphological properties of soil profile in different landforms; classification of soils using soil taxonomy; calculation of weathering indices and its application in soil formation; grouping soils using available data base in terms of soil quality; aerial photo and satellite data interpretation for soil and land use; cartographic techniques for preparation of base maps and thematic maps; processing of field sheets, compilation and obstruction of maps in different scales.

Suggested Readings

Boul, S.W., Hole, R.D., McCracken, R.J. and Southard, R.J. 1997. *Soil Genesis and Classification.* Iowa State University Press, Ames, USA.

Jenny, H. 1941. *Factors of Soil Formation: A System of Quantitative Pedology*. McGraw Hill Book Co. Inc., New York.

Sehgal, J. 2005. *A Textbook of Pedology: Concepts and Applications*. Second Edition. Kalyani Publishers, New Delhi.

Soil Survey Staff 2000. *Soil Survey Manual*. United States Department of Agriculture. **Handbook No.18**. Scientific Publishers, Jodhpur.

Soil Survey Staff. 2006. *Keys to Soil Taxonomy.* 10th Edition. United States Department of Agriculture. Natural Resources Conservation Service.

Wielding, L.P., Smeck, N.E. and Hall, G.F. 1991. *Pedogenesis and Soil Taxonomy: I. Concepts and Interactions* (**11A**). Elsevier Science Publishing Company Inc., New York, USA.

AP 506 PRINCIPLES OF PHYSICAL TECHNIQUES IN AGRICULTURE (3L+1P) III

Objective

To educate about different optical, electrical, colorimetric and nuclear techniques used in agriculture.

Theory

UNIT I

Physical principles of measurement of relationships, direct and indirect measurements, scale of operation, laboratory, field and regional scales, specificity of techniques to characterize objects, resolution, limitations and relative advantages.

UNIT II

Optical microscope, reflection, polarized microscopes, Colorimetric techniques, single and double beam instruments, reflection, transmission and absorption in relation to the properties of the object, UV and Visible sphectrophotometry, applications.

UNIT III

Sensors and transducers, principles of operation of field-based instruments like leaf area meter, canopy analyzer, quantum sensor, spectroradiometer, laser land leveller etc., infrared thermometry, principles, emissivity, infrared spectroscopy, characteristics of agricultural materials.

UNIT IV

X-rays, crystal structure, applications, clay mineralogy, cotton fibres, small angle scattering, electron microscopy, electron optics, aberrations, contrast and image formation, specimen preparation techniques, transmission and scanning electron microscopy.

UNIT V

Morphological characterization of viruses, macromolecules, clay minerals and other material, atomic absorption spectroscopy, principle of operation, detection limits and sensitivity, polarography, applications.

UNIT VI

Nuclear techniques, detection and measurement of charged particles, types of detectors, counting systems, radiation monitoring instruments, radiation hazard evaluation and protection, tracer methodology, isotopes and their applications in different branches of agriculture, seed irradiation, γ chamber and γ irradiation for genetic variability, agricultural produce preservation, mass spectrometer, principle and applications.

Practicals

Photoelectric effect and measurements, Geiger-Muller counter: quenching time, thickness measurement of thin films/foils/paper sheets, half-life determination, tracer applications of artificial radio nuclides, multi-channel analyzer, neutron moisture meter, use of NMR spectrometer, seed irradiation with gamma rays, radiocarbon dating, hands on exposure to radiation safety

Suggested Readings

Burcham, E. 1995. *Nuclear Physics*, ELBS/Longman.

Condon, E.U. and Shortley, G.H. 1935. *Theory of Atomic Spectra*, Cambridge University Press, New York.

Glasstone, Samuel, 1967. *Source Book of Atomic Physics*, Affiliated East West Press, New Delhi.

Herzberg, G., 1944. *Atomic Spectra and Atomic Structure*, Dover, New York.

Kapoor, S.S. and Ramamurthy, V.S. 1986. *Nuclear Radiation Detectors*, Wiley Eastern Ltd, New Delhi.

Krishna, Ram. 1960. *General Properties of Matter*, Kitab Mahal, Allahabad.

Mathur, D.S. 1956. *Elements of Properties of Matter*, S Chand & Co, New Delhi.

Pain, R.H and Smith, B.J. (eds). 1975. *New Techniques in Biophysics and Cell Biology*, Wiley, London.

Pochin, E. 1983. *Nuclear Radiation: Risks and Benefits*, Clarendon Press, Oxford.

Rajam, J.B. 2000. *Atomic Physics*, S Chand & Co, New Delhi.

Sengupta, P.C. and Kohli, B.S. 1967. *Text Book of Physics*, Vol I,II, Kitab Ghar, New Delhi.

Simon, Ivan 1966. *Infrared Radiation*, Affiliated East West Press, New Delhi.

Slater, John C. 1960. *Quantum Theory of Atomic Structure*, Vol.1, McGraw Hill, New York.

Tiwari, P.N. 1985. *Nuclear Techniques in Agriculture*, Wiley Eastern, New Delhi.

Wolf, G. 1964. *Isotopes in Biology,* Academic Press, New York.

Zemansky, M.W. 1966. *Temperatures Very Low and Very High*, Affiliated East West Press, New Delhi.

AP 507 PHYSICS OF RADIATION INTERACTIONS IN AGRICULTURE (3L+0P) III

Objective

To educate students about different types of radiations, their principles, characteristics, interaction with matter and use in agricultural studies.

Theory

UNIT I

Electromagnetic spectrum, energy sources and their characteristics, spectral distribution of radiant energy, energy content in different radiations, radiation units, flux, intensity, emittance, inter conversion of radiometric units.

