FARM MACHINERY & POWER ENGINEERING

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
FMPE 501*	DESIGN OF FARM POWER AND MACHINERY SYSTEMS	3+1	I
FMPE 502*	SOIL DYNAMICS IN TILLAGE AND TRACTION	2+1	II
FMPE 503*	TESTING AND EVALUATION OF TRACTORS AND FARM EQUIPMENT	2+1	II
FMPE 504*	FARM MACHINERY DYNAMICS, NOISE AND VIBRATIONS	3+1	I
FMPE 505/ ❶ CE 505	APPLIED INSTRUMENTATION IN FARM MACHINERY AND STRESS ANALYSIS	2+1	I
FMPE 506	SYSTEM ENGINEERING AND PRODUCTIVITY	2+1	II
FMPE 507	SYSTEM SIMULATION AND COMPUTER AIDED PROBLEM SOLVING IN ENGINEERING	1+1	II
FMPE 508	TRACTOR DESIGN	2+1	I
FMPE 509	OPERATIONS RESEARCH IN FARM POWER AND MACHINERY MANAGEMENT	2+1	II
FMPE 510	ERGONOMICS AND SAFETY IN FARM OPERATIONS	2+1	II
FMPE 511[@]/ ❷ PFE 502	ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS	2+1	I
FMPE 512[@]	AGRO-ENERGY AUDIT AND MANAGEMENT	2+0	I
FMPE 513[@]	DESIGN AND ANALYSIS OF RENEWABLE ENERGY CONVERSION SYSTEMS	3+0	II
FMPE 514	RESEARCH METHODOLOGY	0+1	I
FMPE 591	MASTERôS SEMINAR	1	I, II
FMPE 592	SPECIAL PROBLEM	0+1	II
FMPE 595	INDUSTRY/ INSTITUTE TRAINING	0+1	I
FMPE 599	MASTERôS RESEARCH	20	I, II
SERVICE COURSE			
ABM 525	FARM POWER AND MACHINERY MANAGEMENT	2+0	

*Compulsory courses; [@] Courses open for the Department of Processing & Food Engineering and other departments

To be taught by: ❶ Section of Basic Engineering (CE); ❷Processing & Food Engineering

FARM MACHINERY & POWER ENGINEERING

Course Contents

FMPE 501 DESIGN OF FARM POWER AND MACHINERY SYSTEMS 3+1 SEM - I

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: ï tillage, seeding, planting, intercultural, 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 and prototypes in farm machinery.

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.

Bernacki C, Haman J & Kanafajski CZ.1972. *Agricultural Machines*. 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*. Amrind Publ.

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 DN & Mukesh S. 2008. *Farm Machinery Design*. Jain Bros., New Delhi.

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*. FAO Rome.

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.

FMPE 502 SOIL DYNAMICS IN TILLAGE AND TRACTION 2+1 SEM - II

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- tyre 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 and machines.

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*. Academic Press, U.S.A.

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

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.

FMPE 503 TESTING AND EVALUATION OF TRACTORS AND FARM EQUIPMENT 2+1 SEM - 1I

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 and 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. Indian standard Institution, Nanak Bhavan, Bahadur Shah Zafar Marg, New Delhi.

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

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

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 D, Sims BG & O'Neill DH. *Testing and Evaluation of Agricultural Machinery and Equipment- Principle and Practice.* FAO Agricultural Services Bulletin 110.

FMPE 504 FARM MACHINERY DYNAMICS, NOISE AND VIBRATIONS 3+1 SEM - I

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 earheads/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, Rayleigh'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 & EG Sultan-Shakh. 1990. *Theory, Construction and Calculations of Agricultural Machinery* - Vol. I. Oxonian Press.
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.
ISO Standard Hand Book of Mechanical Vibration and Shock.
Kelly SG. 2000. *Fundamental of Mechanical Vibration*. 2nd Ed. McGraw Hill.
Kepner RA, Bainer R & Berger EL. 1978. Principles of Farm Machinery. AVI Publ.
Klenin NI, Popov IF & Sakoon VA. 1987. *Agricultural Machines. Theory of Operations, Computing and Controlling Parameters and the Condition of Operation*. Amrind Publ.
Marples.1969. *Dynamics of Machines*. McGraw Hill.
Meirovitch L. 1986. *Elements of Vibration Analysis*. 2nd Ed. McGraw Hill.
Nartov PS. *Disc Soil Working Implements*. Amrind Publ.
Srivastav AC. *Elements of Farm Machinery*. Oxford & IBH Publ.
Steidal. 1986. *Introduction to Mechanical Vibrations*. Wiley International & ELBS Ed.
William T Thomson. 1993. *Theory of Vibration with Application.* Prentice Hall.

FMPE 505/ CE 505 **APPLIED INSTRUMENTATION IN FARM MACHINERY AND STRESS ANALYSIS** **2+1** **SEM - I**

(To be taught by Section of Basic Engineering)

Objective

To acquaint and equip with the concept of instrumentation used in farm power and 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 strain gauges.

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 using GLC.

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 linear ICs.

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*. McGraw Hill.

FMPE 506 **SYSTEM ENGINEERING AND PRODUCTIVITY** **2+1** **SEM - II**

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 ï 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 Mathematical modeling and analysis. Practical on Computer use in solving problems of optimization, writing of algorithms for problem solutions and decision making.

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.

FMPE 507 SYSTEM SIMULATION AND COMPUTER AIDED PROBLEM SOLVING IN ENGINEERING 1+1 SEM - II

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 Rayleighôs method, Buckinghamôs Pi theorem and other methods.

UNIT-II: Mathematical modeling and engineering problem solving

UNIT-III: Computers and softwares ï software development process ï Algorithm design, ï program composition- quality control- documentation and maintenance ï 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.

Practical

Extensive practice on Software development process, modeling techniques, use of CAD software in solving engineering problems related to design of farm machinery

Suggested Readings

Averill M Law & David Kelton W. 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.

FMPE 508 TRACTOR DESIGN 2+1 SEM - I

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, driverôs seat, work-place area and controls. Tyre selection

UNIT-III: Mechanics of tractor. Computer aided design and its application in agricultural tractors.

Practical

Extensive practices on the design of tractor engine, hydraulic system, driver seat, place area and control.

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.

Sharma DN & Mukesh S. 2008. *Farm Machinery Design*. Jain Bros., New Delhi.

FMPE 509 OPERATIONS RESEARCH IN FARM POWER AND MACHINERY MANAGEMENT 2+1 SEM - II

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 quality control.

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 mechanization system.

Practical

Management problems and case studies.

Suggested Readings

Carville LA. 1980. *Selecting Farm Machinery*. Lousiana Co-op. Extn.Service Publ.

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

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

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

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.

FMPE 510 ERGONOMICS AND SAFETY IN FARM OPERATIONS 2+1 SEM - II

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 agricultural tasks.

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 his work. Design aspects of foot and hand controls on tractors and farm equipment. Design of operatorôs 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*. Lea & Febiger.

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

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

FMPE 511/ PFE 502 **ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS** **2+1** **SEM - I**

(To be taught by Processing & Food Engineering)

Objective

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

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: 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.

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 food materials.

Suggested Readings

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

Mohesenin NN. 1980. *Physical Properties of Plant and Animal 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.

FMPE 512 AGRO-ENERGY AUDIT AND MANAGEMENT 2+0 SEM - I

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.

FMPE 513 DESIGN AND ANALYSIS OF RENEWABLE ENERGY CONVERSION SYSTEMS 3+0 SEM - II

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*. TMH New 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.

Rajesh K Prasad & Ojha TP. 2009. *Non-conventional Energy Sources*. 2nd Ed. Jain Bros., New Delhi.

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.

FMPE 514 RESEARCH METHODOLOGY 0+1 SEM - I

Practical

The research problem -literature review -types of research, experimental & quasi-experimental research-causal comparative & correlation research Survey research-sampling techniques. Optimization software ï GAMES ï applications, electronic spread sheet ï solver. Image analysis software ï applications. General computational software for research ï MATLAB ï applications ï statistical applications, Report writing ï 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*. McGraw Hill.

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.

FMPE 595 INDUSTRY / INSTITUTE TRAINING 0+1 (NC) SEM – I

(Minimum three weeks)

Objective

To expose the students to the industry.

Practical

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 is enrolled.

