FARM MACHINERY AND POWER ENGINEERING

Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FMPE 501*	DESIGN OF FARM POWER AND MACHINERY SYSTEMS	3+1
FMPE 502*	SOIL DYNAMICS IN TILLAGE AND TRACTION	2+1
FMPE 503*	TESTING AND EVALUATION OF TRACTORS AND FARM EQUIPMENT	2+1
FMPE 504*	SYSTEM SIMULATION AND COMPUTER AIDED PROBLEM SOLVING IN ENGINEERING	1+1
FMPE 505	APPLIED INSTRUMENTATION IN FARM MACHINERY AND STRESS ANALYSIS	2+1
FMPE 506	SYSTEM ENGINEERING AND PRODUCTIVITY	2+1
FMPE 507	FARM MACHINERY DYNAMICS NOISE & VIBRATIONS	3+1
FMPE 508	TRACTOR DESIGN	2+1
FMPE 509	OPERATIONS RESEARCH IN FARM POWER & MACHINERY MANAGEMENT	2+1
FMPE 510	ERGONOMICS AND SAFETY IN FARM OPERATIONS	2+1
FMPE 511/ PFE 502	ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS	2+1
FMPE 512	AGRO-ENERGY AUDIT AND MANAGEMENT	2+0
FMPE 513	DESIGN AND ANALYSIS OF RENEWABLE ENERGY CONVERSION SYSTEMS	3+0
FMPE 514	RESEARCH METHODOLOGY	0+1
FMPE 591	MASTER'S SEMINAR	1+0
FMPE 592	SPECIAL PROBLEM	0+1
FMPE 595#	INDUSTRY/ INSTITUE TRAINING	NC
FMPE 599	MASTER'S RESEARCH	20
FMPE 601**	ADVANCES IN FARM MACHINERY AND POWER ENGINEERING	3+1
FMPE 602**	SIMULATION MODELLING IN FARM MACHINERY AND POWER ENGINEERING	2+0
FMPE 603	ENERGY CONSERVATION AND MANAGEMENT IN FARM MACHINERY AND POWER ENGINEERING	2+0
FMPE 604	COMPUTER AIDED ANALYSIS AND DESIGN OF FARM MACHINERY	2+1
FMPE 605	MACHINERY FOR NATURAL RESOURCE MANAGEMENT AND PRECISION FARMING	3+1
FMPE 606	ADVANCES IN HYDRAULICS AND ELECTRO PNEUMATIC CONTROLS	2+0
FMPE 691	DOCTORAL SEMINAR I	1+0
FMPE 692	DOCTORAL SEMINAR II	1+0
FMPE 693	SPECIAL PROBLEM	0+1
FMPE 694	CASE STUDY	0+1
FMPE 699	DOCTORAL RESEARCH	45

Compulsory for Master's programme; ** Compulsory for Doctoral programme

FPM 595 – Minimum of Three Weeks Training

Note: Some of the identified Minor/Supporting fields are Mechanical Engineering, Processing & Food Engineering, Energy in Agriculture, Civil Engineering, Computer Science, Electrical Engineering, Mathematics and Statistics; the contents of some of the identified Minor/Supporting courses have been given.

FARM MACHINERY AND POWER ENGINEERING

Course Contents

FMPE501 DESIGN OF FARM POWERANDMACHINERY SYSTEMS 3+1

Objective

To acquaint and equip with the latest design procedures of farm power and machinery systems.

Theory

UNIT I

Modern trends, principles, procedures, fundamentals and economic considerations for design and development of farm power and machinery systems. Design considerations, procedure and their applications in agricultural tractors & typical machines. Reliability criteria in design and its application.

UNIT II

Analytical design considerations of linkages/ components in farm machinery and its application.

UNIT III

Design of selected farm equipments: – tillage, seeding, planting, interculture, plant protection, harvesting and threshing. Design of rotary, vibrating and oscillating machines.

UNIT IV : Design and selection of matching power unit.

UNIT V : Safety devices for tractors & farm implements.

Practical :

Statement and formulation of design problems. Design of farm power systems. Design of mechanisms & prototypes in farm machinery.

Suggested Readings

Arther W Judge 1967. *High Speed Diesel Engines*. Chapman & Hall.

BargerEL,LiljedahlJB&McKibbenEC1967.*TractorsandtheirPower Units*. Wiley Eastern.

Bernacki C, Haman J &Kanafajski CZ.1972. *AgriculturalMachines.* Oxford & IBH.

Bindra OS & Singh Harcharan 1971. *Pesticides Application Equipments*. Oxford & IBH.

Bosoi ES, Verniaev OV & Sultan-Shakh EG. 1990. *Theory, Construction and Calculations of Agricultural Machinery.* Vol. I. Oxonian Press.

Klenin NI, Popov IF & Sakoon VA. 1987. *Agricultural Machines. Theory of Operations, Computing and Controlling Parameters and the Condition of Operation.* AmrindPubl.

Lal R & Dutta PC. 1979. *Agricultural Engineering* (through solved examples). Saroj Parkashan.

Maleev VL. 1945. *Internal Combustion Engines*. McGraw Hill.

Mathur ML & Sharma RP. 1988. *A Course in Internal Combustion Engines*. Dhanpat Rai &Sons.

Ralph Alcock.1986. *Tractor Implements System*. AVI Publ.

Raymond N, Yong Ezzat A & Nicolas Skiadas 1984. *Vehicle Traction Mechanics*. Elsevier

Sharma PC & Aggarwal DK. 1989. *A Text Book of Machine Design*. Katson Publishing House.

Theory and Construction. Vol. I. U.S. Dept. of Commerce, National Technical Information Service, Springfield, Virginia.

Thornhill EW & Matthews GA. 1995. *Pesticide Application Equipment for Use in Agriculture*. Vol. II. *Mechanically Powered Equipment.* FAORome.

William. R Gill & Glen E Vanden Berg. 1968. *Soil Dynamics in Tillage and Traction*. US Govt. Printing Office, Washington,D.C.

Yatsuk EP.1981. *Rotary Soil Working Machines Construction, Calculation and Design*. American Publ. Co.

FMPE502 SOIL DYNAMICS IN TILLAGEANDTRACTION 2+1

Objective

To acquaint and equip with the dynamic properties of soil, soil failure and design of tillage tools, prediction of traction performance and dimensional analysis of different variables related to soil- tire system.

Theory

UNIT I

Dynamic properties of soil and their measurement, stress-strain relationships, theory of soil failure.

UNIT II

Mechanics of tillage tools and geometry of soil tool system, design parameters and performance of tillage tools.

UNIT III

Dimensional analysis of different variables related to soil-tyre system; soil vehicle models; mechanics of steering of farm tractor; special problems of wet land traction and floatation.

UNIT IV

Introduction of traction devices, tyres-types, function & size, their selection; mechanics of traction devices. Deflection between traction devices and soil, slippage and sinkage of wheels, evaluation and prediction of traction performance, design of traction and transport devices. Soil compaction by agricultural vehicles andmachines.

Practical

Relationship of soil parameters to the forces acting on tillage tools, wheel slippage and tyre selection, design and performance of traction devices and soil working tools.

Suggested readings

Daniel Hill. 1962. *Fundamentals of Soil Physics*. AcademicPress.

Gill & Vandenberg.1968. *Soil Dynamics in Tillage and Traction*. Supdt. of Documents, U.S. Govt. Printing Office, Washington,D.C.

Sineokov GN. 1965. *Design of Soil Tillage Machines*. INSDOC, New Delhi.

Terzaghi K & Peck Ralph B.1967. *Soil Mechanics in Engineering Practices*. John Wiley &Sons.

FMPE503 TESTING AND EVALUATIONOFTRACTORS AND FARMEQUIPMENT 2+1

Objective

To acquaint and equip with the procedure of testing & performance evaluation of farm power & machinery as per test standards and interpretation of results.

Theory

UNIT I

Types of tests; test procedure, national and international codes.

UNIT II

Test equipment; usage and limitations. Power losses in dynamometers and hydraulic test equipment.

UNIT III

Prototype feasibility testing and field evaluation. Laboratory and field testing of selected farm equipment. Non-destructive testing techniques.

UNIT IV

Tractor performance testing, evaluation and interpretation of results.

UNIT V

Review and interpretation of test reports. Case studies.

Practical

Laboratory and field testing of selected farm equipment. Interpretation and reporting of test results. Material testing and its chemical composition. Accelerated testing of fast wearing components. Non-destructive testing techniques.

Suggested Readings

Anonymous. 1983. *RNAM Test Code & Procedures for Farm Machinery*. Technical Series 12.

Barger EL, Liljedahl JB & McKibben EC. 1967. *Tractors and their Power Units*. Wiley Eastern.

Indian Standard Codes for Agril. Implements. Published by ISI, New Delhi.

Inns FM. 1986. *Selection, Testing and Evaluation of Agricultural Machines and Equipment*. FAO Service Bull. No. 115.

Lal R & Dutta PC. 1979. *Agricultural Engineering* (through solve examples). Saroj Parkashan,

Metha ML, Verma SR, Mishra SK & Sharma VK. 1995. *Testing and Evaluation of Agricultural Machinery.* National Agricultural Technology Information Centre, Ludhiana.

Nebraska Tractor Test Code for Testing Tractor, Nebraska, USA.

Smith DW, Sims BG & O'Neill D H. 2001. *Testing and Evaluation of Agricultural Machinery and Equipment - Principle and Practice*. FAO Agricultural Services Bull. 110.

FMPE504 SYSTEM SIMULATION ANDCOMPUTERAIDED PROBLEM SOLVING INENGINEERING 1+1

Objective

To acquaint and equip with the concept of dimensional analysis, mathematical modeling, software development process and the use of CAD software and in solving the engineering problems related to design of farm machinery

Theory

UNIT I

Concept, advantages and limitation of dimensional analysis, dimensions and units, fundamental and derived units, systems of units, conversion of units of measurement, conversion of dimensional constants, conversion of equations in different units, complete set of dimensionless products and their formulation methods- the Rayleigh's method, Buckingham's Pi theorem and othermethods.

UNIT II

Mathematical modeling and engineering problem solving. UNIT III

Computers and softwares – software development process – Algorithm design, – program composition- quality control- documentation and maintenance – software strategy.

UNIT IV

Approximation- round off errors- truncation errors. Nature of simulation- systems models and simulation- discreet event simulation- time advance mechanisms- components of discreet event simulation model. Simulation of singular server que- programme organization and logic- development of algorithm.

UNIT V

Solving differential equation on computers- modeling engineering systems with ordinary differential equations- solution techniques using computers.

Suggested Readings

Averill M. Law & W David Kelton.2000. *Simulation Modeling and Analysis*. McGraw Hill.

Balagurusamy E. 2000. *Numerical Methods*. Tata McGraw Hill. Buckingham E. 1914. *On Physical Similar System*. Physical Reviews 4: 345.

Langhar H. 1951. *Dimensional Analysis and Theory of Models*. John Wiley & Sons.

Murphy J. 1950. *Similitude in Engineering*. The Roland Press Co.

Robert J Schilling & Sandra L Harries. 2002. *Applied Numerical Methods for Engineers Using MATLAB and C*. Thomson Asia.

Simpson OJ. 2000. *Basic Statistics*. Oxford & IBH.

Singh RP. 2000. *Computer Application in Food Technology*. Academic Press.

Steven Chopra & Raywond Canale. 1989. *Introduction to Computing for Engineers*. McGraw Hill.

Veerarajan T & Ramachnadran T. 2004. *Numerical Methods with Programmes in C and C++*. Tata McGraw Hill.

Wilks SS. 1962. *Mathematical Statistics*. John Wiley & Sons.

FMPE505 APPLIED INSTRUMENTATION IN FARM MACHINERY AND STRESSANALYSIS

2+1

Objective

To acquaint and equip with the concept of instrumentation used in farm power & machinery and measuring devices for force, torque and other parameters.

Theory

UNIT I

Strain and stress, strain relationship, strain gauges. Mechanical, optical, electrical acoustical and pneumatic etc. and their use. Various methods of determining strain/stresses experimentally. Measuring devices for displacement (linear and rotational), velocity, force, torque and shaft power. Strain gauges: types and their application in two and three dimensional force measurement. Design and analysis of straingauges.

UNIT II

Introduction to functional elements of instruments. Active and passive transducers, Analog and digital modes, Null and deflection methods. Performance characteristics of instruments including static and dynamic characteristics.

UNIT III

Devices for measurement of temperature, relative humidity, pressure, sound, vibration, flow etc. Recording devices and their type. Measuring instruments for calorific value of solid, liquid, and gaseous fuels. Measurement of gas composition usingGLC.

UNIT IV

Basic signal conditioning devices - data acquisition system - micro computers for measurement and data acquisition. Data storage and their application.

Practical

Calibration of instruments, Experiment on LVDT, strain gauge transducer, inductive and capacitive pick ups, speed measurement using optical devices, vibration measurement exercises , making of thermocouples and their testing-basic electronic circuits and application of linearICs.

Suggested Readings

Ambrosius EE. 1966. *Mechanical Measurement and Instruments*. The Ronald Press.

BeckwithTG. 1996. *Mechanical Measurements*. Addison-Wesley.

Doeblin EO. 1966. *Measurement System - Application and Design*. McGraw Hill.

Ernest O Doebelin.1995. *Measurement Systems - Application and Design*. McGraw Hill.

Holman P 1996. *Experimental Methods for Engineers*. McGraw Hill.

Nachtigal CL. 1990. *Instrumentation and Control. Fundamentals and Application*. John Wiley & Sons.

Oliver FJ. 1971. Practical; Instrumentation Transducers. Hayden Book Co. Perry CC & Lissner HR.1962. *The Strain Gauge Primer*. McGrawHill.

FMPE506 SYSTEM ENGINEERINGANDPRODUCTIVITY 2+1

Objective

To acquaint and equip with the concept of analysis of data, economic analysis techniques, network theory, dynamic programming and computer use in solving problems of optimization, writing of algorithms for problem solutions and decision making.

Theory

UNIT I

System definition and concept. System engineering function, management and problems. Classification of system analysis models. Economic analysis techniques: Interest and interest estimation of single and multiple alternatives, break even analysis.