UNIT II

Radiation principles, resolution, geometry considerations, solid angle concept, inter conversion of photometric units, interaction of radiation with matter, scattering, reflection, transmission, absorption, diffuse and specular radiations, lambertian surface, different types of scattering.

UNIT III

Photosynthetically active radiation, Einstein, mole, photon units and their inter conversion, colour designations, conversion of optical to thermal and other forms of energy.

UNIT IV

Thermal radiations, blackbody radiation, Kirchoff's law, Stefan-Boltzman law, Planck's law, Wein's displacement law, Rayleigh-Jean's law, thermal properties of interacting materials, thermal emissivity, thermal inertia.

UNIT V

Microwave radiations, dielectric constant, microwave energy dissipation in interacting materials, isotropic and non-isotropic mediums, microwave transmission, reflection, polarization, microwave and radio wave heating, ionizing and non-ionizing radiations, applications in agriculture and biology.

UNIT VI

Energy balance of land surfaces, energy budget of leaf, energy budget of crop canopy, radiation interception, energy flow in ecosystems.

Suggested Readings

Ghadekar, S.P.A. 2001. *Text Book of Agrometeorology*. Agromet Publ.

Haliday.1966. *University Physics*. Academic Press.

Mavi, H.S. and Tupper, G.J. 1993. *Agrometeorology - Principles and Applications of Climatic Studies in Agriculture*. Food Products Press.

Minteith, J.L. and Unsworth, M.H. 2008. *Principles of Environmental Physics*. Academic Press.

Nelkon, M. and Parker, P. 1987. *Advanced Level Physics*. 6th Ed. Arnold-Heinemann.

Panda, B.C. 2005. *Remote Sensing: Principles and Application*. Viva Books.

AP 508 INTRODUCTION TO NANOTECHNOLOGY (2L+0P) III

Objective

To impart basic knowledge about nanoscience, properties of nanoparticles and their applications in biology

Theory

UNIT I

General introduction: Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mössbauer effect and spectroscopy, optical phenomena, bond in solids, anisotropy.

UNIT II

Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano tubes and nano wires, fullerenes (buck balls, graphene). Nanofabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, process of synthesis of nano powders, electro deposition, important nano materials.

UNIT III

Mechanical properties, magnetic properties, electrical properties, electronic conduction with nano particles, investigating and manipulating materials in the nanoscale: Electron microscopy, scanning probe microscopy, optical microscopy for nano science and technology, X-ray diffraction, scanning tunneling microscopy, atomic force microscopy.

UNIT IV

Nano-biology: Interaction between biomolecules and nano-particle surface, different types of inorganic materials used for the synthesis of hybrid nano-bio assemblies, application of nano in agriculture, current status of nano biotechnology, future perspectives of nanobiology, nanosensors.

Suggested Readings

Handbook of semiconductor nanostructures and nanodevices edited by A.A. Balandin and K.L. Wang , California : American Scientific Publishers, 2006

Nanotechnology edited by Gregory Timp, New York : Springer Verlag. 1999

Nanotechnologies for the life sciences - edited by Challa Kumar, Weinheim: Wiley-VCH GmbH, 2006

Nanotechnology: Introduction to nanostructuring techniques by Michael Kohler and Wolfgang Frintzsche – Weinheim : Wiley-VCH Verlag GmbH, 2007

Nanotechnology for chemical and biological defense – Margaret E. Kosal – Dordrecht : Springer, 2009.

AP 511/ AG 511: CROP ECOLOGY AND AGROMETEOROLOGY (3L+1P)III

Objective

To impart knowledge about crop ecology and agrometeorology

Theory

UNIT I

Concept of crop ecology, ecosystem characteristics, energy flow in ecosystem, succession and climax concept, adaptation of crops, agro-ecological regions.

UNIT II

Agrometeorology – aims, scope and development in relation to environment. Historical aspects of meteorology / climatology.

UNIT III

Physiological response of crop plants to weather variables (light, temperature, CO_2, moisture and solar radiation). Atmospheric pollution and its effect on climate. Global climate change and its impact on agriculture.

UNIT IV

Competition in crop plants, environmental manipulation through agronomic practices, agro-climatic indices. Improvement of unproductive lands through crop selection and management.

UNIT V

Stress and strain terminology; nature of stress injury and resistance, causes of stress. Low temperature stress - freezing injury and resistance in plants, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress. High temperature or heat stress - meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

UNIT VI

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

UNIT VII

Monsoons – their origin and characteristics. Weather hazards and their mitigation. Artificial rain making. Weather forecasting in India – short, medium and long range. Remote sensing – aerospace science and weather forecasting. Benefits of weather services to agriculture.

Practicals

Visit to agro-meteorological observatory to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure. Measurement of solar radiation outside and within plant canopy, soil and canopy temperature. Measurement/estimation of evapo-transpiration by various methods. Measurement/estimation of soil water balance. Rainfall variability analysis. Agro-climatic indices - determination of heat-unit / photo-thermal units requirement. Remote sensing and familiarization with agro-advisory service bulletins. Study of weather reports, working principle of automatic weather station.

Suggested Readings

Chadha, K.L. and Swaminathan, M.S. 2006. *Environment and Agriculture*. Malhotra Publ. House.

Critchfield, H.J. 1995. *General Climatology.* Prentice Hall of India.

Hemantarajan, A. 2007. *Environmental Physiology*. Scientific Publ.

Kumar, H.D. 1992. *Modern Concepts of Ecology*. 7th Ed. Vikas.Publ.