FARM MACHINERY & POWER ENGINEERING

List of Journals

- Agricultural engineering Journal (AIT Bangkok)
- Agricultural Engineering Today
- Indian Journal of Agriculture sciences
- Journal of Agricultural Engineering Research
- Journal of Agricultural Engineering, ISAE, New Delhi
- Journal of Agricultural Mechanization in Asia, Africa and Latin America (AMA)
- Journal of Arid Land Research Management
- Journal of Computer and Electronics in Agriculture
- Journal of Terramechanics
- Seed Research Journal, New Delhi
- Transactions of American Society of Agricultural Engineers (TASAE)

Suggested Broad Topics for Master's and Doctoral Research

- Farm Machinery for crop residue management to increase soil fertility for higher productivity
- Machinery for precision agriculture for efficient utilization of inputs and saving in cost of production to have higher productivity
- Application of axial flow principle in thresher to have minimum breakage
- Efficient hand tools for pruning and plucking fruits
- Transplanters- to transplant paddy and vegetable crops
- Cotton pickers- for picking cotton balls
- Forage harvesters ï for forage crops
- Crop planters- for hybrid cotton, bajra and other crops for hybrid seed production
- Efficient tillage and sowing machinery to save irrigation water and increase productivity.
- Development of farm machinery for horticultural crops
- Use of electronics in agriculture
- Use of GIS and GPS in farm machinery for precision agriculture
- Development of software for optimal use of farm machinery under different agro climatic conditions

PROCESSING AND FOOD ENGINEERING

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
PFE 501*	TRANSPORT PHENOMENA IN FOOD PROCESSING	2+1	II
PFE 502*/ ❶ FMPE 511	ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS	2+1	I
PFE 503*	ADVANCED FOOD PROCESS ENGINEERING	2+1	II
PFE 504*	FARM STRUCTURES & ENVIRONMENTAL CONTROL	2+1	I
PFE 505[@]/ ❶ FST 527	ENERGY MANAGEMENT IN FOOD PROCESSING INDUSTRIES	2+1	II
PFE 506[@]	PROCESSING OF CEREALS, PULSES AND OILSEEDS	2+1	I
PFE 507	FOOD PROCESSING EQUIPMENT AND PLANT DESIGN	2+1	II
PFE 508	FRUITS AND VEGETABLES PROCESS ENGINEERING	2+1	II
PFE 509	MEAT PROCESSING	2+1	II
PFE 510[@]/ ❷ FST 505	FOOD PACKAGING	2+1	I
PFE 511	FOOD QUALITY AND SAFETY ENGINEERING	2+1	I
PFE 512[@]	BIOCHEMICAL AND PROCESS ENGINEERING	2+1	II
PFE 513	STORAGE ENGINEERING AND HANDLING OF AGRICULTURAL PRODUCTS	2+1	II
PFE 514[@]/ ❶ SST 507	SEED DRYING, PROCESSING AND STORAGE	2+1	II
PFE 591*	MASTERôS SEMINAR	1	I, II
PFE 592	SPECIAL PROBLEM	0+1	I, II
PFE 595	INDUSTRY/ INSTITUTE TRAINING	0+1	I, II
PFE 599*	MASTERôS RESEARCH	20	I, II

*Compulsory courses; [@]Courses open for PG students of other Deptt./Colleges

To be taught by: ❶ Processing & Food Engineering; ❷ Processing & Food Engineering and Food Science & Technology

PROCESSING AND FOOD ENGINEERING

Course Contents

PFE 501 TRANSPORT PHENOMENA IN FOOD PROCESSING 2+1 SEM - II

Objective

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

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 of foods.

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, Jacketed vessels.

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; design of heat exchangers; performing experiments on heat conduction, convection and radiation heat transfer.

Suggested Readings

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

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

Earle RL. 1985. *Unit Operations in Food Processing*. Pergamon Press.

EcKert ERG & Draker McRobert 1975. *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.

PFE 502/ FMPE 511 ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS 2+1 SEM - I

Objective

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

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: 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.

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 food materials.

Suggested Readings

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

Mohesenin NN. 1980. *Physical Properties of Plant and Animal 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.

PFE 503 ADVANCED FOOD PROCESS ENGINEERING 2+1 SEM - II

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 semisolid 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 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. *Transport Process and Unit Operations*. Allyn & Bacon.
Henderson S & Perry SM. 1976. *Agricultural Process Engineering*. 5th Ed. AVI Publ. Co.
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 Pub.

PFE 504 FARM STRUCTURES AND ENVIRONMENTAL CONTROL 2+1 SEM - I

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, psychrometric 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.

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 migrationbehaviour 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 Bioenvironmental Engineering*. Engineering Press.
Moore FF. 1994. *Environmental Control Systems: Heating, Cooling, Lighting*. Chapman & Hall.
Threlkeld JL. 1970. *Thermal Environmental Engineering*. Prentice Hall.

PFE 505/ FST 527 ENERGY MANAGEMENT IN FOOD PROCESSING INDUSTRIES 2+1 SEM - II

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, norms and scenario, basic principles & fundamentals of energy conservation, status of energy utilization for food processing in India & abroad and opportunities of energy conservation in food processing industries.

UNIT-II: Sources of energy, energy auditing, data collection, analysis and management in various operational units of the food processing industries, passive heating, passive cooling, sun drying and use of solar energy, biomass energy and other non-conventional energy sources in food processing industries.

UNIT-III: Cogeneration and waste heat recovery, 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, milk plants, food industries etc. Energy audit study and management strategies in food processing plants. Identification of energy efficient processing machines. Assessment of energy consumption, production and its cost in food processing plants, visit to related food processing industry.

Suggested Readings

Kreit F & Goswami D Y. 2008. *Energy Management and Conservation Hand Book.* CRC Press.

Murphy W R & Mckay G. 1982. *Energy Management*. BS Publ.

Patrick D R. 1982. *Energy Management and Conservation.* Elsevier Publ.

Patrick DR. Fardo SW, Richardson RE & Steven,2006. *Energy Conservation Guidebook.* The Fiarmont Press Inc.

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.

PFE 506 PROCESSING OF CEREALS, PULSES AND OILSEEDS 2+1 SEM - I

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 milling equipments.

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 product quality.

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.

Suggested Readings

Asiedu JJ.1990. *Processing Tropical Crops*. LBS/MacMillan.

Chakraverty A. 1995. *Post-harvest Technology of Cereals, Pulses and 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.

PFE 507 FOOD PROCESSING EQUIPMENT AND PLANT DESIGN 2+1 SEM - II

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 processing plants.

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 and standard 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 the location.

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 workerôs 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 profitability analysis.

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*. AVI Publ. Co.

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

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.

PFE 508 FRUITS AND VEGETABLES PROCESS ENGINEERING 2+1 SEM - II

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 and vegetables

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. Co.

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

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. Indus Publ. Co.

PFE 509 MEAT PROCESSING 2+1 SEM - II

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: 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, de-sugarisation, preparation of whole egg powder, yolk powder, freezing of fish, drying of fish, canning of fish, visit to meat and fish processing units.

Suggested Readings

Chooksey MK & Basu S. 2003. *Practical Manual on Fish Processing and Quality Control*. 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. Co.

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

PFE 510/ FST 505 FOOD PACKAGING 2+1 SEM - I

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 fiber board boxes, textile and paper sacks, corrosion of containers (tin plate); Flexible packaging materials and their properties; Aluminum as packaging material; Evaluation of packaging material and package performance.

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. Different packaging system for (a) dehydrated foods, (b) frozen foods, (c) dairy products, (d) fresh fruits and vegetables, (e) meat, poultry and sea foods.

UNIT-V: Package standards and regulation; Shrink packaging; Aseptic packaging, CA and MAP, Active packaging; Biodegradable packaging.

Practical

Identification and testing of packaging materials; Determination of wax from wax paper; Testing of lacquered tin plate sheets; Measurement of tin coating weight by Clarkeôs method; To perform sulphide stain test; To conduct ferricyanide paper test for porosity; Determination of equilibrium moisture content; Grading of glass bottles for alkalinity; Determination of water vapour transmission rate of packaging material; To perform vacuum packaging of food sample and carry out its storage study; Testing compression strength of the boxes; Packaging the food material in seal and shrink packaging machine and study its shelf life; Testing the strength of glass containers by thermal shock test; Testing the strength of filled pouches by drop tester.

Suggested Readings

Crosby NT.1981. *Food Packaging: Aspects of Analysis and Migration Contaminants*. App. Sci. Publ.

Kadoya T. (Ed). 1990. *Food Packaging*. Academic Press.

Mahadeviah M & Gowramma RV. 1996. *Food Packaging Materials*. Tata McGraw Hill.

Palling SJ. (Ed). 1980. *Developments in Food Packaging*. App. Sci. Publ.

Painy FA. 1992. *A Handbook of Food Packaging*. Blackie Academic.

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

Stanley S & Roger CG.1970. *Food Packaging*. AVI Publ.

PFE 511 FOOD QUALITY AND SAFETY ENGINEERING 2+1 SEM - I

Objective

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

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.

PFE 512 BIOCHEMICAL AND PROCESS ENGINEERING 2+1 SEM - II

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, enzyme reactors.
UNIT-IV: Watershed management research instrumentation and measurement, problem identification, simulation and synthesis.
UNIT-V: Principles of recovery of fermented products in bio-processing, instrumentation, transport phenomenon.