UNIT II

Mathematical modeling and analysis: Application of linear programming, Network theory – CPM and PERT, Queuing theory and its application, assignment & transportation models and job scheduling/ allocation for the synthesis of agriculture machine systems.

UNIT III

Dynamic programming, Markov chains, application of forecasting in agricultural engineering systems and products. Concept utilization and mathematical formulation of the labor, equipment and material factors affecting productivity.

UNIT IV

Computer use in solving problems of optimization, writing of algorithms for problem solutions and decision making.

Practical

Extensive practice on the packages mentioned in theory.

Suggested Readings

Danovan SS. 2000. *System Programming*. Tata McGraw.

Gillett G. 2001. *Introduction to Operations Research*. Tata McGraw Hill.

Grawham WJ & Vincent TL. 1993. *Modern Control System Analysis and Design*. John Wiley & Sons.

Lewis FL & Syrmos VL. 1995. *Optimum Control*. 2nd Ed. John Wiley & Sons.

Loomba D. 2000. *Linear Programming*. Tata McGraw.

Puttaswamaiah K. 2001. *Cost Benefits Analysis*. Oxford & IBH.

FMPE507 FARMMACHINERYDYNAMICS,NOISE&VIBRATIONS 3+1

Objective

To acquaint and equip with the theoretical aspects of farm machinery used on the farm.

Theory

UNIT I

Principles of soil working tools: shares, discs, shovels, sweeps and blades, rota-tillers and puddlers.

UNIT II

Metering of seeds and granular fertilizers with various mechanism, effect of various parameters on distribution of seed and fertilizer in seed cum fertilizer drills and planters, flow of seeds and fertilizers through tubes and boots. Kinematics of transplanters.

UNIT III

Theory of atomization, specific energy for atomization, electrostatic spraying and dusting, spray distribution patterns. Kinematics of reapers/harvesting machines. Theory of mechanical separation of grains from ear heads/pods. Parameters affecting performance of threshers, aerodynamic properties of straw and grain mixture, theory of root crop harvesters, power requirement of various components of field machines.

UNIT IV

Noise and vibration theory- Definition, units and parameters of measurement and their importance. Types of vibrations- free and forced, in damped and without damped analysis of one , two and multiple degree of freedom systems and their solution using Newton's motion, energy method, longitudinal, transverse and torsional vibrations, Raleigh's methods, Lagrange equation.

UNIT V

Introduction of transient vibration in systems, vibration of continuous media. Balancing of single rotating weight and number of weights in same plane and different planes. Complete balancing of reciprocating parts of engine

Practical

Study of vibration measurement and analysis equipment, Study of different vibration measurement and evaluation, Measurement and analysis of vibration on different components of thresher, combine, reaper, power tiller and tractor. Determination of modulus of elasticity, rigidity, and MI by free vibration test. Evaluation of logarithmic decrement and damping factor. Whirling of shaft. Heat motion in two pendulum system. Detailed analysis of multi- degree of freedom system.

Suggested Readings

Ballaney PL. 1974. *Theory of Machines*. Khanna Publ.

Bosoi ESO, Verniaev V, Smirnov & Sultan-Shakh EG. 1990. *Theory, Construction and Calculations of Agricultural Machinery*. Vol. I. Oxonian Press Pvt. Ltd. No.56.

Getzlaff GE. 1993. *Comparative Studies on Standard Plough Body*. *Engineering Principles of Agricultural Machines.* ASAE Text Book No. 6.

Grover GK. 1996. *Mechanical Vibrations*. New Chand & Bros., Roorkee. Harris CM & Crede CE. 1976. *Shock and Vibration Hand Book*. McGraw Hill.

Holowenko AR. 1967. *Dynamics of Machinery*. McGraw Hill.

Kelly SG. 2000. *Fundamental of Mechanical Vibration*. 2nd Ed. McGraw Hill.

Kepner RA, Bainer R & Berger EL. 1978. *Principles of Farm Machinery*. AVI Publ. Co.

Klenin NI, Popov IF & Sakoon VA. 1987. *Agricultural Machines. Theory of Operations, Computing and Controlling Parameters and the Condition of Operation*. Amrind Publ.Co.

Marples.1969. *Dynamics of Machines*. McGraw Hill.

Meirovitch L. 1986. *Elements of Vibration Analysis*. 2nd Ed. McGraw Hill. Nartov PS. 1985. *Disc Soil Working Implements*. A. A. Balkema, Rotterdam.
Srivastav AC. 2001. *Elements of Farm Machinery*. Oxford & IBH. Steidal.1986. *Introduction to Mechanical Vibrations*. Wiley International & ELBS Ed.
William T Thomson. 1993. *Theory of Vibration with Application.* Prentice Hall.

FMPE 508 TRACTORDESIGN 2+1

Objective

To acquaint and equip with the latest design procedures of tractor and its systems.

Theory

UNIT I

Technical specifications of tractors available in India, modern trends in tractor design and development, special design features of tractors in relation to Indian agriculture.

UNIT II

Parameters affecting design of tractor engine and their selection. Design of fuel efficient engine components and tractor systems like transmission, steering, front suspension, hydraulic system & hitching, chassis, driver's seat,work-place area and controls. Tire selection

UNIT III

Mechanics of tractor. Computer aided design and its application in agricultural tractors.

Practical

Extensive practices on the packages mentioned in the theory.

Suggested Readings

Arther W Judge 1967. *High Speed Diesel Engines*. Chapman & Hall. Barger EL, Liljedahl JB & McKibben EC. 1967. *Tractors and their Power Units*. Wiley Eastern.

Macmillan RH. *The Mechanics of Tractor - Implement Performance, Theory and Worked Example*. University of Melbourne.

Maleev VL. 1945. *Internal Combustion Engines*. McGraw Hill.

Ralph Alcock 1986. *Tractor Implements System*. AVI Publ. Co.

FMPE509 OPERATIONS RESEARCH INFARMPOWER & MACHINERYMANAGEMENT 2+1

Objective

To acquaint and equip with the mechanization status in the country and management techniques for future requirements.

Theory

UNIT I

Nature, methods, impact and scope of operational research; linear programming and integer programming models and applications. Network terminology, shortest route and minimal spanning tree problems, maximal flow problem, project planning and control with PERT and CPM.

UNIT II

System approach in farm machinery management and application of programming techniques to the problems of farm power and machinery selection.

UNIT III

Maintenance and scheduling of operations. Replacement of old machines, repair and maintenance of agricultural machinery, inventory control of spare parts, work study, productivity, method study. First order Markov chains and their applications in sales forecasting and in problems of inventory control and modeling of workshop processes and qualitycontrol.

UNIT IV

Time and motion study. Man-machine task system in farm operations, planning of work system in agriculture. Computer application in selection of power units and to optimize mechanizationsystem.

Practical

Management problems and case studies.

Suggested Readings

Carville LA. 1980. *Selecting Farm Machinery*. Louisiana Cooperative Extn. Service Publication.

Culpin C & Claude S. 1950. *Farm Mechanization; Costs and Methods*. McGraw Hill.

Culpin C & Claude S. 1968. *Profitable Farm Mechanization*. Crosby Lockwood & Sons.

FAO.1984. *Agricultural Engineering in Development: Selection of Mechanization Inputs*. Agricultural ServiceBulletin.

Hunt D. 1977. *Farm Power and Machinery Management*. Iowa State University Press.

Waters WK. 1980. *Farm Machinery Management Guide*. Pennsylvania Agric. Extn. Service Spl. Circular No. 1992

FMPE510 ERGONOMICSANDSAFETYINFARMOPERATIONS 2+1

Objective

To acquaint and equip with the ergonomic aspects in the design of farm machinery and tractors for safety of human beings

Theory

UNIT I

Concept and design criteria for optimum mutual adjustment of man and his work: Importance of ergonomics and its application in agriculture, liberation and transfer of energy in human body, concept of indirect calorimeter, work physiology in various agriculturaltasks.

UNIT II

Physiological stress indices and their methods of measurement: Mechanical efficiency of work, fatigue and shift work.

UNIT III

Anthropometry and Biomechanics: Anthropometric data and measurement techniques, joint movement and method of measurement, analysis and application of anthropometric data, measurement of physical and mental capacities.

UNIT IV

Human limitations in relation to stresses and demands of working environments. Mechanical environment; noise and vibration and their physiological effects, thermal environment; heat stress, thermal comfort, effect on performance and behavior, field of vision, color discrimination, general guidelines for designing visual display, safety standards at work place during various farm operations and natural hazards on the farm. Farm safety legislation.

UNIT V

Man-machine system concept. Human factors in adjustment of man and hiswork.Designaspectsoffootandhandcontrolsontractorsandfarm equipment. Design of operator's seat for tractors and agricultural equipment.

Practical

Laboratory experiments on measurement of physical and mental capacities and limitations of human-being in relation to the stress and environment, anthropometric measurements, study of human response to dust, noise and vibrations, case studies on ergonomics.

Suggested Readings

Bridger RS. 1995. *Introduction to Ergonomics*. McGraw Hill.

Charles D Reese. 2001. *Accident / Incident Prevention Techniques*. Taylor & Francis.

Gavriel Salvendy. 1997. *Hand Book of Human Factors and Ergonomics*. John Wiley & Sons.

Kromer KHE. 2001. *Ergonomics*. Prentice Hall.

Mathews J & Knight AA.1971. *Ergonomics in Agricultural Design*. National Institute of Agric. Engineering, Wrest Park Silsoe, Bedford.

Mathews J Sanders, Cormicks MS & MCEj. 1976. *Human Factors in Engineering and Design*. 4th Ed. McGraw Hill.

William D McArdle. 1991. *Exercise Physiology*.1991. Lea & Febiger.

Zander J. 1972. *Principles of Ergonomics*. Elsevier.

Zander J.1972. *Ergonomics in Machine Design.* Elsevier.

FMPE511/ PFE502 **ENGINEERING PROPERTIESOFBIOLOGICAL MATERIALS** **2+1**

Objective

To acquaint and equip with the different techniques of measurement of engineering properties and their importance in the design of biological material handling equipment.

Theory

UNIT I

Physical characteristics of different food grains, fruits and vegetables; Shape and size, description of shape and size, volume and density, porosity, surface area. Rheology; ASTM standard, terms, physical state of materials, classical ideal material, rheological models and equations, viscoelasticity, creep-stress relaxation, Non Newtonian fluid and viscometry, rheological properties; force, deformation, stress, strain, elastic, plasticbehaviour.

UNIT II

Contact stresses between bodies, Hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity, temperature, water film and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity.

UNIT III

Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high- frequency electric field.

UNIT IV

Application of engineering properties in design and operation ofagricultural equipment andstructures.

Practical

Determination of physical properties like, length, breadth, thickness, surface area, bulk density, porosity, true density, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods, aerodynamic properties like terminal velocity, lift and drag force for food grains, thermal properties like thermal conductivity, thermal diffusivity and specific heat, firmness and hardness of grain, fruits and stalk, electrical properties like dielectric constant, dielectric loss factor, loss tangent and A.C. conductivity of various food materials.

Suggested Readings

Hallstrom B, Meffert HF, Th Spesis WEL & Vos G. 1983. *Physical Properties of Food*. Elsevier.

Mohesenin NN. 1980. *Physical Properties of Plant and Animal Materials*. Gordon & Breach Science Publ.

Mohesenin NN. 1980. *Thermal Properties of Foods and Agricultural Materials*. Gordon & Breach Science Publ.

Peleg M & Bagelay EB. 1983. *Physical Properties of Foods*. AVI Publ. Co. Rao MA & Rizvi SSH. (Eds.). 1986. *Engineering Properties of Foods*. Marcel Dekker.

Ronal Jowitt, Felix Escher, Bengt Hallsrram, Hans F, Th. Meffert, Walter EC Spices & Gilbert Vox. 1983. *Physical Properties of Foods*. Applied Science Publ.

Singhal OP & Samuel DVK. 2003. *Engineering Properties of Biological Materials*. Saroj Prakasan.

FMPE512 AGRO-ENERGY AUDITANDMANAGEMENT 2+0

Objective

To acquaint and equip about the sources of energy, conservation of energy and its management. Energy use scenario in agricultural production system, agro-based industry. Study of energy efficiency, energy planning, forecasting and energy economics.

Theory

UNIT I

Energy resources on the farm: conventional and non-conventional forms of energy and their use. Heat equivalents and energy coefficients for different agricultural inputs and products. Pattern of energy consumption and their constraints in production of agriculture. Direct and indirect energy.

UNIT II

Energy audit of production agriculture, and rural living and scope of conservation.

UNIT III

Identification of energy efficient machinery systems, energy losses and their management. Energy analysis techniques and methods: energy balance, output and input ratio, resource utilization, conservation of energy sources.

UNIT IV

Energy conservation planning and practices. Energy forecasting, Energy economics, Energy pricing and incentives for energy conservation, factors effecting energy economics. Energy modelling.

Suggested Readings

Kennedy WJ Jr. & Wayne C Turner.1984. *Energy Management*. Prentice Hall.

Pimental D. 1980. *Handbook of Energy Utilization in Agriculture*. CRC Fluck RC & Baird CD.1984. *Agricultural Energetics*. AVI Publ.

Rai GD. 1998. *Non-conventional Sources of Energy*. Khanna Publ.

Twindal JW & Anthony D Wier 1986. *Renwable Energy Sources*. E & F.N. Spon Ltd.

Verma SR, Mittal JP & Surendra Singh 1994. *Energy Management and Conservation in Agricultural Production and Food Processing.* USG Publ. & Distr.,Ludhiana.

FMPE513 DESIGNANDANALYSISOFRENEWABLEENERGY CONVERSIONSYSTEMS 3+0

Objective

To acquaint and equip with the conventional and non-conventional energy sources. Energy from biomass, conversion of energy from biomass. Development of biogas and biofuels.

Theory

UNIT I

Energy cycle of the earth; water flow and storage; ocean currents and tides. Energy heat flow and energy storage; photosynthesis and biomass; renewable energy sources.

UNIT II

Thermodynamics of energy conversion; conversion of solar energy, wind energy, water flows, heat, biomass, etc.; other conversion processes.

UNIT III

Development and use of biogas, alcohols and plant oils, plant oil esters in I.C.engines. Study of various parameters for measuring the performance of the output.