Lal, D.S. 1998. *Climatology*. Sharda Pustak Bhawan.

Lenka, D. 1998. *Climate, Weather and Crops in India*. Kalyani Publ.

Menon, P.A.1991. *Our Weather*. National Book Trust Publ.

Sahu, D.D. *Agrometeorology and Remote Sensing: Principles and Practices*.

Sharma, P.D. 1998. *Ecology and Environment*. Rastogi Publ.

Varshneya, M.C. and Balakrishana Pillai, P. 2003. *Textbook of Agricultural Meteorology*. ICAR Publ.

AP 520 PRINCIPLES OF BIOPHYSICS (3L+1P) II

Objective

To impart theoretical and practical knowledge of different life forms, and interactive effects of various physical forces on life processes.

Theory

UNIT I

Introduction and scope of biophysics, weak and strong interactions in biological systems, structure and property of water, physical, chemical and biological origin of life

UNIT II

Experimental techniques used for separation and characterization of biomolecules: sedimentation, ultra-centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography, aminoacid and nucleotide sequence analysis

UNIT III

Spectroscopic techniques for biomolecular characterization: UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction & its application in biology

UNIT IV

Structure and function of biological molecules: Amino acids and peptides, protein structure, nucleic acids, protein synthesis, mechanism of genetic control, polysaccharides and lipids-structure and function

UNIT V

Biomembranes-structure and function of plant and animal cell membranes, basis for cell membrane voltages, bioelectricity of cell membrane and its measurement, artificial membranes, transport phenomena in biological systems, active and passive transport

UNIT VI

Structure and function of plant and animal cells and viruses, unicellular and multi-cellular life forms, types of specialized cells and their functions, cell to cell communication

UNIT VII

Bio-energetic- First and second laws of thermodynamics, heat, work, entropy and free energy, concept of negative entropy & its application in living systems, information theory.

Practicals

Spectroscopy-Verification of Beer-Lambert's law, Spectroscopy-Absorption spectrum of chlorophyll a &b, Viscometer-Measurement of intrinsic viscosity and molecular mass, Polarimeter-Measurement of Molar rotation, Reftractometer-Measurement of specific and molar refractivity, NMR spectroscopy- Relaxation time measurements, Isolation of plant DNA

Melting point of DNA, Electrophoresis of DNA/Protein

Suggested Readings

Basic Biophysics for Biologists-M. Daniel, Agrobios, India

Essentials of Biophysics-P. Narayanan, New Age International Publishers

Biophysics- An Introduction- R.M.J. Cotterill, John Wiley & Sons, Ltd.

Principles of Physical Biochemistry-K.E. van Holde, W.C. Johnson and P. Shing Ho, Printice-Hall International, Inc.

Practical Biochemistry-Principles and Techniques- K.Wilson and J. Walker, Cambridge University Press

AP 530/WST 530 FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY (3L+1P)

Objective

To impart theoretical and practical knowledge about basic physical processes in the atmosphere with an aim to apply in agriculture.

Theory

UNIT I

Atmosphere and its constituents, weather and climate; meteorology and climatology, meteorological elements, instruments for measurement of meteorological elements, meteorological observatory, weather satellites, websites of meteorological organizations – IMD, NCMRWF, IITM, WMO.

UNIT II

Sun and earth; seasons, solstices and equinoxes, solar radiation and laws of radiation, solar constant; radiation receipt on earth surface, heat balance of the earth and atmosphere.

UNIT III

Variation of pressure and temperatures with height; hydrostatic equation, atmospheric moisture; vapour pressure; saturation deficit; psychometric equations, lapse rates, atmospheric stability, tephigram, potential temperature.

UNIT IV

Climatic controls, seasonal distribution of climatologically elements (radiation, temperature, pressure and precipitation) over latitudes.

UNIT V

Clouds and their classification, precipitation processes; artificial rain making, thunderstorms and dust storms; haze, mist, fog and dew, introduction to evapotranspiration,

UNIT VI

Pressure gradient; coriolis force; cyclones and anti-cyclones, local wind systems; land and sea breeze circulation, mountain and valley winds, air masses and fronts,

UNIT VII

Weather charts, forecasting methods – short, medium and long range forecasting techniques, numerical weather prediction.

UNIT VIII

Climatic classification: Koppen and Thornthwaite systems, agroclimatic indices, agroclimatic zones; different agro ecological zones for India,

UNIT IX

Climatology of India; monsoons, rainfall variability; El Nino, La Nina and ENSO, disastrous weather events in different regions, drought climatology and drought indices, climate change and global warming, impacts of climate change on agro-ecosystems.

Practicals

Meteorological observatory, meteorological instruments, recording of weather parameters, daily, weekly and monthly means, meteorological websites, standard meteorological weeks and Julian days, classification of clouds, climatic normal, climatic chart, low and high pressure systems.

Suggested Readings

Barry, R.G. and Chorley, R.J. 1982. *Atmosphere Weather and Climate*. ELBS (UK)

Critchfield, H.J. 1982. *General Climatology*. Prentice Hall of India (New Delhi).

Das, P.K. 1995 . *The Monsoon*. NBT (New Delhi)

Ghadekar, S.R. 2001. *Meteorology*. Agromet Publishers (Nagpur)

Ghadekar, S.R. 2002. *Practical Meteorology*. Agromet Publishers (Nagpur)

Menon, P.A. 1989 . *Our Weather*. NBT (New Delhi)

Petterson, S. 1958. *Introduction to Meteorology*. McGraw Hill (New York).