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

Brennan JG, Butters JR, Cavell ND & Lilly AEI. 1990. *Food Engineering Operations*. Elsevier.
Coulson JM & Richadson JF. 1999. *Chemical Engineering*. Vols. II, IV. The Pergamon Press.
Greanoplis J Christie. 1999. *Transport Process and Unit Operation*. Allyn & Bacon.
Treybal RE. 1981. *Mass Transfer Operations*. 3rd Ed. Harper & Row.

PFE 513 STORAGE ENGINEERING AND HANDLING OF AGRICULTURAL PRODUCTS 2+1 SEM - II

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, 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 stored products.

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. AVI Publ. Co.

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

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.

PFE 514/ SST 507 SEED DRYING, PROCESSING & STORAGE 2+1 SEM - II

Objective

To acquaint the students with drying and processing of seeds, operation and maintenance of different seed processing machinery & dryers

Theory

UNIT-I: Principles and importance of seed processing, preparation of seeds before processing, machines used to prepare seed for processing (Delinters, extractors, debearder, sacrifier etc.)

UNIT-II: Operation maintenance of different seed processing machinery such as air screen cleaner, indented cylinder, dise separator, gravity separator, pneumatic separator, surface texture equipment, shape sizing, colour sorter, magnetic separator, electrostatic separator, seed conveying, different types of conveyers, Seed treating, and treaters.

UNIT-III: Seed drying principles and methods, E.M.C. Theory of drying, calculation of drying time, different types of heated air dryers, importance of scientific seed storage, types of storage structures, methods of maintaining safe seed moisture, thumb rule and its relevance, management and operation/ cleanliness of seed store, design features of medium and long term seed storage structures.

UNIT-IV: Seed packaging, principles, practices, materials weighing and bagging machines, their operation and maintenance, seed quality maintenance during processing, Plant design and lay out, safety considerations in plant design.

Practical

Operation and performance evaluation of various seed processing equipments such as pre cleaner, scalpers, air screen cleaner, indented cylinder, gravity separator, pneumatic separator, colour sorter and other equipments, seed treater, conveyors and elevators, bag closers, different types of dryers, design and layout of seed processing plant and its economics, analysis of cost of operation and processing, determination of seed moisture, seed germination and vigour.

Suggested Readings

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

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

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

PFE 592 SPECIAL PROBLEM 0+1 SEM - I, II

PFE 595 INDUSTRY/ INSTITUTE TRAINING 0+1 (NC) SEM - I, II

(Minimum of 3 weeks training)

Objective

To expose the students to the industry

Practical

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 is enrolled.

PROCESSING AND FOOD ENGINEERING

List of Journals

- Agricultural Mechanization in Asia, Africa and Latin America
- Indian Food Industry, India
- Journal of Agricultural Engineering Research, UK
- Journal of Agricultural Engineering, India
- Journal of Food Engineering
- Journal of Food Science
- Journal of Food Science and Technology, India
- Packaging India, India
- Transaction of American Society of Agricultural Engineers

Suggested Broad Topics for Master's Research

- Controlled atmosphere storage and modified atmosphere packaging
- Development of crop specific post harvest techniques for reduction in quantitative and qualitative losses to farm produce
- Design and development of need based, demand driven technologies for reduction in post harvest losses to farm produce, livestock and horticultural produce
- Development of post harvest processes and equipment for value addition to farm produce
- Development of processes and equipment for better utilization of agricultural residues and by-products
- Packaging of fresh and processed foods
- Drying and dehydration of grains, fruits, vegetables and dairy products
- Engineering properties of food materials

SOIL AND WATER ENGINEERING

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
SWE 501*	WATERSHED HYDROLOGY	2+1	I
SWE 502*	DESIGN OF FARM IRRIGATION SYSTEMS	2+1	I
SWE 503*	AGRICULTURAL DRAINAGE SYSTEMS	2+1	II
SWE 504*	GROUNDWATER ENGINEERING	2+1	II
SWE 505*	SOIL AND WATER CONSERVATION ENGINEERING	2+1	I
SWE 506[@]	CROP ENVIRONMENTAL ENGINEERING	2+0	II
SWE 507[@]	DESIGN OF PUMPS FOR IRRIGATION AND DRAINAGE	2+0	I
SWE 508[@]	OPEN CHANNEL FLOW	3+0	II
SWE 509	FLOW THROUGH POROUS MEDIA	2+0	I
SWE 510	WATER RESOURCES SYSTEM ENGINEERING	3+0	II
SWE 511[@]	GIS AND REMOTE SENSING FOR LAND AND WATER RESOURCES MANAGEMENT	2+1	I
SWE 512[@]	WATERSHED MANAGEMENT AND MODELING	2+1	II
SWE 513	LAND DEVELOPMENT AND EARTH MOVING MACHINERY	2+0	I
SWE 591	MASTERõS SEMINAR	1	I, II
SWE 592	SPECIAL PROBLEM	0+1	I, II
SWE 595	INDUSTRY/INSTITUTE TRAINING	0+1	I, II
SWE 599	MASTERõS RESEARCH	20	I, II

* Compulsory for masterõs programme; [@]Courses open for students of other Departments

SOIL AND WATER ENGINEERING

Course Contents

SWE 501 WATERSHED HYDROLOGY 2+1 SEM - I

Objective

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

Theory

UNIT-I: Hydrologic process and systems; Hydrologic problems of small watershed; Hydrologic characteristics of watershed.

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 unit hydrograph.

UNIT-IV: Concept of hydraulic flood routing, flood routing (reservoir and channel routing).

UNIT-V: 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.

SWE 502 DESIGN OF FARM IRRIGATION SYSTEMS 2+1 SEM - I

Objective

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

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.

Suggested Readings

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

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

Karmeli D, Peri G & Todes M. 1985. *Irrigation Systems: Design and 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.

SWE 503 AGRICULTURAL DRAINAGE SYSTEMS 2+1 SEM - II

Objective

To acquaint and equip students 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 Ernst, Glover Dumm, Kraijenhoff-van-de Leur equations.

UNIT-III: Salt balance, leaching requirement and management practices under drained conditions

UNIT-IV: Design of different components of sub-surface drainage systems, theories of vertical drainage and multiple well point system.

UNIT-V: Disposal of drainage effluents, Management of drainage projects of waterlogged 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 subsurface drainage systems, design of filter and envelop materials.

Suggested Reading

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

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

Luthin JN. 1978. *Drainage Engineering*. WileyEastern.

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

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

SWE 504 GROUNDWATER ENGINEERING 2+1 SEM - II

Objective

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

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.

UNIT-V: Techniques for groundwater recharge.

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 Groundwater Hydrology*. 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*. Wiley Eastern.

SWE 505 SOIL AND WATER CONSERVATION ENGINEERING 2+1 SEM - I

Objective

To acquaint and equip students with the process of degradation of soil and water resources 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 conservation 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 structures sites.

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.

SWE 506 CROP ENVIRONMENTAL ENGINEERING 2+0 SEM - II

Objective

To acquaint and equip students 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 crop canopies.

UNIT-II: Climatic changes and plant response to environmental stresses, evapotranspiration 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 plant behaviour.

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.

SWE 507 DESIGN OF PUMPS FOR IRRIGATION AND DRAINAGE 2+0 SEM - I

Objective

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

Theory

UNIT-I: Basic hydraulic design of centrifugal pump, water hammer 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 measures for pumping systems.

Suggested Readings

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

Michael AM, Khepar SD & Sondhi SK. 2008. *Water Wells and Pumps*. Tata McGraw Hill.

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

Modi PN & Seth SM. 2000 *Hydraulic and Fluid Mechanics*. Standard Book House.

SWE 508 OPEN CHANNEL FLOW 3+0 SEM - II

Objective

To acquaint and equip students 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.

SWE 509 FLOW THROUGH POROUS MEDIA 2+0 SEM - I

Objective

To acquaint and equip students 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 Boussinesq approximations and linearization techniques.

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. Hydro-dynamic 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*. JW Edwards.

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.

SWE 510 WATER RESOURCES SYSTEM ENGINEERING 3+0 SEM - II

Objective

To acquaint and equip students 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.

SWE 511 GIS AND REMOTE SENSING FOR LAND AND WATER RESOURCES MANAGEMENT 2+1 SEM - I

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, Use of GIS packages.

Suggested Readings

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 MODELING 2+1 SEM - II

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: Modeling of flood and drought phenomenon, drought management and dry farming.

Practical

Preparation of watershed development proposal, preparation of watershed 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.

SWE 513 LAND DEVELOPMENT AND EARTH MOVING MACHINERY 2+0 SEM - I

Objective

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

Theory

UNIT-I: Objectives, methods and equipment for land clearing and development. Machinery selection, based on 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 592 SPECIAL PROBLEM 0+1 SEM - I, II

Objective

Identification, planning and formulation of the problem, review of literature, report preparation and presentation.

SWE 595 INDUSTRY/INSTITUTE TRAINING 0+1(NC) SEM - I, II

(Minimum of three weekôs training)

Objective

To expose the students to the industry.