UNIT IV

Design of bio-fuel production units: design of gasifiers, gas flow rates, bio- gas plants. Establishment of esterification plant, fuel blending.

Suggested Readings

Boyle Godfrey. 1996. *Renewable Energy: Power for Sustainable Future*. Oxford Univ. Press.

Culp AW. 1991. *Principles of Energy Conservation*. Tata McGraw Hill. Duffle JA & Beckman WA. 1991. *Solar Engineering of Thermal Processes*. John Wiley.

Garg HP & Prakash J.1997. *Solar Energy - Fundamental and Application*. Tata McGraw Hill.

Grewal NS, Ahluwalia S, Singh S & Singh G. 1997. *Hand Book of Biogas Technology. Solar Energy Fundamentals and Applications*. TMHNew Delhi.

Mittal KM. 1985. *Biomass Systems: Principles & Applications*. New Age International.

Odum HT & Odum EC. 1976. *Energy Basis for Man and Nature*. Tata McGraw Hill.

Rao SS & Parulekar BB.1999. *Non-conventional, Renewable and Conventional* . Khanna Publ.

Sukhatme SP.1997. *Solar Energy - Principles of Thermal Collection and Storage*. 2nd Ed. Tata McGraw Hill.

FMPE514 RESEARCHMETHODOLOGY 0+1

Practical

The research problem -literature review -types of research, experimental & quasi-experimental research-causal comparative & correlation research Survey research- sampling techniques. Optimization software – GAMES – applications, electronic spread sheet – solver. Image analysis software – applications. General computational software for research – MATLAB – applications – statistical applications, Report writing – interpretation and reporting. Scientific writing techniques. Presentation -techniques.

Suggested Readings

Hamdy A Taha. 2001. *Operations Research*. Prentice Hall of India. Holman JP 1996. *Experimental Methods for Engineers*. McGrawHill.

Rudra Pratap. 2003. *Getting Started with MATLAB. A Quick Introduction for Scientists and Engineers*. Oxford Univ. Press.

Santhosh Gupta. 1979. *Research Methodology and Statistical Techniques*. Khanna Publ.

Stephen J Chapman. 2003. *MATLAB Programming for Engineers*. Eastern Press.

Steven C Chapra & Raymond P Canale. 2000. *Numerical Methods for Engineers with Programming and Software Applications*. Tata McGraw.

William J Palm. 2001. *Introduction to Matlab 6 for Engineers*. McGraw Hill.

FMPE595 INDUSTRY /INSTITUTETRAINING 0+1 (NC)

Objective

To expose the students to the industry.

Theory

In-plant training in the relevant farm power and machinery industry during manufacturing, assembly and testing of the machines and equipment. To study the actual working of the equipment and various unit operations. The evaluation will be based on the written report of the student and the comments of the factory managers. The duration of training shall be three weeks. The student shall be required to do training in the institute other than the institute in which he/she isenrolled.

FMPE601 ADVANCES IN FARM MACHINERY ANDPOWERENGINEERING 3+1

Objective

To acquaint and equip with the latest mechanisms being used on the farm equipment and their analysis using computers.

Theory

UNIT I

Farm machinery system, its characteristics and evaluation. Identification of dynamic characteristics of related components of engine and agricultural machines. Mechanism of dynamic elements and analysis of forces, displacement and their equilibrium in machines.

UNIT II

Statement and formulation of design problems. Computer-aided design of mechanical power transmission systems. Half interval search method. Single and double-tie-rod steering systems, development of mathematical models and its computer-aidedsolutions.

UNIT III

Analysis of forces in tractor implement combinations under two and three dimensional conditions. Vibrations, transmissibility and effect of damping on various agricultural machine systems like engine, cutter-bar, straw walker, threshing cylinder and reaper-binder.

UNIT IV

Application of various vibration analysis methods. Tractor dynamics; development of the model. Checking, interpretation and statistical analysis of results.

Practical

Development of computer programs for Half interval search method. Single and double-tie-rod steering systems, Development of mathematical models and its computer aided solutions. Design problems using CAD.

Suggested Readings

Bevan T. 1962. *The Theory of Machines*. Longman.

Close CM, Fredrick DK & Newwell IC. 2001. *Modelling and Analysis of Dynamic System*. John Wiley & Sons.

Franklin GF & Powell JD. 1980. Digital Control of Dynamic System. Addison Wesley Publ.

Kepner RA, Bainer R & Berger EL. 1978. *Principles of Farm Machinery*. AVI Publ.

Mabie HH & Ocrirk FW.1987. *Mechanism and Dynamics of Machinery*. John Wiley & Sons.

Shigley JE & Uicker JJ .1980. *Theory of Machinery andMechanism*. McGraw Hill.

FMPE602 SIMULATION MODELLING IN FARM MACHINERYAND POWER ENGINEERING

Objective

To acquaint and equip with the mathematical modeling of farm machinery, development of models using various techniques.

Theory

UNIT I

System performance and modelling methodologies – transformation of units of measurement – dimensional homogeneity. Buckingham's Pi Theorem. Simulation for system modelling, Formulations of simulation model, validation and testing of the simulationmodel.

UNIT II

Experimentation with physical models and their application in farm machinery design. Sensitivity of models, scale effects, scale factors. Use of models. Complete similarity, kinematics and dynamic similarity. Model laws, empirical methods in model engineering. Principle of similarity in mathematical investigations. Mathematical modelling and its limitations, etc.

UNIT III

Mathematical modelling through ordinary differential equation of first order, second order, partial differential equations. Similarity conditions and abstract parameters determining characteristics of engines. Similitude in tillage tool studies, prediction models for tractiondevices.

Practical

Problems in simulation models & Buckingham's Pi theorem. Problems in scale effects, scale factors and mathematical modelling. Analysis of modelling behaviour in problems related to tillage, traction and earthmovingequipment.

Suggested Readings

Langhaar HL.1954. *Dimensional Analysis and Similitude*. McGraw Hill. Sedov LI. 1991. *Similarity and Dimensional Methods in Mechanics*. Mir Publ., Moscow.

FMPE603 ENERGY CONSERVATION ANDMANAGEMENTIN FARM POWER ANDMACHINERY 2+0

Objective

To acquaint and equip with the energy use pattern in agriculture production systems, conservation of energy, energy planning and economics.

Theory

UNIT I

Energy requirement of different operations in agricultural production systems viz. crop, livestock and aquaculture.

UNIT II

Energy conservation through proper management and maintenance of farm machinery, planning and management of agricultural production systems for energy conservation and energy returnsassessment.

UNIT III

Development of computer program for efficient energy management in a given agricultural production system. Energy use planning and forecasting for a given system.

Suggested Readings

Mittal JP, Panesar BS, Singh S, Singh CP & Mannan KD. 1987. *Energy in Production Agriculture and Food Processing*. ISAE and School of Energy Studies, Ludhiana. ISAE Publ.

Pimental D. 1980. *Handbook of Energy Utilization in Agriculture*. CRC Press.

FMPE604 COMPUTER AIDED ANALYSIS ANDDESIGNOF FARMMACHINERY 2+1

Objective

To acquaint and equip with the computer aided design, analysis and manufacturing of farm machinery with the help of CAD.

Theory

UNIT I

Introduction to CAD – the design process – modelling using CAD – architecture of CAD system. Geometric modelling – requirements – geometric construction methods – representation of curve – desirable modeling facilities. – CAD standards – Graphical Standard system – Exchange of modeling data.

UNIT II

System analysis – Relevance of system approach to biological systems and engineering systems. Role of a system analyst in design of a system and development of computer systems. Characteristics of Agricultural systems. Tools of structured analysis.-The data flow model. Object oriented approach. Feasibility study – Steps in feasibility analysis – cost analysis. System design process – structured design.

UNIT III

Application to farm machinery scheduling problem. Application to farm – factory co-ordination – case study. Design of farm machinery with the help of CAD.

Practical

Practical on CAD software, its uses and application in design of farm machinery. Design procedures. Exercise on agricultural engineering system analysis. Description of the machinery scheduling problem in harvesting and transport system. Investigation of existing software models – cases studies.

Suggested Readings

Chris McMahon & Jimmie Browne. 2000. *CAD /CAM/ Principles, Practice and Manufacturing Management*. Pearson Edu.

Grover Mikell P. 2003. *Automation, Production Systems and Computer Integrated Manufacturing*. Prentice-Hall of India.

Radhakrishnan P, Subramanyan S & Raju V. 2003. *CAD/CAM/CIM*. New Age International.

Rao PN. 2002. *CAD/CAM Principles and Applications*. Tata McGraw Hill. Zeid Ibrahim.1998. *CAD/CAM Theory and Practice*. Tata McGraw Hill.

FMPE605 MACHINERY FORNATURALRESOURCE MANAGEMENT AND PRECISIONFARMING 3+1

Objective

To acquaint and equip with the farm machinery used for natural resources management and machinery for precision farming. Use of GIS and GPS in farm machinery.

Theory

UNIT I

Functional design, specifications, requirements and working of farm machinery needed for natural resources management like rotavator, Precision sowing and planting machines, laser guided leveller, power sprayer ,straw chopper cum spreader, straw bailer , combine harvester etc.

UNIT II

Ag GPS parallel swathing option, data base management, functional systems documentation. Application of relevant software.

UNIT III

An introduction to precision farming. GIS/GPS positioning system for precision farming, Yield monitoring and mapping, soil sampling and analysis. Computers and Geographic information systems. Precision farming- Issues and conditions. Role of electronics in farm machinery for precision farming.

UNIT IV

Engineering fundamentals related to earth moving machinery: Swell, shrinkage and compaction measurements. Use of tractors & Crawlers and effects of altitude & temperature on their performance. Grade resistance and gradability

UNIT V

Land cleaning and reclamation equipment. Land leveling equipment. Power shovels, drag lines, cam shells. Rubber tire for earth moving machinery. Trenching machineries and wagons. Economic analysis of land development machinery. Application of PERT and CPM to the problems related to landdevelopment.

Practical

Introduction to GIS and GPS, study of models vis-à-vis farm machinery usage. Precision farming using GIS and GPS – case study.

Study the mechanism of power shovels, drag lines, earth diggers, clamshells etc. earth work estimation, unit cost of operation, work scheduling, machinery maintenance,entrepreneurship

Suggested Readings

De Mess M. N. Fundamental of Geographic Information System. John Willy and Sons, New York

Dutta SK. 1987. Soil conservation and land management. International distributors, Dehradun.

Kuhar, John. E. 1977. The precision farmimg guide for agriculturalist. Lori J. Dhabalt, USA.

Lille Sand, T and Kaiffer, R. Remote Sensing and Image Interpretation, John Willy and Sons, London.

Nichols HL& Day DH.1998. Moving the earth. The work book of excavation. Mcgraw Hill.

Peurifoy RL 1956.Construction, planning, equipment and methods. Mcgraw Hill

Sabbins, F. Remote Sensing Principle and Interpretation. Freeman, New York

Singh G.1991. Manual of soil and water conservation engineering. Oxford and IBH, Co.

Sigma & Jagmohan.1976. Earth moving machinery. Oxford & IBH Wood & Stuart. 1977. Earth moving machinery. Prentice Hall.

FMPE606 ADVANCES IN HYDRAULICSANDELECTRO PNEUMATICCONTROLS 2+0

Objective

To acquaint and equip with the latest developments in the field of hydraulics and pneumatics with special reference to the usage of these on the modern daytractors.

Theory

UNIT I

Fluid power, its advantages, properties of hydraulic fluids, viscosity, bulk modulus, density. Concepts of energy of hydraulic systems, laws of fluid flow.

UNIT II

Distribution system, pressure rating of tubing and hoses, couplings. Basics of hydraulic flow and hydraulic circuit analysis – pumps, types and theory of operation. Pressure intensifiers. Fluid power actuators, hydraulic rams, gear motors, piston motors and their performance characteristics, electro hydraulic motors and hydrostatic transmissions, control components.

UNIT III

Directional pressure safety and servo valves. Hydraulic circuit design. Regenerative pump unloading, pressure intensifier circuits. Speed control of hydraulic motors, mechanical hydraulic servo systems fortractors.

UNITIV

Pneumatic circuits – properties of air. Compressors, control elements. Design of pneumatic circuits. Electrical control for fluid power circuits. Electronic sensors/ circuits used as controls in modern farm equipment. Maintenance of hydraulic and pneumatic circuits and devices. Trouble shooting.

Suggested Readings

Anthony Esposito. 2003. *Fluid Power with Applications*. Pearsons Edu. Krutz G.1984. *Design of Agricultural Machines*. John Wiley & Sons.

Merritt HE. 1991. *Hydraulic Control System*. John Wiley a& Sons.

Majumdar SR. 2003. *Oil Hydraulic System*. Tata McGraw Hill.

PROCESSING AND FOOD ENGINEERING

Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
PFE 501*	TRANSPORT PHENOMENA IN FOOD PROCESSING	2+1
PFE 502*	ENGINEERING PROPERTIES OF FOOD MATERIALS	2+1
PFE 503*	ADVANCED FOOD PROCESS ENGINEERING	2+1
PFE 504*	UNIT OPERATIONS IN FOOD PROCESS ENGINEERING	2+1
PFE 505	ENERGY MANAGEMENT IN FOOD PROCESSING INDUSTRIES	2+1
PFE 506	PROCESSING OF CEREALS, PULSES AND OILSEEDS	2+1
PFE 507	FOOD PROCESSING EQUIPMENT AND PLANT DESIGN	2+1
PFE 508	FRUITS AND VEGETABLES PROCESS ENGINEERING	2+1
PFE 509	MEAT PROCESSING	2+1
PFE 510	FOOD PACKAGING	2+1
PFE 511	FOOD QUALITY AND SAFETY ENGINEERING	2+1
PFE 512	FARM STRUCTURES AND ENVIROMENTAL CONTROL	1+1
PFE 513	STORAGE ENGINEERING AND HANDLING OF AGRICULTURAL PRODUCTS	2+1
PFE 514	SEED DRYING, PROCESSING AND STORAGE	2+1
PFE 515	BIOCHEMCIAL AND PROCESS ENGINEERING	2+1
PFE 591	MASTER'S SEMINAR	1+0
PFE 592	SPECIAL PROBLEM	0+1
PFE 595#	INDUSTRY/ INSTITUE TRAINING	NC
PFE 599	MASTER'S RESEARCH	20
PFE 601**	TEXTURAL & RHEOLOGICAL CHARACTERISTICS OF FOOD MATERIALS	2+1
PFE 602**	ADVANCES IN FOOD PROCESSING	3+0
PFE 603	MATHEMATICAL MODELS IN FOOD PROCESSING	3+0
PFE 604	ADVANCES IN DRYING OF FOOD MATERIALS	2+1
PFE 605	AGRICULTURAL WASTE AND BY –PRODUCTS UTILIZATION	2+1
PFE 691	DOCTORAL SEMINAR I	1+0
PFE 692	DOCTORAL SEMINAR II	1+0
PFE 693	SPECIAL PROBLEM	0+1
PFE 694	CASE STUDY	0+1
PFE 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme

PFE 595 – Minimum of Three Weeks Training

Note: Some of the identified Minor/Supporting fields are Mechanical Engineering, Processing & Food Engineering, Energy in Agriculture, Civil Engineering, Computer Science, Electrical Engineering, Mathematics and Statistics; The contents of some of the identified Minor/Supporting courses have been given.