Trewartha, G.T. 1954. *An Introduction to Climate*. McGraw Hill(New York).

Journals

Journal of Climate

International Journal of Climatology

Mausam

Vayumandal

Weather

AP 540 PRINCIPLES OF REMOTE SENSING (3L+1P) II

Objective

To teach about basic principles and techniques of remote sensing.

Theory

UNIT I

Introduction, electromagnetic radiation, electromagnetic spectrum, interactions with the atmosphere, remote sensing system, passive versus active remote sensing, characteristics of images, radiometric quantities, BRDF.

UNIT II

Spectral signatures of natural targets in optical and thermal regions, physical basis of signatures, spectral indices.

UNIT III

Platforms, orbits, classification of sensors, satellite characteristics, pixel size, and scale, spectral, radiometric and temporal resolution.

UNIT IV

Cameras and aerial photography, imaging and nonimaging systems, multispectral imaging, hyperspectral imaging, thermal imaging.

UNIT V

Weather, land, ocean and other observation satellites, indian remote sensing satellites, data reception, data products.

UNIT VI

Microwave remote sensing: principles, signatures, interferometry, radar basics, viewing geometry and spatial resolution, image distortion, target interaction, image properties.

UNIT VII

Image analysis: Visual interpretation, digital image processing, preprocessing, enhancement, transformations, classification, accuracy, integration, processing of hyperspectral and microwave images.

UNIT VIII

Overview of remote sensing applications in earth resource management: Agriculture, atmosphere, forestry, land cover/land use, water resources, geology, oceans and coastal zone.

Practicals

Use of Spectroradiometer, Spectral signatures of different , Derivation of spectral indices, Infrared thermometer and its applications, Stress indices derivation from IR thermometer Derivation and analysis of vegetation indices, GPS and ground truth collection, Digital Image processing: Introduction, preprocessing, enhancement, classification, accuracy assessment of satellite data, Analysis of High resolution data and time series satellite data

Suggested Readings

Campbell, J.B. 1996. *Introduction to Remote Sensing*, 2nd ed., The Guilford Press, New York.

Colwell R.N. (Ed.) 1983. *Manual of Remote Sensing*, Vol.I, American Society of Photogrammetry, Falls Church, Va.

Curran, P. J. 1985. *Principles of Remote Sensing*, Longman, London.

David L Verbyla 1995. *Satellite Remote Sensing of Natural Resources*, Lewis Pub.

George, Joseph 2005. *Fundamentals of Remote Sensing*, 2nd ed., University Press.

Jansen, J.R. 2004. *Introductory Digital Image Processing: A Remote Sensing Perspective*, 3rd ed., Prentice Hall.

Lilisand, T.M., Kiefer, R.W. and Chipman, J.W. 2003. *Remote Sensing and Image Interpretation*, 5th ed., John Wiley & Sons, Inc., New York.

Panda B.C. 2008. *Principles and Applications of Remote Sensing*, Viva Publications.

Sabins, F.F. 1996. *Remote Sensing : Principles and Interpretations*, 3rd ed., W.H. Freeman.

AP 541 GIS AND GPS – PRINCIPLES AND APPLICATIONS (2L+1P) III

Objective

To impart knowledge on dealing with spatial data and its applications in crop production and natural resource management.

Theory

UNIT I

Introduction; History of cartography and maps;

UNIT II

Basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS);

UNIT III

Geographical data structures; relational database management system; overview of MS Access;

UNIT IV

Maps and projections: principles of cartography; Basic geodesy: Geiod /Datum/Ellipsoid; cartographic projections, coordinate systems, types and scales; accuracy of maps;

UNIT IV

GIS data collection, linking spatial and non-spatial data; Errors and quality control, data output;

UNIT V

Raster based GIS: spatial referencing, definition and representation, data structure, advantages and disadvantages; Vector based GIS : Definition, concept, data structure, capture and Vector and raster formats, vector to raster and raster to vector conversion, advantages and disadvantages;

UNIT VI

Principles of graph theory, topology and geometry; spatial analysis: statistical analysis, measurement, proximity (buffering), overlay analysis, classification, network analysis, multicriteria analysis, site suitability analysis, nearest neighbour analysis;

UNIT VII

Surface modelling: Thiessen polygon, interpolation, DEM; geostatistical analyses, spatial and non-spatial query.

UNIT VII

Software and hardware requirements of GIS; Integrated image analysis and GIS; GIS for modeling;

UNIT VIII

Web GIS, 3D GIS, object oriented GIS, mobile GIS, knowledge based GIS; data warehousing, data mining; metadata, data interoperability, open GIS consortium, GIS customization, DSS and SDSS;

UNIT IX

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

UNIT X

Basic Concepts, segments, working principles; Measuring distance and timing, errors in GPS data and correction; Differential GPS; Integration of GPS data with GIS data, use of GPS in remote sensing analysis; Past, present and future status of GPS; Applications of GPS in agriculture and natural resource management.

Practicals

Overview of current GIS software: ArcView/ArcGIS/IDRISI, Introduction to MS Access, Data input (spatial data); digitization and scanning, Data input: editing, Data input: non-spatial attributes and linking with spatial data, Database creation and map registration, Spatial analysis: Surface modelling, overlaying, buffering, neighbourhood analysis, Coordinate data collection through GPS and its integration with GIS

Suggested Readings

Burroughs, P.A. Geographical information systems for land resources assessment. Oxford University Press, 1986.

Chakraborty, D. and Sahoo, R.N. *Fundamentals of Geographic Information System*, Viva Books Pvt. Ltd., New Delhi.