Practical

In plant training in the relevant industry/institution related to Soil and Water Engineering field. 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 is enrolled.

SOIL AND WATER ENGINEERING

List of Journals

- Agricultural Water Management
- Ground Water
- Irrigation and Drainage (ICID)
- Journal of Hydrology
- Journal of Soil Conservation
- Journal of Water Management
- Transactions of ASABE
- Transactions of ASCE
- Water Resource Research

Suggested Broad Topics for Master's Research

- Groundwater modeling
- Hydrolgic modeling of watersheds
- Conjunctive use of surface and groundwater
- Design and evaluation of irrigation and drainage systems and soil conservation measures
- Rainfall runoff modeling
- Evaluation of canal command area
- Water productivity analysis
- Water and energy saving technologies
- Application of modern tools such as Remote Sensing, GIS and simulation modeling for soil and water management strategies

BASIC ENGINEERING
Course Structure

SERVICE COURSES (Minor/Supporting)

COURSE NO.	COURSE TITLE	CREDITS	SEM
	CIVIL ENGINEERING		
CE 501	ADVANCED SURVEYING	2+1	I
CE 502	DESIGN OF DAMS AND RESERVOIR	3+1	II
CE 503	WATER QUALITY AND POLLUTION CONTROL	3+1	I
CE 504	FLUVIAL HYDRAULICS	2+1	II
CE 505/ ❶ FMPE 505	APPLIED INSTRUMENTATION IN FARM MACHINERY AND STRESS ANALYSIS	2+1	I
CE 506	SIMILITUDE IN ENGINEERING	2+1	II
CE 507	SOLID WASTES MANAGEMENT	2+0	I
CE 508	DESIGN OF BINS AND SILOS	2+1	II
CE 509	RANDOM VIBRATIONS	2+0	I
CE 510	PROBABILISTIC APPROACH IN DESIGN	2+0	II
CE 511/ ❷ FST 526	WASTE RECYCLING AND RESOURCE RECOVERY SYSTEM	2+1	II
CE 512/ ❸ EE 505/ FST 541	GENERAL ENGINEERING PRINCIPLES	2+1	I
	ELECTRICAL, ELECTRONICS AND COMPUTER ENGINEERING		
EE 501	ADVANCED INSTRUMENTATION	2+1	I
EE 502	PROCESS CONTROL SYSTEMS	2+1	II
EE 503	COMPUTER GRAPHICS	2+1	I
EE 504	NEURAL NETWORK AND ITS APPLICATIONS	2+1	II
EE 505/ ❸ CE 512 FST 541	GENERAL ENGINEERING PRINCIPLES	2+1	I
	MECHANICAL ENGINEERING		
ME 501	MECHANISM ANALYSIS AND SYNTHESES	3+0	I
ME 502	VIBRATION ANALYSIS	3+0	II
ME 503	ADVANCED MACHINE DESIGN	3+0	I
ME 504	THEORY OF INTERNAL COMBUSTION ENGINES	3+0	II

To be taught by: ❶ Basic Engineering (CE) and Farm Machinery & Power Engineering; ❷ Basic Engineering (CE) and Food Science & Technology; ❸ Basic Engineering (CE and EE)

BASIC ENGINEERING

Course Contents

CIVIL ENGINEERING

CE 501 ADVANCED SURVEYING 2+1 SEM - I

Objective

To acquaint students with the principles and methods of land hydrographic and aerial survey on par with global standards.

Theory

UNIT-I: Contouring: Methods of contouring; Interpolation of contours; Use of contours maps; drawing L section and cross-section from contour maps; Tracing contour gradient for alignment of roads and canal etc; finding volume of earth-work and capacity of reservoir from contour map. Use of total station.

UNIT-II: Hydrographic Surveying: Control - Shore line - River surveys - Soundings gauges - Signals - Sextant - Methods of locating soundings.

UNIT-III: Modern Surveying: Aerial Surveying and Ground Photogrammetry: Elementary knowledge of both with the basic principles involved especially of stereoscopic vision and interpretation. Advantages of aerial surveying over conventional methods.

UNIT-IV: Principles of digital aerial photography , Sensors for aerial photography , Digital camera systems , Digital cameras for aerial photography .

Practical

To find Reduced levels and horizontal distances using theodolite as a Tacheometer. Study and use of Total Station for measurement of Horizontal and Vertical angles. Use of Total Station for finding horizontal and vertical distances and reduced levels. Determine the geographical parameters by total station. Stereoscopic vision and interpretation.

Suggested Readings:

Kanetkar TP. *Surveying and Leveling.* Vols. I, II, United Book Corporation, Pune.
Mart CA. *Air Photography Applied to Surveys*.
Moffitt FH. *Photogrammetry.*
Natarajan V. *Advanced Surveying*. BI Publ., New Delhi.
Shahani PB. *Advanced Surveying*. Oxford & IBH.
Subramanian R. *Surveying and Levelling.*

CE 502 DESIGN OF DAMS AND RESERVOIR 3+1 SEM - II

Objective

To acquaint and equip with different types of dams, their design philosophies and use.

Theory

UNIT-I: Dams classification. Suitable site selection for dams and reservoirs. Survey and planning of storage projects.

UNIT-II: Type of concrete dams. Forces acting on concrete dams. Stability analysis. Methods of design of gravity dams. Temperature control for dams.

UNIT-III: Earth dams and their types. Methods of construction. Causes of failure and remedial measures. Seepage and stability analysis of earth dams.

UNIT-IV: Foundation treatment. Abutment grunting. Instrumentation in dams.

UNIT-V: Spill way and spillway capacities and spillway gates.

UNIT-VI: Reservoir planning, Storage, sedimentation, Losses, Economics. Flood routing.

Practical

Exercises on design of concrete and earthen dams, problems on seepage through dams.

Suggested Readings

Bharat Singh. 2002. *Earthen Dams*. New Chand & Bros., Roorkee.
Creager WP, Justin JD & Hinds J. 1945. *Engineering for Dams*. Vols. I-III. John Wiley & Sons.
Sharma HD. 1981. *Concrete Dams*. Metropolitan.

CE 503 WATER QUALITY AND POLLUTION CONTROL 3+1 SEM - I

Objective

To acquaint and equip with different aspects of wastes and waste water quality, treatment and their importance**.**

Theory

UNIT-I: Impurities in water. Water analysis (Physical, Chemical and Bacteriological).

UNIT-II: Indices of water quality for domestic and industrial uses. Monitoring of water quality from various sources of water pollution.

UNIT-III: Purification of water supplies.

UNIT-IV: Waste water characteristics and disposal methods.

UNIT-V: Waste water treatment.

UNIT-VI: Mathematical modeling on pollution control. Environmental legislation on water pollution in India and abroad.

Practical

Determination of pH, dissolved and suspended solids, Chlorides, Sulphates, turbidity, dissolved oxygen hardness, BOD, COD, Nitrogen (Ammonical, nitrate, nitrite), MPN, Total count of bacteria in water/sewage samples.

Suggested Readings

Garg SK. 2004. *Environmental Engineering.* Vols. I, II. Khanna Publ.

Howard S Peavey, Donald R Rod & Tchobanglous G. 1985. *Environmental Engineering.* McGraw Hill.

Manual of Water Supply and Treatment. 1999 Ministry of Urban Development, New Delhi.

Metcalf & Eddy. 2003. *Waste Water Engineering Treatment and Reuse*. Tata McGraw Hill.

CE 504 FLUVIAL HYDRAULICS 2+1 SEM - II

Objective

To acquaint and equip the students with different aspects of Fluvial Hydraulics and their importance in engineering.

Theory

UNIT-I: Sediment properties, Sediment problems. Incipient motion of sediment particles.

UNIT-II: Regimes of flow. Resistance to flow.

UNIT-III: Bed load. Suspended load. Total load transport.

UNIT-IV: Alluvial streams and their hydraulic geometry. Bed level variations in alluvial streams.

UNIT-V: Sediment samples and sampling. Alluvial river models. Sediment transport through pipes. Bed level variations in alluvial streams. River models.

Practical

Problems on determination of sediment properties, regimes of flow, resistance to flow, incipient motion, bed load, suspended load, total load transport and sediment transport.

Suggested Readings

Garde RJ & Ranga Rajan KG. 2001. *Mechanics of Sediment Transport and Alluvial Stream Problems.*

Howard H Chang. 1988. *Fluvial Process in River Engineering*. John Wiley & Sons.

Raudkivi AJ. 1990. *Loose Boundary Hydraulics*. Pergamon Press.

CE 505 / FPME 505 APPLIED INSTRUMENTATION IN FARM MACHINERY AND STRESS ANALYSIS 2+1 SEM - I

(To be taught jointly by Civil Engineering and Farm Machinery & Power Engineering)

Objective

To acquaint and equip with the concept of instrumentation used in farm power and 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 strain gauges.