PROCESSING AND FOOD ENGINEERING

Course Contents

PFE501 TRANSPORT PHENOMENA INFOODPROCESSING 2+1

Objective

To acquaint and equip the students with the principles of heat and mass transfer and its applications in food processing.

Theory

UNIT I

Introduction to heat and mass transfer and their analogous behaviour, steady and unsteady state heat conduction, analytical and numerical solution of unsteady state heat conduction equations, use of Gurnie-Lurie and Heisler Charts in solving heat conduction problems. Applications in food processing including freezing and thawing offoods.

UNIT II

Convective heat transfer in food processing systems involving laminar and turbulent flow heat transfer in boiling liquids, heat transfer between fluids and solid foods. Functional design of heat exchangers: Shell and tube, plate and scraped surface heat exchangers, Jacketedvessels.

UNIT III

Radiation heat transfer and its governing laws, its applications in food processing.

UNIT IV

Molecular diffusion in gases, liquids and solids; molecular diffusion in biological solutions and suspensions molecular diffusion in solids, unsteady state mass transfer and mass transfer coefficients, molecular diffusion with convection and chemical reaction, diffusion of gases in porous solids and capillaries, mass transfer applications in food processing.

Practical

Solving problems on steady and unsteady state conduction with or without generation; numerical analysis; problems in natural and forced convection; radiation; designof heatexchangers;performingexperimentson heat conduction, convection and radiation heat transfer.

Suggested Readings

Benjamin G. 1971. *Heat Transfer*. 2nd Ed. Tata McGraw Hill.

Coulson JM & Richardson JF. 1999. *Chemical Engineering*. Vol. II, IV. The Pergamon Press.

Earle RL. 1985. *Unit Operations in Food Processing*. Pergamon Press. EcKert ERG &Draker McRobert1975. *Heat and Mass Transfer*. McGraw Hill.

Geankoplis J Christie 1999. *Transport Process and Unit Operations*. Allyn &Bacon.

Holman JP. 1992. *Heat Transfer*. McGraw Hill.

Kreith Frank 1976. *Principles of Heat Transfer*. 3rd Ed. Harper & Row. McCabe WL & Smith JC. 1999. *Unit Operations of Chemical Engineering*. McGraw Hill.

Treybal RE. 1981. *Mass Transfer Operations*. McGraw Hill.

Warren Gredt H. 1987.*Principles of Engineering Heat Transfer*. Affiliated East-West Press.

PFE502 ENGINEERING PROPERTIES OF FOOD MATERIALS2+1

Objective

To acquaint and equip the students with different techniques of measurement of engineering properties and their importance in the design of processingequipments.

Theory

UNIT I

Physical characteristics of different food grains, fruits and vegetables; Shape and size, description of shape and size, volume and density, porosity, surface area. Rheology; ASTM standard, terms, physical states of materials, classical ideal material, rheological models and equations, visco- elasticity, creep-stress relaxation, Non-Newtonian fluid and viscometry, rheological properties, force, deformation, stress, strain, elastic, plastic behaviour.

UNIT II

Contact stresses between bodies, Hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity, temperature, water film and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity.

UNIT III

Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high- frequency electric field.

UNIT IV

Application of engineering properties in design and operation of agricultural equipment andstructures.

Practical

Experiments for the determination of physical properties like, length, breadth, thickness, surface area, bulk density, porosity, true density, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods, aerodynamic properties like terminal velocity, lift and drag force for food grains, thermal properties like thermal conductivity, thermal diffusivity and specific heat, firmness and hardness of grain, fruits and stalk, electrical properties like dielectric constant, dielectric loss factor, loss tangent and A.C. conductivity of various foodmaterials.

Suggested Readings

Mohesenin NN. 1980. *Physical Properties of Plant and Animal Materials*. Gordon & Breach Science Publ.

Mohesenin NN. 1980. *Thermal Properties of Foods and Agricultural Materials*. Gordon & Breach Science Publ.

Peleg M & Bagelay EB. 1983. *Physical Properties of Foods*. AVI Publ.

Rao MA & Rizvi SSH. (Eds.). 1986. *Engineering Properties of Foods*. Marcel Dekker.

Ronal Jowitt, Felix Escher, Bengt Hallsrram, Hans F, Th. Meffert, Walter EC Spices, Gilbert Vox. 1983. *Physical Properties ofFoods*. Applied Science Publ.

Singhal OP & Samuel DVK. 2003. *Engineering Properties of Biological Materials*. Saroj Prakasan.

PFE503 ADVANCED FOODPROCESSENGINEERING 2+1

Objective

To acquaint and equip the students with different unit operations of food industries and their design features.

Theory

UNIT I

Thermal processing: Death rate kinetics, thermal process calculations, methods of sterilization and equipments involved, latest trends in thermal processing. Evaporation: Properties of liquids, heat and. mass balance in single effect and multiple effect evaporator, aroma recovery, equipments and applications. Drying: Rates, equipments for solid, liquid and semi-solid material and their applications, theories of drying, novel dehydration techniques.

UNIT II

Non-thermal processing: Microwave, irradiation, ohmic heating, pulsed electric field preservation, hydrostatic pressure technique etc.

UNIT III

Freezing: Freezing curves, thermodynamics, freezing time calculations, equipments, freeze drying, principle, equipments. Separation: Mechanical filtration, membrane separation, centrifugation, principles, equipments and applications, latest developments in separation and novel separation techniques.

UNIT IV

Extrusion: Theory, equipments, applications. Distillation and leaching: Phase equilibria, multistage calculations, equipments, solvent extraction.

Practical

Solving problems on single and multiple effect evaporator, distillation, crystallisation, extraction, leaching, membrane separation and mixing, experiments on rotary flash evaporator, humidifiers, reverse osmosis and ultra filtration - design of plate and packed tower, visit to related food industry.

Suggested Readings

Brennan JG, Butters JR, Cowell ND & Lilly AEI. 1990. *Food Engineering Operations*. Elsevier.

Coulson JM & Richardson JF. 1999. *Chemical Engineering*. VolS. II, IV. The Pergamon Press.

Earle RL. 1985. *Unit Operations in Food Processing*. Pergamon Press. Fellows P. 1988. *Food Processing Technology: Principle and Practice*. VCH Publ.

Geankoplis J Christie. 1999.*TransportProcess and Unit Operations.*Allyn &Bacon.

Henderson S & Perry SM. 1976. *Agricultural Process Engineering*. 5th Ed. AVI Publ.

McCabe WL & Smith JC. 1999. *Unit Operations of Chemical Engineering*. McGraw Hill.

Sahay KM & Singh KK. 1994. *Unit Operation of Agricultural Processing*. Vikas Publ. House.

Singh RP &Heldman DR. 1993. *Introduction to Food Engineering*. Academic Press.

Singh RP. 1991. *Fundamentals of Food Process Engineering*. AVI PubL.

PFE 504 UNITOPERATIONSINFOODPROCESSENGINEERING 2+1

Objective

To acquaint and equip the students with different unit operations of food industries.

Theory

UNIT I

Review of basic engineering mathematics; Units and dimensions; Mass and energy balance.

UNITII

Principles of fluid flow, methods of heat transfer, heat exchangers and their designs.

UNIT III

Psychrometry, dehydration, EMC, Thermal processing operations; Evaporation, dehydration/drying, types of dryers, blanching, pasteurization, distillation, steam requirements in food processing.

UNIT IV

Refrigeration principles and Food freezing. Mechanical separation techniques, size separation equipments; Filtration, sieving, centrifugation, sedimentation. Material handling equipment, conveyors and elevators; Size reduction processes; Grinding and milling.

UNIT V

Homogenization; Mixing- mixers, kneaders and blenders. Extrusion. Membrane technology. Non-thermal processing techniques.

UNIT VI

Food plant design; Food plant hygiene- cleaning, sterilizing, waste disposal methods, engineering aspects of radiation processing. Food packaging: Function materials, technique, machinery and equipment.

Practical

Fluid flow properties, study of heat exchangers problems, application of psychrometric chart, determination of EMC, study of driers, elevating and conveying equipments, size reduction equipments, cleaning and sorting equipments, mixing equipments, sieve analysis, kinetics of fruits and vegetables dehydration, calculation of refrigeration load, food plant design, gas and water transmission rate, solving of numerical problems.

Suggested Readings

Brennan JG, Butters JR, Cowell ND & Lilly AEI. 1990. *Food Engineering Operations*. Elsevier.

Earle RL. 1985. *Unit Operations in Food Processing*. Pergamon Press. Fellows P. 1988. *Food Processing Technology: Principle and Practice*. VCH Publ.

McCabe WL & Smith JC. 1999. *Unit Operations of Chemical Engineering*. McGraw Hill.

Sahay KM & Singh KK. 1994. *Unit Operation of Agricultural Processing*. Vikas Publ. House.

Singh RP &Heldman DR. 1993. *Introduction to Food Engineering*. Academic Press.

PFE505 ENERGY MANAGEMENT IN FOOD PROCESSING INDUSTRIES 2+1

Objective

To acquaint and equip the students with different energy management techniques including energy auditing of food industries.

Theory

UNIT I

Energy forms and units, energy perspective, norms and scenario; energy auditing, data collection and analysis for energy conservation in food processing industries.

UNIT II

Sources of energy, its audit and management in various operational units of the agro-processing units; passive heating, passive cooling, sun drying and use of solar energy, biomass energy and other non-conventional energy sources in agro-processing industries.

UNIT III

Reuse and calculation of used steam, hot water, chimney gases and cascading of energy sources. Energy accounting methods, measurement of energy, design of computer-based energy management systems, economics of energy use.

Practical

Study of energy use pattern in various processing units i.e., rice mills, sugar mills, dal mills, oil mills, cotton-ginning units, milk plants, food industries etc. Energy audit study and management strategies in food processing plants. Identification of energy efficient processing machines. Assessment of overall energy consumption, production and its cost in food processing plants, visit to related food processing industry.

SuggestedReadings

Pimental D. 1980. *Handbook of Energy Utilization in Agriculture*. CRC Press.

Rai GD. 1998. *Non-conventional Sources of Energy*. Khanna Publ.

Twindal JW & Anthony D Wier 1986. *Renewable Energy Sources*. E & F. N. Spon Ltd.

Verma SR, Mittal JP & Surendra Singh. 1994. *Energy Management and Conservation in Agricultural Production and Food Processing.* USG Publ. & Distr.,Ludhiana.

PFE506 PROCESSING OF CEREALS, PULSES AND OILSEEDS2+1

Objective

To acquaint and equip the students with the post harvest technology of cereals, pulses and oilseeds with special emphasis on their equipments.

Theory

UNIT I

Production and utilization of cereals and pulses, grain structure of major cereals, pulses and oilseeds and their milling fractions; grain quality standards and physico-chemical methods for evaluation of quality of flours.

UNIT II

Pre-milling treatments and their effects on milling quality; parboiling and drying, conventional, modern and integrated rice milling operations; wheat roller flour milling; processes for milling of corn, oats, barley, gram, pulses, paddy and flour millingequipments.

UNIT III

Dal mills, handling and storage of by-products and their utilization. Storage of milled products, Expeller and solvent extraction processing, assessment of processed productquality.

UNIT IV

Packaging of processed products, design characteristics of milling equipments; selection, installation and their performance, BIS standards for various processed products.

Practical

Physical properties of cereals and pulses, raw and milled products quality evaluations; parboiling and drying; terminal velocities of grains and their fractions; study of paddy, wheat, pulses and oilseeds milling equipments; planning and layout of various milling plants, visit to related agro- processing industry.

Suggested Readings

Asiedu JJ.1990. *Processing Tropical Crops*. ELBS/MacMillan. Chakraverty A. 1995. *Post-harvest Technology of Cereals, Pulsesand Oilseeds*. Oxford & IBH.

Morris Lieberman. 1983. *Post-harvest Physiology and Crop Preservation*. Plenum Press.

Pandey PH. 1994. *Principles of Agricultural Processing*. Kalyani.

Pillaiyar P. 1988. *Rice - Post Production Manual*. Wiley Eastern.

Sahay KM & Singh KK. 1994. *Unit Operations in Agricultural Processing*. Vikas Publ. House.

PFE507 FOODPROCESSINGEQUIPMENTANDPLANTDESIGN 2+1

Objective

To acquaint and equip the students with the design features of different food processing equipments being used in the industries and with the layout, planning of different food and processingplants.

Theory

UNIT I

Design considerations of processing agricultural and food products.

UNIT II

Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation.

UNIT III

Human factors in design, selection of materials of construction andstandard component, design standards and testing standards. Plant design concepts and general design considerations: plant location, location factors and their interaction with plant location, location theory models, computer aided selection of thelocation.

UNIT IV

Feasibility analysis and preparation of feasibility report: plant size, factors affecting plant size and their interactions, estimation of break-even and economic plant size; Product and process design, process selection, process flow charts, computer aided development of flow charts.

UNIT V

Hygienic design aspects and worker's safety, functional design of plant building and selection of building materials, estimation of capital investment, analysis of plant costs and profitabilities, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.

Practical

Detailed design and drawing of mechanical dryers, milling equipment, separators, evaporators, mixers and separators. Each individual student will be asked to select a food processing plant system and develop a plant design report which shall include product identification and selection, site selection, estimation of plant size, process and equipment selection, process flow-sheeting, plant layout, and its evaluation and profitabilityanalysis.