Laurini, R. and Thompson, D. 1992. *Fundamentals of Spatial Information Systems*. London, Academic Press, New York, 1992.

Longley, P.A., Goodchild, M.F., Maguire, D. J. and Rhind, D.W. 1997. *Geographical Informatics Systems.* II Edition, New York, John Wiley.

Online useful materials (Tutorials)

http://www.gisdevelopment.net/tutorials/tuman006.htm

http://www.colorado.edu/geography/gcraft/notes/datacon/datacon_f.html

http://egsc.usgs.gov/isb/pubs/gis_poster/

http://www.quantdec.com/SYSEN597/

http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Tutorials (especially for ArcGIS user)

AP 610 PHYSICS OF SOIL AND WATER EROSION AND THEIR CONTROL (2L+1P) II

Objective

To teach the physical factors and processes describing erosion, its estimation , measurement of soil loss and runoff and methods of erosion control in arable and non-arable lands.

Theory

UNIT I

Factor affecting soil erosion by water: Effect of climate: Rainfall erosivity- kinetic energy of rainfall, Wischmeir's equation for its prediction, rainfall erosivity indices, isoerodent map of India. Effect of soil: Soil erodibility- soil physical parameters affecting soil erodibilty and its measurement, various indices of soil erodibility. Effect of topography, crop cover and soil management on soil erosion.

UNIT II

Method of soil loss estimation and measurement; Universal Soil Loss Equation(USLE): Estimation of various factors effecting erosion by water, soil loss tolerance, applicability and limitations of USLE and its revision .Water erosion prediction programme (WEPP)- sediment transport equations: rate of sediment detachment ,transport and deposition, sediment transport capacity, rill and inter rill erodibility and their measurement in field. Measurement of different types of soil erosion: Splash erosion and its measurement. Measurement of rill and gully erosion. Use of remote sensing methods for delineating different eroded areas according to their severity.

UNIT III

Runoff measurement & estimation : Gauges for long term/average prediction of stages of rivers and streams, stage level recorder for measuring short term variations of water levels, current meters for measurement of water discharge , hydrographs; Calibrated devices for runoff measurement: Theory of sub and super critical flow. Flumes, weirs and orifice - types, equations for calculating water head, suitable conditions for their use and their installation in field; Methods for runoff estimation: Rational formula, soil cover complex/ curve number method;

UNIT IV

Sediment measurement: Multislot divisor, cshocton wheel sampler, point and depth integrated sediment samplers;

UNIT V

Soil and water conservation: Concept of watershed: need for implementation of soil and water conservation programmes on watershed basis, Size of watershed, understanding concept of integrated water shed management through case studies. Outline of steps of integrated watershed management plan. Characterization and management of watersheds using remote sensing and GIS, Land capability classification: land capability classes, sub-classes and units

UNIT VI

Methods of erosion control in arable and nonarable lands: contour farming ,strip cropping, physical techniques of conservation forestry, bunds, terraces, ponds, gabion check dams, drop structures, trenches ,retention walls and spurs. Problems of soil and water erosion in India & conservation techniques: Types of soil erosion by water in different parts of India & their control measures – Hill side erosion, ravines, erosion on black soils, torrents, landslides, erosion due to mining and seaside erosion, water harvesting & recycling: water harvesting techniques for alfisols, vertisols, inceptisols and aridsols, methods for controlling seepage losses.

UNIT VII

Wind erosion-wind velocity, initiation and movement of soil particles, siltation, suspension and surface creep and mechanics involved, soil physical properties affecting wind erosion, wind erosion equation and its computation, control of wind erosion.

Practicals

Computation of Kinetic energy of falling rain drops and Wishmeir's formula, Measurement of Land slope, erosivity index (EI_{30}) using rain gauge data, Determination of erodibility Indices, Land capability classification of a watershed, sediment discharge estimation from a river basin, sediment detachment and transport rates, transport capacity, rill and interrill erodibility from field runoff and soil loss measurements, soil loss estimation using RUSLE software.

Suggested Readings

Agricultural handbook AH703 – RUSLE Document from USDA

Training manuals on 'Soil conservation and watershed management- vol.1 &2'by CSWCRT&I, Dehradun

Land and water resources by V.N.Murty

Watershed management by P.N. Bhatt (CSWCRT&I, Dehradun publication)

Watershed management by V.V.Dhruvnarayana

Water erosion prediction programme (WEPP) manual

AP 611/SSAC 611 SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH (3L+1P) III

Objective

To impart knowledge about characterization and management of soil physical environment in relation to plant growth and yield.

Theory

UNIT I

Introduction: Effect of soil physical properties on plant growth - soil water, soil air, soil temperature, mechanical impedance and tillage practices.

UNIT II

Soil water: Soil moisture – plant water relations, available water, newer concepts of water availability, least limiting water range, soil-plant-atmosphere system as a physical continuum, plant uptake of soil moisture, evaporation, transpiration and evapotranspiration, dynamics of water in the soil-plant-atmosphere continuum.

UNIT III

Root growth – germination and seedling emergence, hydraulic properties of roots, characterization of root growth parameters, water balance of the root zone, soil physical properties and root growth, flow of water to roots.

UNIT IV

Soil Temperature – effect of soil temperature on plant growth, soil temperature management, thermal regimes, mulching, radiation – heat budget and energy balance in the field, radiation use efficiency, radiation exchange in the field, exchange of heat and vapour to the atmosphere.

UNIT V

Aeration – critical oxygen concentration and factors affecting.