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 using GLC.

UNIT-IV: Basic signal conditioning devices - data acquisition system ï 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 linear ICs.

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*. McGraw Hill.

CE 506 SIMILITUDE IN ENGINEERING 2+1 SEM - II

Objective

To acquaint and equip the students with different aspects of similitude in Engineering and its importance in engineering.

Theory

UNIT-I: Dimensions and units.

UNIT-II: Dimensional and similarity analysis. Theory of models.

UNIT-III: True, distorted and dissimilar models.

UNIT-IV: Application to different systems with special reference to Structural and fluid flow systems, Analogues.

Practical

Equations for the period of simple pendulum. Uniform rectangular cantilever beam. Spring mass level system. Investigation of extrapolation. Deflection of a cantilever beam. Prediction of the deflection of a beam using a model. Analogue model experiments

Suggested Readings

Green Murphy.1950. *Similitude in Engineering*. Ronald Press.

Huntley HE. 1974. *Dimensional Analysis*. Dover Publ.

Stephen J Klin.1965. *Similitude and Approximation Theory*. McGraw Hill.

CE 507 SOLID WASTES MANAGEMENT 2+0 SEM - I

Objective

To acquaint and equip the students with different methods for management of solid wastes and their importance.

Theory

UNIT-I: Definition. Sources. Quality, Classification and characteristics of solid waste collection, Transport and reduction at source.

UNIT-II: Handling, Collection , Storage, transport of Solid wastes.

UNIT-III: Disposal methods and their merits and demerits.

UNIT-IV: Processing of solid wastes. Fertilizers, fuel and food values.

UNIT-V: Recycling and reuse materials and energy recovery operations.

Suggested Readings

Kreith F & Tchobanoglous G. 2002. *Handbook of Solid Waste Management*. McGraw Hill.

Ramachandra TV. 2006. *Management of Municipal Solid Waste*. Capital Publ. Co.

CE 508 DESIGN OF BINS AND SILOS 2+1 SEM - II

Objective

To acquaint and equip the students with Design practices for optimum design of grains storage structures.

Theory

UNIT-I: Computer aided design manuals. Rankineôs and Coloumbôs theories of active and passive pressures.

UNIT-II: Janssenôs and Airyôs theories grain pressure theories for design of deep and shallow silos. Reimbertôs theory of silo design.

UNIT-III: Comparison of Australian (AS) and Indian (BIS) design criteria for bins and silos.

UNIT-IV: Computer aided design of grain silos by developing flowcharts and programs for underground and over ground silos.

Practical

Analysis and design of silos of various capacities using available software. Use of different standard codes and theories in the development of flowcharts and design program for various capacity silos.

Suggested Readings

AS-3774.1990. *Loads on Bulk Solid Containers*.

BS-5061.1974. *Specifications for Cylindrical Storage Tower Silos and Recommendations for their Use*. BIS Relevant Standards.

Rajgopalan K. 1989. *Storage Structure*. Oxford & IBH.

Reimbert M & Reimbert A.1956. *Design of Bins*.

CE 509 RANDOM VIBRATIONS 2+0 SEM - I

Objective

To acquaint and equip the students with design by linear and nonlinear random loading analysis.

Theory

UNIT-I: Response to linear single and multi-degree of freedom system to stationary and non-stationary random excitation.

UNIT-II: Response of continuous systems. Normal mode method.

UNIT-III: Non-linear random vibration. Level crossing. Peak and envelope statistics. First excursion and fatigue failures.

UNIT-IV: Applications to mechanical, aero, civil, ocean and agricultural engineering systems.

Suggested Readings

Benjamin JR & Allen C. 1975. *Probability Statistics and Decision for Civil Engineers.* MGH New York.

Lipson C & Shets NJ. 1973. *Statistical Design and Analysis of Engineering Experiments*. McGraw Hill.

Subra Suresh. 1998. *Fatigue of Materials*. Cambridge Univ. Press.

CE 510 PROBABILISTIC APPROACH IN DESIGN 2+0 SEM - II

Objective

To acquaint and equip the students with different probabilistic methods for dynamic loading design.

Theory

UNIT-I: Review of various approaches in engineering design and introduction of probabilistic approach.

UNIT-II: Random variables. Probability distribution and density functions. expected values, Mean. Variance, Conditional probability. Characteristic functions.

UNIT-III: Function of random variable. Concepts of stationary, ergodic and nonstationary processes.

UNIT-IV: Auto correlation. Cross-correlation. Covariance functions. Power spectral and cross spectral density functions and their determination from experimental data.

UNIT-V: Broad-band and Narrow band random processes., White noise. Application in various disciplines of engineering.

Suggested Readings

Benjamin JR & Allen C. 1975. *Probability Statistics and Decision for Civil Engineers*. MGH New York.

Evan DH.1992. *Probability and its Applications for Engineers*. ASQC Press & Marcel Dekker.

CE 511/ FST 526 **WASTE RECYCLING AND RESOURCE RECOVERY SYSTEM** **2+1** **SEM - II**

(To be taught jointly by Civil Engineering and Food Science & Technology)

Objective

To acquaint with importance of food wastes for resource generation. To familiar with various technologies for recycling of waste.

Theory

UNIT-I: Waste & its consequences in pollution and global warming, Types of food processing wastes & their present disposal methods.

UNIT-II: Treatment of plant waste by physical, chemical and biological methods, Effluent treatment plants, Use of waste and waste water.

UNIT-III: Types, availability and utilization of by-products of cereals, legumes & oilseeds, Utilization of by-products from fruits and vegetables processing industries, sugar and agro based industries, and brewery & distillery waste.

UNIT-IV: Status and utilization of dairy by-products i.e. whey, buttermilk and ghee residues, Availability & utilization of by-products of meat industry, poultry industry and fish processing units.

UNIT-V: Biomethanation and biocomposting technology for organic waste utilization, incineration & efficient combustion technology, Integration of new and renewable energy sources for waste utilization.

Practical

Study of waste utilisation processes; Various treatments in use for waste disposal; Study on operational precautions; Extraction of volatile oils from organic waste; Use of crop residue for the production of cellulose; Use of mango kernels for manufacturing of starch; Production of pectin from organic waste. Preparation of design of sewage treatment plants.

Suggested Readings

Beggs C. *Energy Management and Conservation*. Elsevier Publ.

Chaturvedi P. 2000. *Energy Management: Challenges for the Next Millennium. Energy Conservation through Waste Utilization*. American Society of Mechanical Engineers, New York.

Kreit F & Goswami DY. 2008. *Energy Management and Conservation Handbook*. CRC Press.

Murphy WR & Mckay G. 1982. *Energy Management*. BS Publ.

Patrick DR. 1982. *Energy Management and Conservation*. Elsevier Publ.

Patrick DR., Fardo SW, Richardson RE & Steven Patrick DR. 2006. *Energy Conservation Guidebook*. The Fairmont Press.

Wulfinghoff DR. *Energy Efficiency Manual*. Energy Institute Press.

CE 512/ EE 505/ FST 453 **GENERAL ENGINEERING PRINCIPLES** **2+1** **SEM - I**

(To be taught jointly by Basic Engineering - CE, EE)

Objective

To acquaint with basic principle of General Engineering required for food processing. To familiarize with techniques for process heat and their availability.

Theory

UNIT-I: Alternating current fundamentals - Electromagnetic induction magnitude of induced E.M.F, Alternating current, R.M.S. value and average value of an alternating current. Phase relations and vector representation. A.C. series and parallel circuits, Concept of resonance, polyphase alternating current circuits, three-phase concept, Star and delta connections, star delta transformation.

UNIT-II: Energy measurement- Transformers: Fundamental of transformer, Theory, vector diagram without load and with load, Losses, voltage regulation and efficiency of transformer, auto-transformer.

UNIT-III: Alternators - Elementary principles and different types of alternators; E.M.F. in alternators, circuit breakers; Induction motors ï Fundamental principles, production of rotating fields, construction; Rotor winding squirrel cage and phase wound rotors; Analysis of current and torque; starting of induction motors, motor housing, selection of motor and its controls.

UNIT-IV: D.C. Machines - Construction and operation of D.C. generator, Types of generators, various characteristics of generator, D.C. motors, torque-speed characteristics of D.C. motors, Starting and speed control of D.C. motors.

UNIT-V: Industrial sheds: Materials for the construction , various types of trusses, ventilation and lighting in industrial building. Various types of floors, roofs and foundations. Rough cost estimation.

Practical

Study of voltage resonance in L.C.R. circuits at constant frequency; (a) Star connection-study of voltage and current relation (b) Delta connection-study of voltage and current relation; Measurement of power in 3-phase circuit; (a) For balanced loads (b) For unbalanced loads, by wattmeter and energy meters; Polarity test, no-load test, efficiency and regulation test of single phase; Voltage and current relation in a 3-phase transformer of various kinds of primary and secondary connection systems; Test on 3-phase induction motor. Tests on various construction materials, study of drawings and various symbols.