Suggested Readings

Ahmed T. 1997. *Dairy Plant Engineering and Management*. 4th Ed. Kitab Mahal.

Chakraverty A& De DS. 1981. *Post-harvest Technology of Cereals, Pulses and Oilseeds*. Oxford &IBH.

Gary Krutz, Lester Thompson & Paul Clear. 1984. *Design of Agricultural Machinery*. John Wiley & Sons.

Hall CW& Davis DC. 1979. *Processing Equipment for Agricultural Products*. AVIPubl.

Henderson S & Perry SM. 1976. *Agricultural Process Engineering*. 5th Ed. AVI Publ.

Johnson AJ. 1986. *Process Control Instrumentation Technology*. 2nd Ed. Wiley International & ELBS.

Rao T. 1986. *Optimization: Theory and Applications*. 2nd Ed. Wiley Eastern.

Richey CB. (Ed.). 1961. *Agricultural Engineers' Hand Book*. McGraw Hill. Romeo T Toledo. 1997. *Fundamentals of Food Process Engineering*. CBS. Slade FH. 1967. *Food Processing Plant*. Vol. I. Leonard Hill Books.

PFE508 FRUITSANDVEGETABLESPROCESSENGINEERING 2+1

Objective

To acquaint and equip the students with processing of fruits and vegetables and the design features of the equipments used for their processing.

Theory

UNIT I

Importance of post harvest technology of fruits and vegetables, structure, cellular components, composition and nutritive value of fruits and vegetables, fruit ripening, spoilage of fruits and vegetables.

UNIT II

Harvesting and washing, pre-cooling, preservation of fruits and vegetables, blanching, commercial canning of fruits and vegetables, minimal processing of fruits andvegetables.

UNIT III

Cold storage of fruits and vegetables, controlled atmosphere packaging of fruits and vegetables, gas composition, quality of storage.

UNIT IV

Dehydration of fruits and vegetables, methods, osmotic dehydration, foam mat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources.

UNIT V

Intermediate moisture foods, ohmic heating principle, high pressure processing of fruits and vegetables, applications, sensory evaluation of fruit and vegetable products, packaging technology for fruits and vegetables, general principles of quality standards and control, FPO, quality attributes.

Practical

Determination of size, shape, density, area-volume-mass relationship of fruits and vegetables, sugar-acid ratio of fruits, evaluation of washer, grader and packaging methods, experiments on drying of fruits and vegetables, controlled atmosphere storage and quality evaluation.

Suggested Readings

Cruesss WV. 2000. *Commercial Fruit and Vegetable Products*. Agrobios. Mircea Enachesca Danthy. 1997. *Fruit and Vegetable Processing*. International Book Publ.

Srivastava RP & Sanjeev Kumar. 1994. *Fruit and Vegetable Preservation. Principles and Practices*. International Book Distr.

Sumanbhatti & Uma Varma. 1995. *Fruit and Vegetable Processing*. CBS.

Thompson AK. 1996. *Post Harvest Technology of Fruits and Vegetables*. Blackwell.

Verma LR & Joshi VK. 2000. *Post Harvest Technology of Fruits and Vegetables*. Vols. I-II. IndusPubl.

PFE 509 MEATPROCESSING 2+1

Objective

To acquaint and equip the students with processing of meat and meat products and the design features of the equipments used for their processing.

Theory

UNIT I

Meat and poultry products: Introduction, kinds of meat animals and poultry birds, classification of meat, composition of meat.

UNIT II

Slaughtering: Pre slaughter operations, post slaughter operations, wholesale and retail cuts.

UNIT III

Preservation of poultry: different methods, stuffed products, frozen products, poultry concentrates and flavours, synthetic poultry flavour.

UNIT IV

Different preservation methods of meat: Smoking, curing and freezing, chilling of meat and different methods of chilling, freezing of meat and different methods of freezing of meat, physical and chemical changes during chilling and freezing, packaging of meat and meat products, quality control.

UNIT V

Classification, composition and nutritive value of eggs: Grading of eggs, different quality parameters of eggs, Haugh unit, processing of egg, yolk processing, egg breaking mechanisms, freezing of egg, pasteurization, desugarisation and dehydration of egg, different dehydration methods, quality control and specification of egg products.

UNIT VI

Fish: Nutritional quality of fish and fish products, fillet and steaks, different preservation techniques, chilling, freezing, drying, canning, curing and smoking, quality control in fish processing.

Practical

Experiments in slaughtering, dressing, wholesale and retail cutting: Curing, preservation of meat and meat products, estimation of quality of egg, Haugh unit, desugarisation, preparation of whole egg powder, yolk powder, freezing of fish, drying of fish, canning of fish, visit to meat and fish processingunits.

Suggested Readings

Chooksey MK & Basu S. 2003. *Practical Manual on Fish Processing andQuality Contro*l. CIFE, Kochi.

Chooksey MK. 2003. *Fish Processing and Product Development*. CIFE, Kochi.

Hall GM. 1997. *Fish Processing Technology*. Blabie Academic &Professional.

Lawrie RS. 1985. *Developments in Meat Sciences*. Vol. III. Applied Science Publ.

Mead GC. 1989. *Processing of Poultry*. Elsevier.

Pearson AM & Tauber FW. 1984. *Processed Meats*. AVI Publ.

Stadelman WJ & Cotterill OJ. 1980. *Egg Science and Technology*. AVI Publ.

PFE 510 FOODPACKAGING 2+1

Objective

To acquaint and equip the students with packaging methods, packaging materials, packaging machineries, modern packaging techniques etc.

Theory

UNIT I

Introduction of packaging: Package, functions and design. Principle in the development of protective packaging. Deteriorative changes in foodstuff and packaging methods of prevention.

UNIT II

Food containers: Rigid containers, glass, wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks, corrosion of containers (tin plate); Flexible packaging materials and their properties; Aluminium as packaging material; Evaluation of packaging material and packageperformance.

UNIT III

Packaging equipments: Food packages, bags, types of pouches, wrappers, carton and other traditional package; Retortable pouches; Shelf life of packaged foodstuff.

UNIT IV

Methods to extend shelf life; Packaging of perishables and processed foods; Special problems in packaging of food stuff.

UNIT V

Package standards and regulation; Shrink packaging; Aseptic packaging, CA and MAP, Active packaging; Biodegradable packaging.

Practical

Thickness, substance weight, water absorption capability of flexible packaging materials; Strength properties of packaging materials; Water vapour and gas transmission rate of flexible packaging materials; Identification and chemical resistance of plastic films; Packaging of fruits/vegetables; Estimation of shelf-life of packaged food stuff; Familiarization of types of packaging material.

Suggested Readings

Crosby NT. 1981. *Food Packaging Materials*. Applied Science Publ. Mahadeviah M & Gowramma RV. 1996. *Food Packaging Materials*. Tata McGraw Hill.

Palling SJ. (Ed). 1980. *Developments in Food Packaging*. Applied Science Publ.

Sacharow S & Grittin RC. 1980. *Principles of Food Packaging*. AVI Publ.

PFE511 FOOD QUALITY ANDSAFETYENGINEERING 2+1

Objective

To acquaint and equip the students with the latest standards to maintain food quality as well as to study HACCPprotocol.

Theory

UNIT I

Food safety, need for quality control and safety, strategy and criteria, microbiological criteria for safety and quality, scope of food toxicology, toxic potential and food toxicants, biological and chemical contaminants.

UNIT II

Food additives and derived substances, factors affecting toxicity, designing safety in products and processes, intrinsic factors, establishing a safe raw material supply, safe and achievable shelf life.

UNIT III

Process equipment and machinery auditing, consideration of risk, environmental consideration , mechanical quality control.

UNIT IV

Personnel hygienic standards, preventative pest control, cleaning and disinfesting system, biological factors underlying food safety.

UNIT V

Preservation and stability, contaminants of processed foods, adulteration, prevention and control, FPO, PFA, Codex, GMP, BIS and HACCP; Practices, principles, standards, specifications, application establishment and implementation; HACCP and quality management system.

Practical

Microbiological examination of food, hazard analysis, premises design, HACCP project plan; CCP, CCP Decision tree, HACCP control chart. HACCP case studies; Survey, BIS, FPO, Codex standards and specifications. Visits to food industries to study the various quality and safety aspects adopted.

Suggested Readings

Chesworth N. 1997. *Food Hygiene Auditing.* Blackie Academic Professional, Chapman &Hall.

David A Shapton & Norah F Shapton. 1991. *Principles and Practices for the Safe Processing of Foods*.Butterworth-Heinemann.

Jacob M 2004. *Safe Food Handling*.CBS.

Jose M Concon. 1988. *Food Toxicology, Part A. Principles and Concepts, Part B. Contaminants and Additives.* Marcel Dekker.

Sara Mortimore & Carol Wallace. 1997. *HACCP - A Practical Approach*. Chapman & Hall.

PFE512 FARM STRUCTURES AND ENVIRONMENTAL CONTROL 1+1

Objective

To acquaint and equip the students with the techniques to control temperature, humidity and other composition of air to create favourable environment in the agricultural structures.

Theory

UNIT I

Thermodynamic properties of moist air, psychorometric chart and computer programmes for thermodynamic properties.

UNIT II

Farm structures, their design , constructional details and design of low cost structures. Heating, ventilating and exhaust systems, air distribution and air cleaning, combustion of fuels and equipment.

UNIT III

Drying and dehumidification system, air-water contact operations and evaporation, process and product air conditioning, energy efficient environmental control practices.

UNIT IV

Instruments and measurements; codes and standards.

Practical

Calculation of heating and cooling load; design calculation of moisture condensation in agricultural buildings; study of moisture migration behaviour in storage bins; design aspect of cold storage.

Suggested Readings

Albright LD. 1990. *Environmental Control for Animals and Plants*. ASAE Textbooks.

Esmay ML & Dixon JE. 1986. *Environmental Control for Agricultural Buildings*. The AVI Corp.

Gaudy AF & Gaudy ET. 1988. *Elements of BioenvironmentalEngineering*. Engineering Press.

Moore FF. 1994.*Environmental Control Systems: Heating, Cooling, Lighting*. Chapman & Hall.

Threlkeld JL. 1970. *Thermal Environmental Engineering*. Prentice Hall.

PFE513 STORAGE ENGINEERING ANDHANDLINGOF AGRICULTURALPRODUCTS 2+1

Objective

To acquaint and equip the students with the safe storage of food materials, design of storage structures and the design of different material handling equipments used in the industries.

Theory

UNIT I

Storage of grains, biochemical changes during storage, production, distribution and storage capacity estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements.

UNIT II

Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, bio-engineering properties of stored products, function, structural and thermal design of structures, aeration system.

UNIT III

Grain markets, cold storage, controlled and modified atmosphere storage, effects of nitrogen, oxygen, and carbon dioxide on storage of durable and perishable commodities, irradiation, storage of dehydrated products, food spoilage and preservation, BIS standards.

UNIT IV

Physical factors influencing flow characteristics, mechanics of bulk solids, flow through hoppers, openings and ducts; design of belt, chain, screw, roller, pneumatic conveyors and bucket elevators; principles of fluidization; recent advances in handling of food materials.

Practical

Quality evaluation of stored products, design of storage structures, cold storage, load estimation, construction, maintenance, static pressure drop, experiment on controlled and modified atmosphere storage system, estimation of storage loss, and quality of storedproducts.

Suggested Readings

FAO. 1984. *Design and Operation of Cold Stores in Developing Countries*. FAO.

Hall CW. 1970. *Handling and Storage of Food Grains in Tropical and Sub-tropical Areas*. FAO Publ. Oxford & IBH.

Henderson S &Perry SM. 1976. *Agricultural Process Engineering*. 5th Ed. AVIPubl.

McFarlane Ian. 1983. *Automatic Control of Food Manufacturing Processes*. Applied SciencePubl.

Multon JL. (Ed). 1989. *Preservation and Storage of Grains, Seeds and their By-products*.CBS.

Ripp BE. 1984. *Controlled Atmosphere and Fumigation in Grain Storage*. Elsevier.

Shefelt RL & Prussi SE. 1992. *Post Harvest Handling – A System Approach*. Academic Press.

Shejbal J. (Ed). 1980. *Controlled Atmosphere Storage of Grains*. Elsevier.

Vijayaraghavan S. 1993. *Grain Storage Engineering and Technology*. Batra Book Service.

PFE514 SEED DRYING, PROCESSINGANDSTORAGE 2+1

Objective

To acquaint and equip the students with processing of seeds and the design features of the equipments used for their processing.

Theory

UNIT I

Processing of different seeds and their engineering properties, principles and importance of seedprocessing.

UNIT II

Performance characteristics of different unit operations such as pre- cleaning, grading, conveying, elevating, drying, treating, blending, packaging and storage, seed processing machines like scalper, debreader, huller, velvet separator, spiral separator, cleaner-cum-grader, specific gravity separator, indent cylinder, disc separator, and colour sorter, seed treater, weighing and bagging machines, their operation and maintenance, installation and determination of their capacity, seed quality maintenance during processing, plant design and layout, economy and safety consideration in plant design.

UNIT III

Seed drying principles and methods, theory of seed drying, introduction to different types of heated air dryers, significance of moisture equilibrium, method of maintaining safe seed moisture, thumb rule and its relevance, importance of scientific seed storage, types of storage structures to reduce temperature and humidity; management and operation/cleanliness of seed stores, packaging-principles, practices, materials and hermetic packaging, seed treatment methods and machines used, method of stacking and their impact, design features of medium and long term seed storage building.

Practical

Study of various seed processing equipments such as pre-cleaners, scalpers, air screen cleaners, graders, spiral and pneumatic separators, seed treating equipment, bag closures, scale etc. and their performance evaluation, design and layout of seed processing plant and its economics, analysis of cost of operation and unit cost of processed product, effect of drying temperature and duration of seed germination andstorability.

Suggested Readings

Gregg *et al.* 1970. *Seed Processing*. NSC.

Henderson S & Perry SM. 1976. *Agricultural Process Engineering*. 5th Ed. AVI Publ.

Sahay KM & Singh KK. 1994. *Unit Operation of Agricultural Processing*. Vikas Publ. House.