UNIT VI

Field water balance – field water balance, irrigation and water use efficiency, consumptive use, plant uptake of soil moisture

UNIT VII

Nutrient- nutrient uptake and use by plants, managing soil physical condition for improved nutrient use efficiency, Integrated nutrient management in relation to soil physical condition.

UNIT VIII

Resource conservation technologies- bed planting & zero-tillage - types, suitability and effect on soil physical properties, other resource conservation technologies and the impact (short and long term) on soil health.

UNIT IX

Modelling: Interactions of soil, management and climatic factors on plant growth, development of sustainability indices.

Practicals

Measurement of penetration resistance & LLWR, Plant water potential, Field saturated hydraulic conductivity, transpiration using Porometer, Root Length Density, Root Diameter, Root weight using Root Scanner, plant N content, Germination percentage as affected by temperature, Estimation of evapo-transpiration losses, estimation of consumptive water use, production functions, field water balance components, water uptake by plants

Suggested Readings

Doorenbos, J. and Pruitt, W.O. 1975. *Crop Water Requirements*, FAO,Irrigation and Drainage Paper 24. Rome.

Hanks and Ascheroft. 1980. *Applied Soil Physics*. SpringerVerlag.

Hillel, D. 1971. *Soil and Water: Physical Principles and Processes*. Academic Press.

Hillel, D. 1998. *Environmental Soil Physics*. Academic Press.

Slatyer, R.O. 1967. *Plant-Water Relations*. Academic Press

AP 612 ADVANCE SOIL PHYSICS I - SOIL WATER AND NUTRIENT TRANSPORT (3L+1P) II

(Pre-requisite: AP 110 & AP 104)

Objective

To study the physical processes for transport of water and nutrients in soil.

Theory

UNIT I

Soil water transport: saturated flow equations: Poiseuille's and Darcy's equations, Laplace equation of steady flow and unsteady flow equation and their solutions, three dimensional saturated hydraulic conductivity and fluxes, hydraulic conductivity for layered soil, conductance coefficient, unsaturated flow equations: Buckinghum-Darcy equation, Richards equation, dynamics of water flow, stationary water flux, diffusivity, Boltzmann transformation and a wetting front, unsaturated hydraulic conductivity, Infiltration, profile controlled and supply controlled infiltration, horizontal infiltration, vertical infiltration, Green-Ampt model, Philip model, homogeneous and layered soil infiltration, curve number method, preferential flow, measurement of unsaturated hydraulic conductivity: lab methods: direct method - constant head and falling head methods; indirect method- parameterization of hydraulic functions. Field methods- infiltrometers and permeameters, instantaneous profile and field inverse methods. Numerical models of water flow, finite element and finite difference methods

UNIT II

Root water uptake modeling: computation of root water uptake using Richard's equation; Ritchie's root water uptake model.

UNIT III

Solute transport: solute transport mechanisms: mass flow, diffusion, hydrodynamic dispersion, miscible and immiscible displacement, hypothetical and experimental breakthrough curves, Convective-Diffusive equation (CDE), linear and non-linear adsorption, solution of CDE, analytical solution by variable transformation and Laplace transformation, numerical solutions by finite difference and finite element methods, applications, methods of determination of dispersion and diffusion coefficients.

Practicals

Guelph Permeameter for field saturated hydraulic conductivity, Hydraulic conductivity by instantaneous profile method, Computation of dispersion and diffusion coefficients of CDE, Computation of solute (nonreactive) distribution in profile by analytically solving solute transport equation under different initial and boundary conditions

Suggested Reading

Advanced Soil Physics by Daniel Hillel.
Advanced Soil physics by Kirkham and Powers.
Soil Physics Companion by A.W. Warrick.

AP 613 ADVANCE SOIL PHYSICS II (2L+1P) I

(Pre-requisite: AP 110 & AP 104)

Objective

To study the use of advanced mathematical tools in understanding the soil physical processes related to transport of soil heat and soil air.

Theory

UNIT I

Variability in soil physical properties: classical measures of variability, spatial variability of soil physical properties: spatial dependence, autocorrelation function and spatial structure studies : empirical semivariogram, semivariogram models, classical and geostatistical interpolation: IDW, spline , global polynomial, Kriging – stationarity, trend ,solving kriging equations, type of kriging, GIS for geospatial analysis, Kriging for precision farming

UNIT II

Mathematical tools: Fourier series, Bessel functions, Infinite series of orthogonal functions, Numerical approximations: finite elements and finite difference model of applicability of numerical approximations, numerical simulations.

UNIT III

Soil heat flow: equation of heat transport by conduction and its sine wave solution, measurement and estimation of soil thermal properties- single and dual probe, heat flux plates, Jackson and Kirkham's method, numerical simulation technique.

UNIT IV

Sediment transport by runoff: equations of sediment transport for rill and interrill erosion, measurement of inter-rill and rill erodibility, computation of sediment detachment , transport and deposition rates.

UNIT V

Movement and exchange of gases in soils: Darcy's law for advective transport (nonisobaric system) of gas, deviation from Darcy's law, gas transport by diffusion in isobaric system (Fick's law). Multi component gas transport- Dusty Gas model, Stefan Maxwell equation. Gas permeability: laboratory and field measurement of gas permeability.