Suggested Readings

Thareja BL. *Electrical Machines*.

Farral AW. 1979. *Food Engineering Systems*. Vols. I, II. AVI Publ.

Sharma and Kaul. *Building construction*.

ELECTRICAL, ELECTRONICS AND COMPUTER ENGINEERING

EE 501 ADVANCED INSTRUMENTATION 2+1 SEM - I

Objective

To acquaint and equip the students with various types of transducers for study and analysis of various variables.

Theory

UNIT-I: Basic instrumentation systems and transducer principles. Displacement Transducers: Potentiometer, LVDT, Piezoelectric and capacitive transducers. Digital Transducers. Velocity transducers ï Analog and Digital

UNIT-II: Acceleration and absolute motion measurement. Force transducer _ Strain Gauge, Hydraulic load cell, Cantilever type and Probing ring. Method of separation of force ï Torque, Power and Energy measuring techniques.

UNIT-III: Temperature measurement using Bi-metals, PTRs, Thermistors, Thermocouples, Electronic IC sensors and Pyrometers. Heat flux measurement. Humidity measurement ï Dry and Wet bulb, Hair hygrometer and Humister. Soil and Grain moisture transducers, pressure measurement ï Manometers, Bourdon Tube, Diaphragm type transducer. High pressure and vacuum sensing techniques.

UNIT-IV: Flow transducers, Positive displacement, venturimeter, Rotameter, Drag force, Ultrasonic, Electromagnetic, Hot wire anemometers. Time and frequency measurement.

UNIT-V: Level measurement, OD and pH measurement, PCO2 and grain quality measurement. Biomedical measurement ï BP, ECG etc., Ultrasonic flaw detection, Spectroscopy.

Practical

Study the characteristics of various transducers : Potentiometer, LVDT, Proximity sensors and Photo pickups, Load cell, Thermistor and Thermocouple, LM 335/AD 590se of various Analog interfacing blocks: Attenuators, Amplifiers, A/D converters, Filters, digital interfaces using Wave shapers and level shifters. Practice of using interfaces and developing suitable software for data acquisition through PC/Microcomputer: Use of Microcomputer kit, Study the use of 8255 I/O IC, Study the use of printer port in a PC. Data acquisition through PC/Kit.

Suggested Readings

Doebelin EO.1990. *Measurement Systems Applications and Design*. Tata McGraw Hill.

Nakra BC &Chaudhary KK. 2004. *Instrumentation Measurement and Analysis*. Tata McGraw Hill.
Sawhney AK. 2008. *Electrical and Electronics Measurement and Instrumentation*. Dhanpat Rai & Sons.

EE 502 PROCESS CONTROL SYSTEMS 2+1 SEM - II

Objective

To acquaint and equip the students about the concepts involved in process control system to control variables at the desired level.

Theory

UNIT-I: Introduction to Process Control - Controlled Variable, Control strategy, Single Variable and multi variable control systems, Process Control loop, Open loop and closed loop control system, Linear and non linear control system, Transfer function and procedure for determining the Transfer function of Complex Control System, Representation of a Control System by block diagram and its Reduction

UNIT-II: Characteristics of real Process - Process Equation, Controlling & Controlled Variable, Transient & steady state response, Self Regulation Property, Control System Parameters, Evaluation of Control System.

UNIT-III: Improved Control through Complex Control of process - Controller Modes or actions, On/OFF Mode, Proportional Mode, Integral Mode, Derivative Mode, Composite Control Mode (PD, PI, PID, Modes).

UNIT-IV: Analysis of Common loop, involving - Flow control (Solid, liquid and gaseous flow), Pressure regulation (Pressure Transducers), Liquid level (Mechanical & Electrical Systems), Temperature Control (Thermistor and thermocouple).

UNIT-V: Introduction to Computer Control of Process Application and design - Signal Conditioning, Design of OP AMPS circuits used to implement Proportional Integral, Derivative and Composite Modes. Study of various computer Controlled Electrical and Mechanical Systems.

Practical

Study of various controllers by using Op-Amps, Use of microprocessors in process control.

Suggested Readings

Johnson CD.1977. *Process Control Instrumentation Technology*. PPH.
Manke BS. 2006. *Linear Control System*. Khanna Publ.

EE 503 COMPUTER GRAPHICS 2+1 SEM - I

Objective

To acquaint and equip the students with the under lined concepts for generating various geometrical shapes and processing them.

Theory

UNIT-I: Graphic display devices, interactive devices, line and circle plotting techniques by using Bresenhamôs algorithm, windowing and clipping, Sutherland Cophen algorithm, Cyrus and Beck method.

UNIT-II: Curve drawing using Hermite polynomial, Bezier curve, B splines, picture transformation, translation, rotation, scaling and mirroring

UNIT-III: 3D Graphics, 3D transformation rotation about an arbitrary axis. Curved surface generation, hidden surface removal.

UNIT-IV: Orthogonal projection and multiple views, isometric projection, perspective projection, 3D clipping

UNIT-V: Generation of solids, sweep method, interpolation, Graphic Standards, CGS Modeling, Applications of Computer Graphics.

Practical

Practices on 2-D and 3-D, drawings using AUTOCAD software.

Suggested Readings

Hearn Donald.1996. *Computer Graphics*. PHI.
Schaum. Series. 2004. *Computer Graphics*. TMH.

EE 504 NEURAL NETWORKS AND ITS APPLICATIONS 2+1 SEM - II

Objective

To acquaint and equip the students about the concepts of neural network for solving engineering problems.

Theory

UNIT-I: Introduction to neural network and its comparison with biological system. Perceptron and linear separable functions, multi-layers perceptrons.

UNIT-II: Back propagation, one basic learning algorithm for feed-forward neural network, variation and improvement for back-propagation algorithm,
Generalisation of learning algorithm.

UNIT-III: Recurrent Networks: Hopefield networks and Boltzmann Machine.

UNIT-IV: Unsupervised learning and self organized features maps.

UNIT-V: Application of neural network in function approximation, time series predictions, pattern recognition, control systems and optimization in
engineering problems.

Practical

Development of neural network by back-propagation learning algorithm using MATLAB for function approximation, time series predictions, pattern recognition, control systems and optimization in engineering problems.

Suggested Readings

Haykins S.1999. *Neural Network- Comprehensive Study*. PHI.

Hertz J, Krogh A & Palmer RG. 1991. *Introduction to Theory of Neural Computation.* Addison-Wesley.

EE 505/ CE 512/ FST 453 GENERAL ENGINEERING PRINCIPLES 2+1 SEM - I

(Same as CE 512)

MECHANICAL ENGINEERING

ME 501 MECHANISM ANALYSIS AND SYNTHESIS 3+0 SEM - I

Objective

To acquaint and equip the students with important area for analysis and design of Farm Machinery Mechanism.

Theory

UNIT-I: Introduction to kinematics of mechanisms, kinematic analysis and synthesis, mobility and degree of freedom of a mechanism, systematics of mechanisms deriving other mechanisms from linkages.

UNIT-II: Relative motion, instantaneous center method, Kennedyôs theorem. Graphical and analytical methods of displacement, velocity and acceleration analysis, Computer ï Aided analysis of mechanisms.

UNIT-III: Dimensional synthesis of linkages for path generation, function generation and rigid-body guidance problems. Graphical techniques. Relative pole method and method of inversion etc. Analytical kinematics synthesis of linkages, Freudensteinôs method, Loop closure equations based on complex variable approach.

UNIT-IV: Kinematics of gears-Analysis of epicyclic gear trains. Synthesis of gear trainscompound and epicyclic. Cam ï follower system; standard follower motions and combinations, importance of follower acceleration in cam system dynamics, terms related to cam deisgn- their importance. Cam synthesis ï graphical cam profile layout for a desired follower motion. Analytical determination of cam profile co-ordinates for disc cam operating common types of follower.

Suggested Readings

George N Sandor & Arthur G Erdman.1984. *Advanced Mechanism Design - Analysis and Synthesis.* Vols. I, II. Prentice Hall.

Norton. 2003. *Design of Machinery - An Introduction to the Synthesis and Analysis of Mechanisms and Machines.* McGraw Hill.

Shigley Vicker. 2007. *Theory of Machines and Mechanisms*. McGraw Hill.

Soni AH. 1974. *Mechanism Synthesis and Analysis*. McGraw Hill.

ME 502 VIBRATION ANALYSIS 3+0 SEM - II

Objective

To acquaint and equip the students with Significant field in the study and Analysis of farm machinery dynamics.

Theory

UNIT-I: Vibration motion and its terminology. Undamped free vibrations, equations of motion-natural frequency. Energy method, Rayleigh method; effective mass Principle of Virtual work. Equivalent spring stiffness in parallel and in series. Harmonic analysis and Fourier Series. Damping ï viscous, solid, coulomb equivalent dampers. Viscosity damped free vibrations, Logarithmic decrement. Forced vibrations with harmonic excitation and rotating unbalance, Energy dissipated by dampling. Forced vibration with damping, Vibration isolation and force and motion transmissibility.