PFE515 BIOCHEMICAL ANDPROCESSENGINEERING 2+1

Objective

To acquaint and equip the students with the basic principles of biochemical and process engineering.

Theory

UNIT I

Applications of engineering principles; mass and energy balance, fluid flow principles, unit operations of process engineering.

UNIT II

Fundamentals of growth kinetics, maintenance energy and yield concepts, principles of media sterilization, media formulations of industrial fermentation.

UNIT III

Aerobic and agitated rheology of fermentative fluids, design and scale-up of bioreactors, enzymereactors.

UNIT IV

Principles of recovery of fermented products in bio-processing, instrumentation, transportphenomenon.

Practical

Kinetics of one substitute reactions, kinetics of growth in batch cultures, design consideration for bioreactors, media preparation and sterilization, microprocessor based monitoring of bioprocess parameters.

Suggested Readings

Coulson JM & Richadson JF. 1999. *Chemical Engineering*. Vols. II, IV. The Pergamon Press.

Treybal RE. 1981. *Mass Transfer Operations*. 3rd Ed. Harper & Row. Brennan JG, Butters JR, Cavell ND & Lilly AEI. 1990. *Food Engineering Operations*. Elsevier.

Greanoplis J Christie. 1999. *Transport Process and Unit Operation*. Allyn & Bacon.

PFE595 INDUSTRY/INSTITUTETRAINING 0+1(NC)

Objective

To expose the students to the industry.

Theory

In-plant training in the relevant food industry during processing operation of the plant to study the actual working of the equipment and various unit operations. The evaluation will be based on the written report of the student and the comments of the factory managers. The duration of training shall be three weeks. The student shall be required to do training in the institute other than the institute in which he/she isenrolled.

PFE601 TEXTURAL &RHEOLOGICALCHARACTERISTICS OF FOODMATERIALS 2+1

Objective

To acquaint and equip the students with the textural & rheological properties of food materials.

Theory

UNIT I

Texture classification. Relation of food texture with structure and rheology. Principles and practices of objective texture measurements, viscosity measurements.

UNIT II

Sensory methods of texture and viscosity measurements and their correlation. Rheological properties of foods.

UNIT III

Mathematical models and their application along with pipe line design and pump selection for non-Newtonian fluids. Recent advances in textural, rheological and viscoelastic characteristics of foods and their associated mathematical models.

Practical

Determination of viscosity of liquid foods, guminess, chewiness, springiness and hardness of various fruits, vegetables and processed foods using texture profile analysis. Determination of force-distance relationship. Sensory evaluation/ subjective measurement and correlation between subjective and objective measurements offoods.

Suggested Readings

Bourne MC. 2002. *Food Texture and Viscosity: Concept and Measurement*. Academic Press

Deman JM. *et al.* 1976. *Rheology and Texture in Food Quality*. AVI Publ.

Journal of Food Science and Technology

Journal of Texture Studies

Mohsanin NN.1989. Physical Properties of Plant and Animal Material. Vol. I, II. Gordon and Breach Science Publ.

Steffe JF. 1992. *Rheology and Texture in Food Quality*. AVI Publ.

PFE602 ADVANCES INFOODPROCESSING 3+0

Objective

To acquaint and equip the students with the modern and latest techniques of food engineering

Theory

UNIT I

Preservation of foods – physical and chemical methods-microbiological aspects thermo bacteriology, process calculation and selection.

UNIT II

Low temperature preservation - cooling and cold storage - freeze concentration and membrane separation process - hurdle technology - principles and applications - food irradiation - advantages and applications, microwave processing - interaction with food materials- microwave equipment - hydrostatic pressure treatment of food - equipment, processing and effect on microorganisms.

UNIT III

Application of heat energy and ultrasound - inactivation of microorganisms and enzymes -electrical resistance heating of food - heat generation, ohmic heater, heating models - pulsed electric field preservation- principles and application - influence on microorganisms and food ingredients - decontamination of microorganisms by surface treatment.

UNIT IV

Extrusion cooking - recent developments, methods, equipment, design criteria of extruders.

Suggested Readings

Heldman R Dennis and LundB Daryl. 1992. *Hand Book of Food Engineering.* Marcel Dekker.

Goldblith SA, Rey I &Rothmayr WW. 1975. *Freeze Drying and Advanced Food Technology*. AcademicPress.

Gould GW (Ed.).1996. *New Methods of Food Preservation*. Blackie Academic & Professional.

Leniger HA & Beverloo WA. 1975. *Food Process Engineering*. D. Reidel Publishing Co.

Rao MA &Rizvi SSH..1986.*Engineering Properties of Foods.*Marcel Dekker.

Ronald Jowitt. 1984. *Extrusion Cooking Technology.*Elsevier.

PFE603 MATHEMATICAL MODELS INFOODPROCESSING 3+0

Objective

To acquaint and equip the students with the mathematical modeling techniques and their applications in food processing

Theory

UNIT I

An overview of the modeling process. Introduction to mathematical, correlative and explanatory models. Formulation, idealization and simplification of the problems.

UNIT II

Probability models, series and linear mathematical approximation, dynamic and interacting dynamic processes.

UNIT III

Applications of mathematical modelling techniques to food processing operations like parboiling, convective drying, pasteurization, dehydration, shelf-life prediction, fermentaiton, aseptic processing, moisture diffusion, deep fat drying, microwave processing, infrared heating and ohmic heating. Stochastic finite element analysis of thermal food processes. Neural networks approach to modelling food processing operations.

Suggested Readings

Bailey NTJ, Sendov B &.Tsanev R.1974. *Mathematical Models in Biology and Medicine*. Elsevier.

Fischer M, Scholten HJ & Unwin D. 1996. *Spatial Analytical Perspectives on GIS*. Taylor & Francis.

Fish NM & Fox RI. 1989. *Computer Application in Fermentation Technology: Modelling and Control of Biotechnological Processes*. Elsevier.

Getz WM.1979. *Mathematical Modeling in Biology Processes*. Elsevier. Gold HJ.1977. *Mathematical Modelling of Biological Systems - An Introductory Guidebook*. John Wiley & Sons.

Hunt DR.1986. *Enginering Models for Agricultural Production*. The AVI Publ.

Kapur JN.1989. *Mathematical Modeling*. Wiley Eastern.

Koeing HE, Tokad Y, Kesacan HK & Hedgers HG. 1967. *Analysis of Discrete Physical Systems*. Mc Graw Hill.

Meyer JW. 2004. *Concepts of Mathematical Modeling*. Mc Graw Hill. Peart RM & Curry RB.1998. *Agricultural Systems, Modellingand Simulation*. Marcel Dekker.

Tijms HC. 1984. *Modelling & Analysis. A Congrtational Approach*. Wiley Publ.

Ver Planck & Teare BR 1954. *General Engineering Analysis - An Introduction to Professional Methods*. John Wiley & Sons.

PFE604 ADVANCES IN DRYING OFFOODMATERIALS 2+1

Objective

To acquaint and equip the students with the latest technologies of dehydration of food products and the design features of different dryers.

Theory

UNIT I

Importance of drying, principles of drying, moisture determination, equilibrium moisture content, determination of EMC, methods and isotherm models, psychrometry, psychrometric terms, construction and use of psychrometriccharts.

UNIT II

Air flow and resistance, principles and equipments for air movement and heating, drying methods and theory of drying, driers, classification and other allied equipment, thin layer drying of cereal grains, deep bed and continuous flow drying, dryingmodels.

UNIT III

Heat requirements and thermal efficiency of drying system, aeration, tempering and dehydration, operation of driers and their controls, selection of driers, performance testing of grain driers, drying characteristics of cereals, pulses and oilseeds, microwave drying, radio frequency drying and tunnel drying, principles andequipment.

UNIT IV

Drying of liquid foods, spray drying, drum drying, freeze drying, foam mat drying, heat pump drying, osmotic dehydration; Principles, methods, construction and adjustments, selection of dryers, heat utilization factor and thermal efficiency.

Practical

Experiments on batch type thin layer drier, fluidized bed drier, continuous flow mixing type drier, continuous flow non mixing type drier, sand medium drier (conduction type drying), agricultural waste fired furnace drier, spray dryer, drum dryer, foam mat drying and osmotic dehydration, to evaluate the thermal efficiency and heat utilization factor.

Suggested Readings

Bala BK. 1998. *Drying and Storage of Cereal Grains*. Oxford & IBH. Brooker DB, Bakker Arkema FW & Hall CW. 1974. *Drying Cereal Grains*. The AVI Publ.

Chakraverty A& De DS. 1999. *Post-harvest Technology of Cereals, Pulses and Oilseeds*. Oxford &IBH.

Hall CW. 1970. *Drying of Farm Crops*. Lyall Book Depot.

Tadensz Kudra & Majumdar AS. 2002. *Advanced Drying Technologies*. Marcel Dekker.

WallaceBVanArsdel&MichaelJCopley.1963. *Food Dehydration.* AVIPubl.

PFE605 AGRICULTURAL WASTEANDBY-PRODUCTS UTILIZATION 2+1

Objective

To acquaint and equip the students with the proper utilization of agricultural waste and by-products and also about development of value added products fromwastes.

Theory

UNIT I

Generation of by-products, agricultural and agro industrial by- products/wastes, properties, on site handling, storage and processing.

UNIT II

Collection of wastes, utilization pattern as fuel, agricultural waste fired furnaces: Mechanism, construction and efficiency, suitability of wastes as fuel, fuel briquettes, briquetting process, equipment, factors affecting briquetting.

UNIT III

Utilization of wastes for paper production, production of particle board, utilization, by-products from rice mill, rice husk, rice bran, utilisation.

UNIT IV

Thermo-chemical conversions, densification, combustion and gasification, extraction, biological conversions, anaerobic digestion, biochemical digestion process, digestion systems, energy from anaerobic digestion, cellulose degradation, fermentation process.

Practical

Exercises on stepped grate and fixed grate rice husk furnaces, waste fired furnace, briquette machine, production of alcohol from waste materials, production and testing of paperboards and particleboards from agricultural wastes.

Suggested Readings

ASAE Standards. 1984. *Manure Production and Characteristics*. Bor S

Luh (Ed.). 1980. *Rice: Production and Utilization.* AVI Publ.

Chahal DS.1991. *Food, Feed and Fuel from Biomass*. Oxford & IBH.

Chakraverty A. 1989. *Biotechnology and other Alternative Technologies for Utilisation of Biomass/ Agricultural Wastes*. Oxford &IBH.

David CWilson. 1981. *Waste Management - Planning, Evaluation, Technologies*.Oxford.

Donald L Klass & Emert H George 1981. *Fuels from Biomass and Wastes*. Ann. Arbor. Science Publ.

Srivastava PK, Maheswari RC & Ohja TP. 1995. *Biomass Briquetting and Utilization*. Jain Bros.

USDA 1992. *Agricultural Waste Management Field Handbook*. USDA.

Wilfred A Cote.1983. *Biomass Utilization*. Plenum Press.

SOIL AND WATER ENGINEERING

Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
SWE 501*	WATERSHED HYDROLOGY	2+1
SWE 502*	DESIGN OF FARM IRRIGATION SYSTEMS	2+1
SWE 503*	AGRICULTURAL DRAINAGE SYSTEMS	2+1
SWE 504*	GROUND WATER ENGINEERING	2+1
SWE 505	SOIL AND WATER CONSERVATION ENGINEERING	2+1
SWE 506	CROP ENVIRONMENTAL ENGINEERING	2+0
SWE 507	DESIGN OF PUMPS FOR IRRIGATION AND DRAINAGE	2+0
SWE 508	OPEN CHANNEL FLOW	3+0
SWE 509	FLOW THROUGH POROUS MEDIA	2+0
SWE 510	WATER RESOURCES SYSTEM ENGINEERING	3+0
SWE 511	GIS AND REMOTE SENSING FOR LAND AND WATER RESOURCE MANAGEMENT	2+1
SWE 512	WATERSHED MANAGEMENT AND MODELLING	2+1
SWE 513	LAND DEVELOPMENT AND EARTH MOVING MACHINERY	2+0
SWE 591	MASTER'S SEMINAR	1+0
SWE 592	SPECIAL PROBLEM	0+1
SWE 595#	INDUSTRY/ INSTITUE TRAINING	NC
SWE 599	MASTER RESEARCH	20
SWE 601**	ADVANCED HYDROLOGY	3+0
SWE 602**	SOIL AND WATER SYSTEMS' SIMULATION AND MODELLING	2+1
SWE 603	MODELLING SOIL EROSION PROCESSES	2+1
SWE 604	ADVANCED HYDRO-MECHANICS IN SOIL AQUIFER SYSTEMS	3+0
SWE 605	HYDRO-CHEMICAL MODELLING AND POLLUTANT MANAGEMENT	3+0
SWE 606	PLANT GROWTH MODELLING AND SIMULATION	3+0
SWE 607	ADVANCES IN IRRIGATION AND DRAINAGE	2+0
SWE 691	DOCTORAL SEMINAR I	1+0
SWE 692	DOCTORAL SEMINAR II	1+0
SWE 693	SPECIAL PROBLEM	0+1
SWE 694	CASE STUDY	0+1
SWE 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme

SWE 595 – Minimum of Three WeeksTraining

Note: Some of the identified Minor/Supporting fields are Mechanical Engineering, Processing & Food Engineering, Energy in Agriculture, Civil Engineering, Computer Science, Electrical Engineering, Mathematics and Statistics; The contents of some of the identified Minor/Supporting courses have been given.

SOIL AND WATER ENGINEERING

Course Contents

SWE501 WATERSHED HYDROLOGY 2+1

Objective

To acquaint and equip the students about hydrological process and analysis of hydrological data required for design process.

Theory

UNIT I

Hydrologic processes and systems; Hydrologic problems of small watersheds; Hydrologic characteristics ofwatersheds.

UNIT II

Measurement and analysis of hydrologic parameters, rainfall- runoff models, stream flow measurement and analysis of data.

UNIT III

Hydrograph analysis; Unit hydrograph theory; Synthetic and dimension less hydrograph, convolution of unithydrograph.

UNIT IV

Concept of hydraulic flood routing, flood routing (reservoir and channel routing).

UNITV

Definition and concept of different types of hydrologic models for simulation of hydrologic problems.