UNIT VI

Soil quality: definitions, selection of minimum data set of physical, chemical and biological characteristics for quality assessment, indices of soil quality-nonquantitative and quantitative systems, least limiting water range(LLWR) for assessment of soil physical health, soil conditioner: water soluble conditioners and soil hydrogels, their effects on soil structure, water and nutrient retention and other soil hydraulic properties

Practicals

Empirical semivariogram and fitting appropriate semivariogram model, Preparation of prediction map of a soil property by kriging, Computation of sediment detachment rate, sediment transport rate, interrill and rill erodibility, Computation of LLWR under different soil management practices, Computation of thermal properties using finite difference method

Suggested Readings

Advanced Soil Physics by Daniel Hillel

Advanced soil physics by Kirkham and Powers

Mathematical Physics by B.D.Gupta

Soil Physics Companion by A.W.Warrick

AP 630 CROP MICROMETEOROLOGY **(2L+1P) II**

(Pre-requisite AP 530)

Objective

To impart advanced theoretical and practical knowledge about the physical processes in the atmosphere near the ground for growing crop plants.

Theory

UNIT I

Micro-, meso- and macro-climates and their importance, Atmosphere near the ground – bare soil and crop surfaces, exchange of mass, momentum and energy between surface and overlaying atmosphere, exchange coefficients, Richardson number & Reynold's analogy, Boundary layer, frictional affects, eddy diffusion, forced & free convection.

UNIT II

Micrometeorological parameters; instruments and measuring techniques, agromet observatory.

UNIT III

Radiation, temperature, wind, humidity and carbon dioxide profiles in crops, radiation interception and utilization by crops – albedo, net radiation, PAR, LAI, biomass; photoperiodism, carbon dioxide and photosynthesis; net photosynthesis.

UNIT IV

Air, canopy and leaf temperatures and their biological effects – cardinal temperatures, thermal time, growing degree days, heat use efficiency and their application in field crops.

UNIT V

Wind profile near the ground; roughness and zero plane displacement, evapotranspiration –potential and actual; advection.

UNIT VI

Modification of microclimate by cultural practices, protection of crops from extreme weather.

UNIT VIII

Crop yield and weather parameters; climatic normal of crop plants, crop weather calendars, crop growth models, use of remote sensing for crop growth and yields estimation. Weather based insect pest and disease forecasting, Weather based agro-advisory.

Practicals

IPAR, FAPAR, PAR Extinction Coefficient, RUE, Temperate profile, Wind profile, humidity, Net Radiation profile of the crops at different stages. Thermal indices, albedo, canopy temperature, CATD, SDD and CWSI.

Suggested Readings

Chang, Jen-Hu. 1968. *Climate and Agriculture: An Ecological Survey*. Aldine Publishing Company.

Geiger, Rudolf. 1966. *The Climate near the ground*. Harvard University Press.

Mavi, H.S. 1994. *Introduction to Agrometeorology*. Oxford IBH.

Monteith, J.L. 1972. *Survey of Instruments for Micrometeorology*. Blackwell Scientific Publications, London.

Montieth, J.L.1973. *Principles of Environmental Physics*. Edward Publishers, London.

Oke, T.R. 1987. *Boundary Layer Climates*, 2nd Ed. Halsted Publishers, New York.

Pal, Arya, S. 1988. *Introduction to Micrometeorology*. Academic Press Inc.

Rosenberg, N.J., Blad, B.L. and Verma, S.B. 1983. *Microclimate: The Biological Environment*. John Wiley & Sons, New York.

Sutton, O.G. 1953. *Micrometeorology*. McGraw-Hill Publishers, New York.

Journals

Agricultural and Forest Meteorology

Boundary Layer Meteorology

Journal of Agrometeorology

Journal of Hydrometeorology

Mausam

AP 631 EVAPOTRANSPIRATION (2L+1P) III

(Pre-requisite 130)

Objective

To impart theoretical and practical knowledge about crop ET estimation and measurement

Theory

Theory

UNIT I

Radiation and its interaction with crop environment and radiation use efficiency, energy balance, its components and their estimation in crop canopy.

UNIT II

Theories of evapotranspiration – concept of evapotranspiration; potential, reference and actual evapotranspiration;

UNIT III

Estimation of potential evapotranspiration using different approaches – empirical, aerodynamic, radiation, Bowen ratio, combination and eddy correlation techniques, factors affecting evapotranspiration – meteorological, soil and cultural.

UNIT IV

Thornthwaite's climatic water balance.

UNIT V

Measurement of evapotranspiration using various types of lysimeters, water use efficiency, irrigation scheduling and yield functions.

UNIT VI

Estimation of evapotranspiration using remote sensing technique.

Practicals

Radiation balance, Thornthwaite's method, Blaney Criddle method, Radiation (Makkink's) method, Bowen's Ratio, Aerodynamic method, Combination (Penman's) method, Combination (FAO 56) method, Pan Evaporation, Climatic Water Balance, Lysimeter

Suggested Readings

Allen, R.G., Pereira, L.S., Raes, D., and Smith, M. 1998. Crop evapotranspiration: Guidelines for computing crop water requirements. FAO FAO Irrigation and Drainage paper 56, Rome.

Chang, Jen-Hu. 1968. *Climate and Agriculture: An Ecological Survey.* Aldine Publishing Company.

Doorenbos, J. and Pruitt, W.O. 1977. *Crop Water Requirements*. FAO Irrigation and Drainage paper 24, Rome.

Rosenberg, N.J., Blad, B.L. and Verma, S.B. 1983. *Microclimate: The Biological Environment*. John Wiley & Sons, New York.

Journals

Agricultural and Forest Meteorology

Agricultural Water Management

Irrigation Science

Journal of Irrigation and Drainage Engineering

Water Resources Research

AP 632 SATELLITE AGROMETEOROLOGY (2L+1P) I

(Pre-requisite: AP 140)

Objective

To teach the use of satellite images for agro-meteorological purposes.