UNIT-II: Two degree of freedom systems. Principal modes of vibration, co-ordinate coupling. Vibration absorbers, Free vibration equation of motion for multidegree of freedom systems. Influence coefficients and Maxwellôs reciprocal theorem, stiffness coefficients. Numerical methods for finding natural frequencies for multi degree of freedom systems.

UNIT-III: Vibration of lumped parameter systems and continuous systems. Lagrange equations. Vibration measuring instruments: Vibrometers, velocity pickups, Accelerometer and frequency measuring instruments. Applications of vibrations.

Suggested Readings

Grover GK.1996. *Mechanical Vibrations*. New Chand & Bros., Roorkee.

Rao SS. 2005. *Mechanical Vibration*. John Wiley.

William T Thomson.2004. *Theory of Vibration with Application*. 5th Ed. Marie Dillon Dahleh Amazon Co.

ME 503 ADVANCED MACHINE DESIGN 3+0 SEM - I

Objective

To acquaint and equip the students with advanced design of machine components, fatigue analysis and optimum design.

Theory

UNIT-I: Theories of falures, stress concentration and its evaluation, fatigues of machine components, influence of stress concentrations on fatigue.

UNIT-II: Endurance limit of metals, low cycle fatigue and cumulative fatigue damage. Fatigue testing and presentation of fatigue data, correlation between fatigue limit and ultimate strength of materials.

UNIT-III: Optimum system design of machine components (Springs, gears, linkages, shells, plates, and pressure vessels).

UNIT-IV: Designing for finite and infinite life, improving fatigue resistance of machine elements, stress corrosion.

UNIT-V: Failure analysis of various machine components, matrix method of design.

Suggested Readings

Khurmi RS & Gupta JK. *Text book on Machine Design*. Eurasia Publ.

Maleev V & James B Hartman. 1983. *Machine Design*. 3rd Ed. CBS.

Sharma CS & Purohit Kamalesh. 2003. *Design of Machine Elements*. Prentice Hall of India.

Shigley JE & Mischke CR. 1989. *Mechanical Engineering Design*. 5th Ed. McGraw Hill.

Spotts MF. 1991. *Design of Machine Elements*. 6th Ed. Prentice Hall India.

ME 504 THEORY OF INTERNAL COMBUSTION ENGINES 3+0 SEM - II

Objective

To acquaint and equip the students with various thermodynamic laws, and functioning of fuel combustion systems and IC engines.

Theory

UNIT-I: Basic laws of thermodynamics, availability concept. Gibbs Holmholtz functions of energy, ideal and actual cycle analysis, irreversible thermal process and its applications.

UNIT-II: Heat balance sheet for 2-stroke and 4-stroke cycle engines, calculations of air-fuel ratios in carburetors, fuel and combustion, ignition delay and theory of detonation and its control.

UNIT-III: Design methods of combustion chambers for I. C. engines, various performance tests.

UNIT-IV: Theory of cooling and lubrication, supercharging types and methods for improving design, design of smokeless engines.

Suggested Readings

Cloin R Furguson. 1986. *Internal Combustion Engine.* John Wiley.

Ganesan V. 2007. *Internal Combustion Engines*. Tata Mc Graw Hill.

Gupta. 2009. *Fundamentals of Internal Combustion Engines*. Prentice Hall of India.

John B Heywood. 1988. *Internal Combustion Engine Fundamentals*. McGraw Hill.

Rowland S Benson. 1982. *Internal Combustion Engines*. Oxford University Press.

FARM MACHINERY AND POWER ENGINEERING

COURSE NO.	COURSE TITLE	CREDIT HRS.	SEMESTER
FMPE 601**	ADVANCES IN FARM MACHINERY AND POWER ENGINEERING	3+0	I
FMPE 602**	MATHEMATICAL MODELING IN FARM MACHINERY AND POWER ENGINEERING	3+0	II
FMPE 603	ENERGY CONSERVATION AND MANAGEMENT IN PRODUCTION AGRICULTURE	2+0	I
FMPE 604	COMPUTER AIDED ANALYSIS AND DESIGN OF FARM MACHINERY	2+1	I
FMPE 605	MACHINERY FOR NATURAL RESOURCE MANAGEMENT AND PRECISION FARMING	3+1	I
FMPE 606	SOIL MECHANICS	3+1	II
FMPE 607	DYNAMICS OF FARM MACHINERY	2+1	I
FMPE 608	PRODUCTION TECHNOLOGY	2+1	II
FMPE 609	SPECIAL PROBLEM IN FARM MACHINERY AND POWER ENGINEERING	0+1	
FMPE 691	DOCTORAL SEMINAR - I	1+0	I
FMPE 692	DOCTORAL SEMINAR - II	1+0	II
FMPE 699	DOCTORAL RESEARCH	0+45	

**Compulsory for Doctoral programme

FMPE 601 Advances in Farm Machinery and Power Engineering 3(3+0)
Sem. I

Farm machinery system, its characteristics and evaluation. Identification of dynamic characteristics of related components of engine and agricultural machines. Method of dealing with engineering problems. 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-aided solutions. Force analysis in tractor-implement combination. Vibration transmissibility and damping in various farm machines. Tractor dynamics, development of the model and computer-aided design. Checking, interpretation and statistical analysis of results.

FMPE 602 Mathematical Modeling in Farm Machinery and Power Engineering 3(3+0)

Sem. II

Mathematical modeling, its classifications, characteristics and approach and limitations. Dimensional homogeneity, Buckingham pi-theorem. Simulation for system modeling. Similitude in tillage tool studies, prediction models for traction devices. Review of probability theory, analysis of random data, formulation and analysis of models: deterministic and stochastic application of modeling in farm machinery: case studies.

FMPE 603 Energy conservation and Management in Production Agriculture 2(2+0)
Sem. II

Energy requirement of different operations in agricultural production systems viz. crop, livestock and aquaculture: limits of conservation: planning and management of agricultural production systems for energy conservation and energy returns assessment.

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

FMPE 604 Computer Aided Analysis and Design of Farm Machinery 3(2+1) Sem. I

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

FMPE 605 Machinery for Natural Resource Management and Precision Farming 4(3+1) Sem.I

Practical : Introduction to GIS and GPS, study of models - farm machinery usage. Precision farming using GIS and GPS ï case study. Mechanism of power shovels, drag lines, earth diggers, clamshells etc. Earth work estimation, unit cost of operation, work scheduling, machinery maintenance, entrepreneurship

FMPE 606 Soil Mechanics 4(3+1) Sem.II

Physical and engineering properties of soil, stress, deformation, shear strength, consolidation, stability and compaction, radation, moisture content, compaction of soils for earth dams, embankments, piles, foundation and walls theory. Pressure distribution diagram, earth pressure theory, retaining walls, forces acting on earth retaining structures, lateral earth pressure, Coulombôs earth pressure theory, assumptions and deficiencies, active and passive earth pressures. Bearing capacity of soils, stability requirements of a foundation, soil rating, soil loading tests, Houselôs bearing capacity method, perimeter-area ratio method.Settlement and lateral expansion of soils.

Practical: Extensive practices on different aspects covered in the theory.

FMPE 607 Dynamics of Farm Machinery 3(2+1) Sem.I

Farm machine systems characteristics and evaluation. Analysis of forces, motion and their equilibrium in the elements of farm machines. Dynamic balancing and stability of farm machines, analysis of typical problems in tractor implement systems. Research reviews on design and analysis of farm machines and components.

Practical : Extensive practices on practices on different aspects covered in the theory.

FMPE 608 Production Technology 3(2+1) Sem.II

Reliability of engineering. product, risk analysis. workshop planning and layout. Theory of plastic properties and heat treatment of metals, workshop practices applied in prototype production Common tools, press operations: theory and practice of welding; welding processes; metal cutting and machining process; jigs, fixtures and gauges; casting and die casting processes Non-traditional methods of machining. Computer aided manufacturing system, CNC, DNC, robotics.

Practical : Hands on practices on different aspects covered in the theory.

FMP 699 Doctoral Researches

PROCESSING AND FOOD ENGINEERING

COURSE NO.	COURSE TITLE	CREDIT HRS.	SEM
PFE 601**	Textural and Rheological Characteristics of Food Materials	2+1	I
PFE 602**	Advances in Food Processing	3+0	II
PFE 603	Mathematical Models in Food Processing	3+0	I
PFE 604	Advances in Drying of Food Materials	2+1	II
PFE 605	Agricultural Waste and By-Products Utilization	2+1	II
PFE 609	Special Problem in Processing & Food Engg.	0+1	I,II
PFE 691	Doctoral Seminar ï I	1+0	I
PFE 692	Doctoral Seminar ï II	1+0	II
PFE 699	Doctoral Research	45	I, II

**Compulsory courses for Doctoral programme

PFE 601 Textural and Rheological Characteristics of Food Materials 3(2+1) Sem. I

Texture classification. Relation of food texture with structure and rheology. Principles and practices of objective texture measurements, viscosity measurements. Sensory methods of texture and viscosity measurements and their correlation. Rheological properties of foods. 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 of foods.