Practical

Rainfall analysis, runoff computation, construction of hydrographs, Delineation of watershed, hydrograph analysis, reservoir and channel routing, hydrologic models, visit to dam sites.

Suggested Readings

Chow VT, David, M & Mays LW. 1988. *Applied Hydrology*. McGraw Hill.

Ghanshyan Das 2000.*Hydrology and Soil Conservation Engineering*. Prentice Hall.

Tideman EM. 1996. *Watershed Management*. Omega Scientific Publ.

SWE502 DESIGN OF FARM IRRIGATION SYSTEMS
2+1

Objective

To acquaint and equip with the irrigation principles, design consideration of surface irrigation and micro irrigation systems and their evaluation system.

Theory

UNIT I

Concepts of Irrigation; Irrigation principles, losses, conveyance, distribution; Application, scheduling parameters, water budgeting.

UNIT II

Surface irrigation, hydraulics of water advance and recession, hydraulic resistance to flow, gravity irrigation.

UNIT III

Design of Border irrigation, furrow irrigation, check basin irrigation; Sub Irrigation methods and concepts.

UNIT IV

Preliminary design criteria of sprinkler and micro irrigation systems, hydraulics of sprinkler and micro irrigation systems. Design of lateral, submain and main line of sprinkler and micro irrigation. Fertigation aspects.

UNIT V

Underground water conveyance system; Evaluation of irrigation systems and practices.

Practical

Design and evaluation of border, furrow, check basin, sprinkler and micro irrigation, computation of frictional losses, Design of underground water conveyance systems, economics of irrigation methods, visit to mechanized farms.

SuggestedReadings

Finkel HJ. 1983. *Handbook of Irrigation Technology*. Vols. I-II. CRC Press.

Ivan E Henk. 1951. *Irrigation Engineering*. Vol. I. John Wiley & Sons.

KarmeliD,PeriG&TodesM.1985.*IrrigationSystems:Designand Operation*. Oxford Univ. Press.

Pillsbury AF. 1972. *Sprinkler Irrigation*. FAO Agricultural Development Paper No. 88, FAO.

Rydzewski 1987. *Irrigation Development Planning*. John Wiley & Sons.

Sivanappan RK, Padmakumari O & Kumar V. 1987. *Drip Irrigation*. Keerthy Publ. House.

Sivanappan RK. 1987. *Sprinkler Irrigation*. Oxford & IBH.

SWE503 AGRICULTURAL DRAINAGE SYSTEMS 2+1

Objective

To acquaint and equip with the importance and phenomenon of drainage system along with design consideration of surface and sub-surface drainage systems.

Theory

UNIT I

Theories and applications of surface and sub-surface drainage, steady state, unsteady state drainage equations for layered and non-layered soils, horizontal sub-surface drainage.

UNIT II

Principle and applications of Earnst, Glover Dumm, Kraijenhoff-van-de- leur equations.

UNIT III

Salt balance, leaching requirement and management practices under drainedconditions.

UNIT IV

Design of different components of sub-surface drainage systems, theories of vertical drainage and multiple well pointsystem.

UNIT V

Disposal of drainage effluents, Management of drainage projects of water-logged and saline soils, case studies.

Practical

Measurement of in-situ hydraulic conductivity, estimation of drainage coefficient and leaching requirements, Delineation of waterlogged areas through isobar, isobath and topographic maps. Design of surface and sub-surface drainage systems, design of filter and envelop materials.

Suggested Readings

Battacharaya AK & Micheal AM. 2003. *Land Drainage*. Vikas Publ.

Clande Ayres & Daniel Scoates A.E. 1989. *Level Drainage and Reclamation*. McGraw Hill.

Luthin JN. 1978. *Drainage Engineering*. Wiley Eastern.

Ritzema HP. (Ed.). 1994. *Drainage Principles and Applications*.

ILRI Roe CE 1966. *Engineering for Agricultural Drainage*. McGraw Hill.

SWE504 GROUND WATER ENGINEERING 2+1

Objective

To acquaint and equip with the occurrence, development, hydraulics of groundwater flow and groundwater pumping

Theory

UNIT I

Properties affecting groundwater storage and movement, Groundwater balance studies.

UNIT II

Well hydraulics, Two dimensional flow, Steady and unsteady state flow in confined, unconfined and semi-confined aquifers, Steady flow in sloping aquifers, Partial penetrating wells, Analysis of multi-aquifers.

UNIT III

Flow analysis in interfering wells. Pumping tests and determination of aquifer parameters.

UNIT IV

Groundwater modeling for water resources planning, Techniques for groundwater recharge.

UNIT V

Principle and performance characteristics of centrifugal pump, Vertical turbine pump, Submersible pump and axial flow pump. Non-conventional energy sources for pumping, Solar pumps, Hydraulic ram, Design criteria of pumping station, Techno-economic evaluation, energy conservation measures for pumping systems

Practical

Water table contour maps and determination of groundwater flow, estimation of aquifer characteristics, problems on non leaky and leaky aquifers, analysis of pumping test data; Computation of interference of wells; groundwater computer simulation models.

Suggested Readings

Boonstra J & de Ridder NA. 1981. Numerical Modeling of Groundwater Basins. ILRI.

Domenico PA. 1972. Concept and Models in GroundwaterHydrology. McGraw Hill.

Hantush MS. (Ed.). 1964. Advances in Hydro Sciences. Vol. I. Academic Press.

Harr ME 1990. Ground Water and Seepage. Wiley Eastern. Huisman L. 1972. Groundwater Recovery. MacMillan.

Polubarinova Kochina P Ya 1962. Theory of Ground Water Movement. Princeton Univ. Press.

Raghunath HM. 1992. Ground Water. Wiley Eastern. Todd DK. 1997. Ground Water Hydrology. WileyEastern.

SWE505 SOIL AND WATERCONSERVATION ENGINEERING 2+1

Objective

To acquaint and equip students with the process of degradation soil and water conservation and their remedial measures including design of structures.

Theory

UNIT I

Probability and continuous frequency distribution; Fitting empirical distributions.

UNIT II

Layout and planning of soil and water conservation measures; Design principles of soil and water structures including contour bunds and terraces; Gully control measures.

UNIT III

Hydraulic jump and energy dissipaters for soil conservation structures; Hydrologic, hydraulic and structural design of drop structures.

UNIT IV

Sediment deposition process. Estimation of sediment load, earthen dams, seepage through dams and stability analysis.

UNIT V

Rainwater harvesting, Flood control and stream bank protection measures.

Practical

Design of Drop spillway, chute spillway, drop inlet spillway, hydraulic jump calculation, design of bench terrace, contour bunds and contour trenches, design and problems on earthen dam, silt detention tanks and check dams, visit to soil conservation structuressites.

Suggested Readings

Garde RJ & Ranga Raju KG. 1977. *Mechanics of Sediment Transport and Alluvial Stream Problems*. Willey Eastern.

Gurmel Singh *et al.*1994. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

Hudson N.1971. *Soil Conservation*. B.T. Batsford Ltd.

Murthy VVN. 1998. *Land and Water Management Engineering*. Kalyani.

USDA 1969. *A Manual on Conservation of Soil and Water*. Oxford & IBH.

SWE506 CROP ENVIRONMENTAL ENGINEERING 2+0

Objective

To acquaint and equip with the process of soil-water-plant relationship and their interaction for crop growth.

Theory

UNIT I

Aerial and edaphic environments for plant growth, energy and mass transfer in and above cropcanopies.

UNIT II

Climatic changes and plant response to environmental stresses, evapo-transpiration models. Instrumentation and techniques for monitoring plant environments.

UNIT III

Processes and aspects of growth and development, soil-root interface, root sink functions.

UNIT IV

Water movement in soil-plant atmosphere continuum, artificial environments and plantbehaviour.

UNIT V

Design and operation of controlled environment facilities and their instrumentation. Crop growth and yield modeling.

Suggested Readings

Ghildyal BP & Tripathy RP. 1987. *Fundamental of Soil Physics*. Wiley Eastern.

Slatyor OP. 1967. *Plant Water Relationship*. Academic Press.

SWE507 DESIGN OF PUMPS FOR IRRIGATION AND DRAINAGE 2+0

Objective

To acquaint and equip with requirement of pumps for irrigation and drainage system and their design features.

Theory

UNIT I

Basic hydraulic design of centrifugal pump, water hammering problem in centrifugal pump.

UNIT II

Principle and performance characteristics of vertical turbine pump, submersible pump and axial flow pump and their design.

UNIT III

Non-conventional energy sources for pumping, wind mills, micro turbines, solar pumps, hydraulic ram- their selection and design criteria.

UNIT IV

Design of pumping station, techno-economic evaluation. Energy conservation mea

Suggested Readings

Church AH & Jagdish Lal 1973. *Centrifugal Pumps and Blowers*. Metropolitan Book Co.

Michael AM & Khepar SD. 1989. *Water Well and Pump Engineering*. Tata McGraw Hill.

Michael AM. 1990. *Irrigation Theory and Practice*. Vikas Publ. House.

ModiPN&SethSM.2000*HydraulicandFluidMechanics*.

Standard

Book House.

SWE508 OPEN CHANNEL FLOW 3+0

Objective

To acquaint and equip with the hydraulics of surface water flow phenomenon in open channels.

Theory

UNIT I

Open channel and their properties, energy and momentum, critical flow computation and application.

UNIT II

Uniform flow; gradually varied flow theory and analysis, methods of computation.

UNIT III

Practical problems such as design of transitions, flow passing Islands etc. spatially varied flow, rapidly varied flow.

UNIT IV

Hydraulic jump and its use as energy dissipator, flow through channel of non-linear alignment and flow through non-prismatic channel sections.

UNIT V

Unsteady flow, gradually varied unsteady flow and rapidly varied unsteady flow.

Suggested Readings

Chaudhry MH. 1993. *Open Channel Flow*. Prentice Hall. Chow VT. 1959. *Open Channel Hydraulics*. Mc-Graw Hill. Henederson FM. 1966. *Open Channel Flow*. MacMillan.

SWE509 FLOW THROUGH POROUS MEDIA 2+0

Objective

To acquaint and equip with the hydraulics and process of water flow in the water bearing formation under saturated as well as unsaturated conditions.

Theory

UNIT I

Aquifer and fluid properties, forces holding water in soils, hydrodynamics in porous media and limitations of governing laws.

UNIT II

Differential equations of saturated flow, initial and boundary conditions. Dupuit and Business approximations and linearizationtechniques.

UNIT III

Stream functions, potential functions and flow net theory. Analysis of seepage from canals and ditches.

UNIT IV

Unsaturated flow theory, Infiltration and capillary rise flux dynamics. Hydrodynamic dispersion in soil-aquifer system.

Suggested Readings

Harr Milton E. 1962. *Groundwater and Seepage*. McGraw-Hill.

Jacob Beer 1972. *Dynamics of Fluid Flow in Porous Media*.Elsevier.

Muskat M & Wyckoff RD. 1946. *The Flow of Homogeneous Fluids through Porous Media*. JWEdwards.

Patrick A Domenico & Schwartz FW. 1998. *Physical and Chemical Hydrogeology*. John Wiley & Sons.

Remson I, Hornberger GM & Moiz Fred J. 1971. *Numerical Methods in Subsurface Hydrology*. Wiley Interscience.

SWE510 WATER RESOURCES SYSTEM ENGINEERING 3+0

Objective

To acquaint and equip with the techniques for optimization of water resources for achieving maximum output.

Theory

UNIT I

Concepts and significance of optimization in water resources, objective functions, deterministic and stochastic inputs.

UNIT II

Mathematical programming techniques, linear programming and its extension: gradient method, simplex method, non-linear programming classical optimization.

UNIT III

Geometric programming and dynamic programming, application of optimization techniques for water resources.

UNIT IV

Development and management including conjunctive use, crop production functions and irrigation optimization.

Suggested Readings

Larry WM. 1996. *Water Resources Handbook*. McGraw-Hill.

Loucks DP *et al.* 1981. *Water Resource System Planning and Analysis*. Prentice Hall.

Rao SS. 1978. *Optimization Theory and Applications*. Wiley Eastern.

SWE511 GIS AND REMOTE SENSING FORLAND AND WATER RESOURCE MANAGEMENT 2+1

Objective

To acquaint and equip with the techniques of Remote Sensing and application of GIS for land and water resources management.

Theory

UNIT I

Basic principles of remote sensing and sensors. Elements of photogrametry. UNIT II

Electromagnetic spectrum. Energy interaction with surface features, Aerial photo and satellite imagery. Photo and image interpretation.

UNIT III

Principles of Geographical Information System tools, their types and capabilities, Advantages of GIS over conventional methods.

UNIT IV

Importance of ground truth establishment, GIS and remote sensing for land and water resources data collection, analysis and interpretation, Application of GIS in water and land resource development and management.

Practical

Familiarization with remote sensing and GIS hardware, software and their principle of working, Methods of establishing ground truth, Comparison between ground truth and remotely sensed data, Application of GIS packages.

Suggested Reading

De Mess MN. 2004. *Fundamental of Geographic Information System*. John Wiley & Sons.

Lille Sand T & Kaiffer R.1987. *Remote Sensing and Image Interpretation.* John Wiley & Sons.

Sabbins F.1987. *Remote Sensing Principle and Interpretation*. Freeman

SWE 512 WATERSHED MANAGEMENT AND MODELLING 2+1

Objective

To acquaint and equip the students with the watershed management modeling and modeling systems

Theory

UNIT I

Problems of desertification and degradation. Models of sediment yield UNIT II

Survey, monitoring, reclamation and conservation of agricultural and forest lands, hill slopes and ravines

UNIT III

Concept of operational watershed. National land use policy, legal and social aspects

UNIT IV

Watershed management research instrumentation and measurement, problem identification, simulation and synthesis

UNIT V

Modelling of flood and drought phenomenon, drought management and dry farming

Practical

Preparation of watershed development proposal, preparation of water shed evaluation report. Application of Models of flood and drought phenomenon. Application of watershed models.

Suggested Readings

Isobel W Heathcote**.** 1998. *Integrated Watershed Management: Principles and Practice*. Wiley Publ.

Kenneth N Brooks, Peter F Ffolliott, Hans M Gregersen, Leonard F DeBano. 1991. *Hydrology and the Management of Watersheds*. Wiley-Blackwell.