Theory

UNIT I

Scope and importance of agrometeorology from space, types of meteorological satellites – Geostationary and Polar orbiting.

UNIT II

International satellite systems and their payloads – NOAA, LANDSAT, SPOT, TERRA and AQUA, DMSP, METEOSAT, GOES, TRMM etc., National satellite systems and their payloads – INSAT, IRS, MEGHA-TROPIQUES, RISAT etc., Agromet parameter's requirements and satellite data products available.

UNIT III

Retrieval of cloud type and structure in visible and infrared regions, estimation of rainfall by visible, infrared and passive and active microwave techniques.

UNIT IV

Retrieval of land surface emissivity and temperature – single channel and split window algorithms, components of surface radiation balance – global radiation, surface albedo and outgoing long wave radiation, estimation of latent heat flux (ET), sensible heat and roughness parameter.

UNIT V

Retrieval of surface soil moisture by thermal and passive microwave, retrieval of crop biophysical parameters by empirical and physical techniques.

UNIT VI

Vegetation phenology and dynamics, crop yield modeling, linking Simulation models and remote sensing, crop growth monitoring system

UNIT VII

Drought monitoring, assessment and management, modeling net primary productivity of agroecosystems, agroecological zoning using remote sensing and GIS, remote sensing of air pollutants and green house gases.

Practicals

MODIS Products (Reflectance, LAI, fAPAR, LST), SPOT VGT Products, PROSAIL MODEL, Retrieval: LST, Albedo, Radiation, Crop Phenology, Drought indices, Drought assessment, Net Primary Productivity

Suggested Readings

Lecture Notes Module II : *RS & GIS Applications in Agriculture & Soil Science*, CCSTEAP, Indian Institute of Remote Sensing, Dehradun, India

Lecture Notes on *Satellite Meteorology & Global Change*, Vol 1, 2 & 3, CSSTEAP, Space Applications Centre, ISRO, Ahmedabad, India

Molly E. Brown 2008. *Famine Early Warning Systems and Remote Sensing Data*, Springer.

Okamoto, K. (Ed) 2001. *Global Environment Remote Sensing*, IOS Press.

Shivkumar, M.V.K., Roy, P.S., Harmsen, K. and Saha, S.K. 2004. *Satellite Remote Sensing and GIS Applications in Agricultural Meteorology*, WMO, Geneva.

Special Issue on Remote Sensing Applications in Meteorology, *MAUSAM*, Vol 54, No. 1, Jan 2003.

Toselli, F. (Ed.) 1989. *Applications of Remote Sensing to Agrometeorology*, Kluwer Academic Publishers, London.

Ustin, S. 2004. *Remote Sensing for Natural Resource Management and Environmental Monitoring*, 3rd ed., Wiley.

Vaughan, R.A. 1987. *Remote Sensing Applications in Meteorology and Climatology*, NATO Science Series C.

AP 640 REMOTE SENSING IN AGRICULTURE (2L+1P) III

(Pre-requisite: AP-140)

Objective

To impart knowledge about the remote Sensing techniques and their applications in agriculture.

Theory

UNIT I

Scope of remote sensing in agriculture, sensors and platforms, data availability for agricultural remote sensing.

UNIT II

Spectral characteristics of soils, differentiation and identification of soils, spectroscopy of soils, soil parameters by hyperspectral remote sensing, soil survey and resource mapping.

UNIT III

Interaction of EM radiation with plant components and crop canopies, spectral signatures, spectral and hyper-spectral indices, crop identification and acreage estimation, crop growth monitoring and yield modeling.

UNIT IV

Infra red thermometry, crop abiotic and biotic stress differentiation and assessment, retrieval of crop biophysical parameters – empirical and radiative transfer approach, advanced digital image processing and classification techniques for crops.

UNIT V

Land use/ land cover mapping, land planning with reference to different agro eco-regions, land degradation process and their evaluation by remote sensing.

UNIT VI

Role of remote sensing in water resource development and management, identification of ground water potential zones, generation of different thematic maps for integrated watershed management; utility of SAR data for crop inventory, salinity mapping, soil moisture mapping, flood assessment and management by remote sensing.

UNIT VII

Precision farming principles - VRT, Modern techniques and machines.

Practical

Use of Infrared thermometry and spectral data for crop stress monitoring, Hyperspectral data for soil and crop characterization, Computation of Spectral Indices for Soil and Vegetation, Processing of microwave Remote Sensing Data, Salinity mapping from remote sensing data, Pre-processing of time series satellite data, Crop discrimination and acreage estimation, Crop yield modeling from satellite data, Land use land cover classification and change detection

Suggested Readings

Barret, E.C. and Curtis, L.F. 1982. *Introduction to Environmental Remote Sensing*, Chapman & Hall, London.

Colwell, R.N. (Ed.) 1983. *Manual of Remote Sensing*, Vol. II, American Society of Photogrammetry, Falls Church, Va.

Jensen, J.R. 2006. *Remote Sensing of the Environment: An Earth Resource Perspective*, 2nd ed., Prentice Hall.

Narayan, L.R.A. 1999. *Remote Sensing and its Applications,* Oscar Publ.

Patel, A.N. and Singh S. 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.

Thenkabail, P., Turral, H., Biradar C. and Lyon, J.G. (Eds) 2009. *Remote Sensing of Global Croplands for Food Security,* CRC Press.

Ustin S. 2004. *Remote Sensing for Natural Resource Management and Environmental Monitoring*, 3rd ed., Wiley.