PFE 602 Advances in Food Processing 3(3+0) Sem. II

Low temperature preservation - advantages and applications cooling and cold storage ï freeze concentration and membrane separation process - hurdle technology - principles and applications - food irradiation -, microwave processing - microwave equipment - hydrostatic pressure treatment of food - 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. extrusion cooking - equipment, design criteria of extruders.

PFE 603 Mathematical Models in Food Processing 3(3+0) Sem. I

An overview of the modeling process. Introduction to mathematical, correlative and explanatory models. Formulation, idealization and simplification of the problems. Probability models, series and linear mathematical approximation, dynamic and interacting dynamic processes. Applications of mathematical modelling techniques to food processing operations like parboiling, convective drying, pasteurization, dehydration, shelf-life prediction, fermentation, 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.

PFE 604 Advances in Drying of Food Materials 3(2+1) Sem. II

Isotherm models, psychrometry, construction and use of psychrometric charts. Air flow and resistance, principles and equipments for air movement and heating, drying methods and theory of drying, driers, classification and other allied equipment, drying models. 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 and equipment. Drying of liquid foods, spray drying, drum drying, freeze drying, foam mat drying, heat pump drying, osmotic dehydration.

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.

PFE 605 Agricultural Waste and By-Products Utilization 3(2+1) Sem. II

Generation of by-products, agricultural and agro industrial byproducts/ wastes, properties, on site handling, storage and processing. 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. Utilization of wastes for paper production, production of particle board, utilization, by-products from rice mill, rice husk, rice bran, utilization. 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.

PFE 609 Special Problem in Processing & Food Engg. 1(0+1) Sem. I, II

Planning and formulation of a problem related to Processing & Food Engineering and identification of suitable solutions

PFE 699 Doctoral Research 45 Sem. I, II

SOIL AND WATER ENGINEERING

COURSE NO.	COURSE TITLE	CREDIT HRS.	SEM
SWE 601**	Advanced Hydrology	3+0	II
SWE 602**	Advanced Hydro-Mechanics in Soil Aquifer Systems	3+0	I
SWE 603	Modeling Soil Erosion Processes	3+0	I
SWE 604	Soil and Water Systems Simulation and Modelling	2+1	I
SWE 605	Hydro-Chemical Modelling	2+0	I
SWE 606	Plant Growth Modelling and Simulation	3+0	II
SWE 607	Advances in Irrigation and Drainage	2+0	II
SWE 608	Design of Pressurised Irrigation Systems	2+1	II
SWE 609	Special Problem in Soil & Water Engg.	0+1	I,II
SWE 691	Doctoral Seminar - I	1+0	I
SWE 692	Doctoral Seminar - II	1+0	II
SWE 699	Doctoral Research	0+45	I, II

**Compulsory courses for Doctoral programme

SWE 601 Advanced Hydrology 3(3+0) Sem. II

Stochastic analysis of hydrological data. Application of continuous probability distributions like Normal, Uniform, Triangular, Exponential, Gamma, Lognormal and Extreme value distributions in hydrological events. Simulation and synthetic methods in hydrology, Monte Carlo simulation. Parameter estimation in flood frequency analysis, Return period flood estimation, Risk and reliability concepts, Peak over threshold models. Hydrologic models, processes and systems, Uncertainty in hydrological event. Develop simple and multiple hydrologic linear regressions, correlation, statistical optimization and reliability of linear regression models. Analysis of hydrologic time series and modeling, Autoï correlation and partial auto-functions analysis, Test for randomness and trend, Transformation of hydrological data, Model parameter estimation, Diagnostic checks to measures goodness of fit. Markov processes**,** Stochastic programming methods in system engineering.

SWE 602 Advanced Hydro-dynamics in Soil Aquifer Systems 3(3+0) Sem. I

Physical and mathematical concept of soil aquifer system. Two dimensional flows in a vertical plane. Confined seepage under hydraulic structures. Application of method of inversion, Mixed problem of the theory of functions and its application to the seepage theory. Application of analytic theory of linear differential equations, Unconfined flow in strata on bed rock. Dynamics of groundwater spreading, Groundwater flow in heterogeneous and anisotropic soils, Unsaturated hydraulic conductivity and Diffusivity.

SWE 603 Modeling Soil Erosion Processes 3(3+0) Sem. I

Mechanics of soil erosion. Dynamics of raindrop erosion, Erosion-sedimentation systems of small watersheds. Estimation of critical wind velocity for erosion. System and conceptual models of runoff hydrograph. Sedimentation, Theory of particle and sediment transport, sediment deposition process, trap efficiency of reservoirs, sedimentation rate, distribution of sediment and control of sedimentation in reservoirs. Sedimentation retention structures, Preparing and evaluating an erosion and sediment control plan. Modeling upland erosion and component processes. Channel erosion. Concepts of watershed modeling, Multi-linear regression, Lumped parameter conceptual models, Fitting a watershed model. Application of Universal Soil Loss Equation. Erosion control measures and their evaluation.

SWE 604 Soil and Water Systems Simulation and Modelling 3(2+1) Sem. I

Systems engineering for water management; Complexity of resources management process, systems analysis. Rainfall-runoff models, Infiltration models, Evapo-transpiration models, simulation methods, structure of a water balance model. Overland and Channel flow simulation ï modeling approaches, parameters, stream flow statistics, surface water storage requirements. Flood control storage capacity. Total reservoir capacity ï surface water allocations. Groundwater simulation models.

Practical: Rainfall ï Runoff models, Infiltration models, ET models, Overland flow and channel flow modeling. Stanford watershed model ï model parameters and input data requirements of various Hydrologic Modeling Systems. Soil Water Assessment Tool ï Catchments, Simulation Hydrologic Model ï use of unit hydrograph. Generalized groundwater models.

SWE 605 Hydro-Chemical Modeling 2(2+0) Sem. I

Review of hydrodynamics in flow through porous media. Miscible displacement, physical processes, breakthrough curves and mathematical models for miscible displacement. Hydrodynamic dispersion convection equation. Statistical models for dispersion. Concept of adsorption in solute transport. Analytical and numerical models of contaminant transport in unsaturated soil profile and groundwater aquifers.

SWE 606 Plant Growth Modelling and Simulation 3(3+0) Sem. II

Introduction to crop growth modeling. Simulation and simulation techniques. Types of models and modeling approaches. Relational diagram for principal process, structures of a generalized agricultural simulator. Input environment and techniques of monitoring plant environment, process and aspect of growth and development. Input yield models. Quantitative analysis of plant processes like photo-synthesis, respiration, growth, water uptake and their mathematical modeling.

SWE 607 Advances in Irrigation and Drainage 2(2+0) Sem. II

Advances in surface irrigation system and modeling ï surge irrigation: effect of surging on surface flow hydraulics, cablegation: water supply management. Atomation and

fertigation design in micro irrigation systems; multi purpose and special uses of micro irrigation. Synthetic materials for drainage systems. Environmental issues related to irrigation and drainage. Socio economic impacts of irrigation and drainage systems. Controlled drainage for reducing agricultural non point pollution. Study and application of simulation models for irrigation and drainage systems.

SWE 608 Design of Pressurised Irrigation System 3(2+1) Sem. II

Pipeline hydraulic and economics; Uniformity, efficiency and design criteria for different pressurised methods; Pipe diameter selection methods; Set and continuous move sprinkler systems and their adaptability; Precipitation profile for different types of sprinkler heads; Design of travelling, centre pivot and linear moving systems; Types of emitters for micro irrigation systems; Emitter discharge-pressure head relationship; Clogging problems-causes and remedial measures; Filtration requirements; Assessment of wetted area under micro irrigation system; Emitter discharge and head requirements; Design strategy for micro irrigation systems; Selection of suitable pressurised irrigation system.

Practical:

Economic pipe size selection; Design of lateral pipes laid uphill and down hill with and without flow control valves; Identification of adaptations required in operating and layout conditions to meet design requirements; Computation of average and instantaneous application rates for set sprinkler systems; Design of examples of travelling, centre pivot and linear moving systems and micro irrigation systems; Determination of discharge exponent and discharge coefficient for different types of emitters. Development of irrigation schedules for drip and sprinkler irrigation methods; Study of filter clogging and cleaning processes; Estimation of chemical injection requirement for different types of emitter clogging.

SWE 609 Special Problem in Soil & Water Engg. 1(0+1) Sem. I, II

Planning and formulation of a problem related to Soil and Water Engineering and identification of suitable solutions

SWE 699 Doctoral Research 45 Sem. I, II