SWE513 LANDDEVELOPMENT AND EARTH MOVING MACHINERY 2+0

Objective

To acquaint and equip the students with the Land Development and Earth Moving Machinery modeling and modeling systems.

Theory

UNIT I

Objectives, methods and equipment for land clearing and development. Machinery selection, mechanics of operation and vegetation types.

UNIT II

Earth moving machinery and earthmoving mechanics. Grading of sloppy lands. Principles of mechanisms used in crawler mounted tractors.

UNIT III

Earth diggers and ditchers. Bull dozers and scrapers. Elevating and self powered graders. Automation of earth moving and grading machines. Lazer guided leveler with global positioning system.

UNIT IV

Boring machines. Different methods of boring.

Suggested Readings

Dutta SK. 1987. *Soil Conservation and Land Management*. International Distributors, Dehradun.

Eric C Orlem.1997. *Earth-Moving Machines*. Motorbooks International.

Kuhar JE. 1977. *The Precision Farming Guide for Agriculturalist*. Lori J. Dhabalt, USA.

Nichols HL & Day DH.1998. *Moving the Earth. The Work Book of Excavation*. McGraw Hill.

Peurifoy RL. 1956. *Construction, Planning, Equipment and Methods*. McGraw Hill.

Roger V Amato & Donald J Heimburger 2003. *Classic Vintage Crawlers and Dozers*. B Heimburger House Publ.

Singh G.1991. *Manual of Soil and Water Conservation Engineering*. Oxford & IBH.

SWE 514 ENGINEERING HYDRAULICS 4+0

Objective

To acquaint and equip with the hydraulics of flow in open channels and closed conduits.

Theory

UNIT I

Fluids flow concepts and basic equations; Kinematics and dynamics of fluid flow. Fundamental equations derived from principles of mass, momentum and energy conservation. Irrotational and rotational flow; velocity potential; stream function; flow net

UNIT II

Open channel and their properties, Energy and momentum, Critical flow computation and application.

UNIT III

Steady and unsteady flow, Uniform and non-uniform flow; Theory and analysis of gradually varied, Rapidly varied and spatially varied flows and methods of computation

UNIT IV

Hydraulic jump and its use as energy dissipator, Flow through channel of non-linear alignment and flow through non-prismatic channel sections.

UNIT V

Flow through closed conduits, Pipe networks, pipes in series and parallel, Hydraulics of piped irrigation network.

Suggested Readings

Bansal, RK. 2025. Fluid Mechanics & Hydraulic Machines, Laxmi Publications (P) Ltd., New De;hi

Shames, Irving H. 1992. Mechanics of Fluid,McGraw-Hill

Mays, Larry W. 2010. Water Transmission and Distribution Principles and Practices of Water Supply Operations, American Water Works Association.

SWE 601 ADVANCED HYDROLOGY 3+0

Objective

To acquaint and equip the students with advanced hydrological process, analysis of hydrological data and hydrologic modeling.

Theory

UNIT I

Hydrologic models, Processes and systems. Atmospheric hydrology, Impact of climate change on hydrological processes. Uncertainty in hydrological event. Statistical homogeneity.

UNIT II

Hortonian and saturation overland flow, Accounting abstraction losses, Overland and channel flow modeling. Response functions of linear hydrologic systems, their inter-relationships, Unit hydrograph, Synthetic unit hydrograph and IUH

UNIT III

Probabilistic concept. Frequency analysis. Co-relation and regression analysis. Probability distribution of hydrological variables.

UNIT IV

Time series analysis. Markov processes. Hydrologic design and forecasting.

UNIT IV

Formulation of various steps of statistical models and their application in hydrology.

Suggested Readings

Chow, VT., Maidment, DR, Mays, LW. 1988 Applied Hydrology, McGraw-Hill

Garg SK.1987. Hydrology and Water Resources Engineering. Khanna Publ.

Hann CT. Advanced Hydrology. Oxford Publ. House.

Linseley RK Jr., Kohler MA & Paulhus JLH. 1975. Applied Hydrology. McGraw Hill.

Mutreja KN.1986. Applied Hydrology. Tata McGraw Hill.

SWE 602 SOIL AND WATER SYSTEMS'SIMULATION AND MODELLING 2+1

Objective

To acquaint and equip the students with the simulation of soil water systems and modeling techniques.

Theory

UNIT I

Systems engineering for water management, Complexity of resources management process, systems analysis.

UNIT II

Rainfall-runoff models - Infiltration models, Simulation methods, Structure of a water balance model. Exploratory data analysis for model development and validation.

UNIT III

Channel flow simulation, input parameters, Sensitivity analysis and calibration – stream flow statistics, Surface water storage requirements.

UNIT IV

Flood control storage capacity; total reservoir capacity - surface water allocations, flood simulation and ground water models.

UNIT V

Artificial Intelligence and soft computing techniques for modeling of surface runoff, Design of model network, General systems frame work – Description of the model; Irregular boundaries, General –Numerical approaches.

Practical

Rainfall - Runoff models - Infiltration models - Stanford watershed model (SWM) - channel flow simulation problems, Stream flow statistics, Model parameters and input data requirements of various softwares of surface hydrology and groundwater, Hydrologic Modelling System, Soil Water Management Model – Soil Water Assessment Tool – Catchments, Simulation Hydrology Model – Stream flow model and use of dimensionless unit hydrograph, Generalized groundwater models. ANN, MARS and deep learning techniques in modelling of surface and ground water flow.

Suggested Readings

Biswas AK. 1976. Systems Approach to Water Management. McGrawHill.

Cox DR &Mille HD. 1965. The Theory of Stochastic Processes. John Wiley & Sons.

Eagleson PS. 1970. Dynamic Hydrology. McGraw Hill.

Himmel Blau DM & Bischoff KB. 1968. Process Analysis and Simulation Deterministic Systems. John Wiley & Sons.

Linsley RK, Kohler MA & Paulhus JLH. 1949. Applied Hydrology. McGraw Hill.

Schwar RS & Friedland B. 1965. Linear Systems. McGraw Hill.

Ven Te Chow, David R Maidment & Mays LW. 1998. Applied Hydrology. McGraw Hill.

SWE603 MODELLING SOILEROSIONPROCESSES 2+1

Objective

To acquaint and equip the students with the advance erosion process along with tools required and application of soil erosion models.

Theory

UNIT I

Overland flow, basic theory of particle movement and sediment transport; sediment deposition process.

UNIT II

Estimation of sediment load; mechanics of soil erosion by water and wind. UNIT III

Water and wind erosion control measures. UNIT IV

Universal soil loss equation; stochastic models and dynamic models.

Practical

Computation of soil erosion index; Estimation of soil erodibility factor; Design of erosion control structures. Computation of suspended load and sediment load using empirical formulae; Application of sediment yield models, prediction of sediment loss – computation of reservoir sedimentation – sounding method.

Suggested Readings

Garde RJ & Ranga Raju KG. 1977. *Mechanics of Sediment Transport and Alluvial Stream Problems*. Wiley Eastern Ltd.

Morgan RPC. (Ed. D. A. Davidson). 1986. *Soil Erosion and Conservation*. ELBS,Longman.

USDA. 1969. *A Manual on Conservation of Soil and Water*. Oxford & IBH.

SWE604 ADVANCED HYDO-MECHANICSINSOIL AQUIFERSYSTEMS 3+0

Objective

To acquaint and equip the students with the advance soil-aquifer-water mechanics and various techniques for the analysis of the system

Theory

UNIT I

Soil aquifer system. Flow of water in partially saturated soils. Partial differential equation of flow.

UNIT II

Determination of unsaturated hydraulic conductivity and models for its estimation.

UNITIII

Infiltration and exfiltration from soils in absence and presence of water table. Movement of groundwater in fractured and swelling porous media.

UNIT IV

Spatial variability. Theory of krigging. Statistical approaches in soil water dynamics.

Suggested Readings

Kirkham & Powers.1972. *Advanced Soil Physics*. John Wiley & Sons.

Muskut M.1937. *The Flow of Homogeneous Fluid through Porous Media*. McGraw Hill.

SWE 605 HYDRO-CHEMICAL MODELLING AND POLLUTANT MANAGEMENT 3+0

Objective

To acquaint and equip the students with the hydrodynamics of fluid and pollutant flow in soil-water-aquifer system and the impact analysis of contaminant transport through modeling

Theory

UNIT I

Hydrodynamics in flow through porous media, hydrodynamic dispersion, diffusion, convection equation.

UNIT II

Partial differential equations for flow and solute transport. Analytical and numerical models for flow and contaminant transport in unsaturated soil profile and ground water.

UNIT III

Water quality assessment and management in lakes. Reservoirs and coastal aquifers. Physical characteristics; hydrologic and chemical budgets; bio-geochemical processes of pollutants; assessment methods.

UNIT IV

Classical wastewater problems; Water reclamation, reuse, water quality constraints and considerations for reuse in irrigation and industry. Biological wastewater treatment.

UNIT V

Modern stream pollution problem. Quality of groundwater and sources of contaminants. Cost economics – environment impact assessment.

Suggested Readings

Larry W Mays 1996. *Water Resources Handbook*. McGraw Hill.

Metcalf and Eddey 1994. *Wastewater Treatment Engineering and Reuse*. John Wiley.

Soli J Arceivala 1998. *Wastewater Treatment for Pollution Control*. Tata McGraw-Hill.

SWE606/ ES 606 PLANT GROWTH MODELLINGANDSIMULATION 2+1

Objective

To acquaint and equip the students with the simulation and modeling techniques in the soil, plant and water environment for crop growth and to impart the theoretical and practical knowledge of using simulation models on crop-environment interactions at plant to ecosystem level for improved and knowledge based agricultural management and research optimization.

Theory

UNIT I

Introduction to crop growth modeling. Simulation and simulation techniques. Types of models and modeling approaches. Fundamentals of dynamic simulation, systems, models and simulation.

UNIT II

Relational diagram for principal process, structures of a generalized agricultural simulator for principal process, structures of a generalized agricultural simulator.

UNIT III

Input environment and techniques of monitoring plant environment, process and aspect of growth and development. Input yield models. Numerical integration, introduction to a simulation languages and programmes. Simulation of different production levels; recent advances in modeling approaches, introduction to AI, ML and big data analysis, image based modeling.

UNIT IV

Introduction to crop simulation model; modeling plant growth and development; Crop growth parameterization; modeling crop environment and crop pest interactions. Quantitative analysis of plant processes light photo-syntheses, respiration, growth, water uptake etc. and their mathematical modeling. Basics of modeling crop communities/ intercrops/ perennial crops; parameterization and estimation of genetic coefficients; data requirements, model calibration, validation, evaluation & sensitivity analysis- concepts.

UNIT V

Modelling soil water balance. Modelling soil nitrogen and carbon balance; modeling greenhouse gas methane, carbon-di-oxide and nitrous oxide) emission. Modeling soil carbon sequestration. Concepts of hydrological modeling, farm level modeling, geo-spatial modeling, ecosystem level modeling; concepts of modeling ecosystem components. Assessing crop growth, scheduling and management practices and resource use planning through simulation tools.

UNIT VI

Applications of simulation modelling in agricultural management, climate change studies, yield forecasting techniques. Modeling air and water pollutant dispersion. Application of air and water pollution model. Environmental impact assessment, greenhouse gas emission estimation methods, concepts of ecosystem data analysis. Limitations and advantages of modeling. Recent approaches in agricultural

systems modelling; model inter-comparison, integrated modelling, uncertainty and up-scaling concepts

Practical

Drawing relational diagrams, applying numerical integration techniques, fitting probability distribution functions, programming language, hands on to InfoCrop, InfoRCT, DSSAT, DNDC, CROPWAT, SWAT, InVest, Ecosystem Models; Environment Impact Models. Assessing crop growth using InfoCrop model. Assessing climate change impacts, yield forecast, adaptation to climate change and GHG emissions from agricultural fields using InfoCrop model.

Suggested Readings

Loomis RS, Connor DJ.1992. *Crop Ecology: Productivity andManagement in Agricultural System.* Cambridge Univ.Press.

Spedding CRW. 1979. *An Introduction to Agricultural Systems*. Applied Science Publ.

Thornley JHM & Johnson IR. 1990. *Plant and Crop Modelling. A Mathematical Approach to Plant and Crop Physiology*. Clarendon Press. Oxford Science Publ.

F.W.T. Penning de Vries, D.M. Jansen, H.F.M. ten Berge and A. Bakema. 1989. *Simulation of ecophysiological processes of growth in several annual crops,* Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen, the Netherlands.

Keulen, H. van & Wolf, J. 1986. *Modelling of agricultural production: Weather, soils and crops*, PUDOC, Wageningen, The Netherlands.

Leffelaar, P. A. 1993. On Systems Analysis and Simulation of Ecological Processes: With Examples in CSMP and FORTRAN, Kluwer.

Hanks, J. and J.T Ritchie. 1991. Modelling Plant and Soil Systems. American Society of Agronomy, Madison.

SWE607 ADVANCES IN IRRIGATIONANDDRAINAGE 2+0

Objective

To acquaint and equip the students with the advance application of irrigation and drainage system along with applicability of variousmodels.

Theory

UNIT I

Advances in surface irrigation systems- surge irrigation: effect of surgingon surface flow hydraulics, cablegation: water supply management.

UNIT II

Atomization in sprinkler and micro irrigation system; multipurpose and special uses of micro irrigation.

UNIT III

Synthetic materials for drainage systems. Environmental issues related to drainage. Socio-economic impacts of drainage systems.

UNIT IV

Controlled drainage for reducing agricultural non point pollution. Application of simulation models for drainagesystems.

Suggested Readings

FAO. 1982. *Mechanized Sprinkler Irrigation*. FAO Irrigation & Drainage Paper 35.

FAO. 1989. *Guidelines for Designing and Evaluating Surface Irrigation System*. FAO Irrigation & Drainage Paper 45.

Keller J & Bliesner RD. 1990. *Sprinkler and Trickle Irrigation*. Chapman & Hall.

Ritzema HP. (Ed.). 1994. *Drainage Principles and Applications*.

ILRI. Walker WR & Skogerboe GV. 1987. *Surface Irrigation: Theory and Practice*. Prentice Hall.