ORGANIZATION OF COURSE CONTENTS
&
CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level. A Ph. D. student must take a minimum of two 600-series courses, but may also take 500-series courses, if not studied during Master's programme.
- Credit seminar for Master's level is designated by code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Subject	Master's programme	Doctoral programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	**55**	**75**
Compulsory Non Credit Courses	See relevant section	

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to student's major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph.D. students may be exempted from these courses, if already studied during Master's degree.

SOIL AND WATER ENGINEERING

Course structure at a glance

CODE	COURSE TITLE	CREDITS
SWE 501*	WATERSHED HYDROLOGY	2+1
SWE 502*	DESIGN OF FARM IRRIGATION SYSTEMS	2+1
SWE 505*	SOIL AND WATER CONSERVATION ENGINEERING	2+1
SWE 504*	GROUND WATER ENGINEERING	2+1
SWE 503	AGRICULTURAL DRAINAGE SYSTEMS	2+1
SWE 506	CROP ENVIRONMENTAL ENGINEERING	2+0
SWE 507	DESIGN OF PUMPS FOR IRRIGATION AND DRAINAGE	2+0
SWE 508	OPEN CHANNEL FLOW	3+0
SWE 509	FLOW THROUGH POROUS MEDIA	2+0
SWE 510	WATER RESOURCES SYSTEM ENGINEERING	3+0
SWE 511	GIS AND REMOTE SENSING FOR LAND AND WATER RESOURCE MANAGEMENT	2+1
SWE 512	WATERSHED MANAGEMENT AND MODELING	2+1
SWE 513	LAND DEVELOPMENT AND EARTH MOVING MACHINERY	2+0
SWE 591	MASTER'S SEMINAR	1+0
SWE 592	SPECIAL PROBLEM	0+1
SWE 595#	INDUSTRY/ INSTITUTE TRAINING	NC
SWE 599	MASTER RESEARCH	20

SWE 601**	ADVANCED HYDROLOGY	3+0
SWE 602**	SOIL AND WATER SYSTEMS' SIMULATION AND MODELING	2+1
SWE 603	MODELING SOIL EROSION PROCESSES	2+1
SWE 604	ADVANCED HYDRO-MECHANICS IN SOIL AQUIFER SYSTEMS	3+0
SWE 605	HYDRO-CHEMICAL MODELING AND POLLUTANT MANAGEMENT	3+0
SWE 606	PLANT GROWTH MODELING AND SIMULATION	3+0
SWE 607	ADVANCES IN IRRIGATION AND DRAINAGE	2+0
SWE 691	DOCTORAL SEMINAR I	1+0
SWE 692	DOCTORAL SEMINAR II	1+0
SWE 693	SPECIAL PROBLEM	0+1
SWE 694	CASE STUDY	0+1
SWE 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme
# SWE 595 – Minimum of Three Weeks Training

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

SOIL AND WATER ENGINEERING

Course Contents

SWE 501 WATERSHED HYDROLOGY 2+1

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

Theory
UNIT I
Hydrologic processes and systems; Hydrologic problems of small watersheds; Hydrologic characteristics of watersheds.
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

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

Theory
UNIT I
Concepts of Irrigation; Irrigation principles, losses, conveyance, distribution; Application, scheduling parameters, water budgeting.
UNIT II
Surface irrigation, hydraulics of water advance and recession, hydraulic resistance to flow, gravity irrigation.
UNIT III
Design of Border irrigation, furrow irrigation, check basin irrigation; Sub Irrigation methods and concepts.

UNIT IV

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

UNIT V

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

Practical

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

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

Salt balance, leaching requirement and management practices under drained conditions.

UNIT IV

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

UNIT V

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

Practical

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

Suggested Readings

Battacharaya AK & Micheal AM. 2003. *Land Drainage*. Vikas Publ.
Clande Ayres & Daniel Scoates A.E. 1989.*Level Drainage and Reclamation*. McGraw Hill.
Luthin JN. 1978. *Drainage Engineering*. Wiley Eastern.
Ritzema HP. (Ed.). 1994. *Drainage Principles and Applications*. ILRI.
Roe CE 1966. *Engineering for Agricultural Drainage*. McGraw Hill.

SWE 504 GROUNDWATER ENGINEERING 2+1

Objective

To acquaint and equip 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

Objective

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

Theory

UNIT I

Probability and continuous frequency distribution; Fitting empirical distributions.

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

Rainwater harvesting, Flood control and stream bank protection measures.

Practical

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Design of pumping station, techno-economic evaluation. Energy conservation measures for pumping systems.

Suggested Readings

Church AH & Jagdish Lal 1973 *Centrifugal Pumps and Blowers*. Metropolitan Book Co.
Michael AM & Khepar SD. 1989. *Water Well and Pump Engineering*. Tata McGraw Hill.
Michael AM. 1990. *Irrigation Theory and Practice*. Vikas Publ. House.
Modi PN & Seth SM. 2000 *Hydraulic and Fluid Mechanics*. Standard Book House.

SWE 508 OPEN CHANNEL FLOW 3+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

Suggested Readings

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

SWE 509 FLOW THROUGH POROUS MEDIA 2+0

Objective

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

Theory

UNIT I

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

UNIT II

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Suggested Readings

Larry WM. 1996. *Water Resources Handbook*. McGraw-Hill.
Loucks DP *et al.* 1981.*Water Resource System Planning and Analysis*. Prentice Hall.
Rao SS. 1978. *Optimization Theory and Applications*. Wiley Eastern.

SWE 511 GIS AND REMOTE SENSING FOR LAND AND WATER RESOURCE MANAGEMENT 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

Suggested Reading

De Mess MN. 2004. *Fundamental of Geographic Information System*. John Wiley & Sons.
Lille Sand T & Kaiffer R.1987. *Remote Sensing and Image Interpretation.* John Wiley & Sons.
Sabbins F.1987. *Remote Sensing Principle and Interpretation*. Freeman.

SWE 512 WATERSHED MANAGEMENT AND MODELING 2+1

Objective

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

Theory

UNIT I

Problems of desertification and degradation. Models of sediment yield.

UNIT II

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

UNIT III

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

UNIT IV
Watershed management research instrumentation and measurement, problem identification, simulation and synthesis.
UNIT V
Modelling of flood and drought phenomenon, drought management and dry farming.

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

Suggested Readings
Isobel W Heathcote**.** 1998. *Integrated Watershed Management: Principles and Practice*. Wiley Publ.
Kenneth N Brooks, Peter F Ffolliott, Hans M Gregersen, Leonard F DeBano. 1991. *Hydrology and the Management of Watersheds*.Wiley-Blackwell.

SWE 513 LAND DEVELOPMENT AND EARTH MOVING MACHINERY 2+0

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

Theory
UNIT I
Objectives, methods and equipment for land clearing and development. Machinery selection, mechanics of operation and vegetation types.
UNIT II
Earth moving machinery and earthmoving mechanics. Grading of sloppy lands. Principles of mechanisms used in crawler mounted tractors.
UNIT III
Earth diggers and ditchers. Bull dozers and scrapers. Elevating and self powered graders. Automation of earth moving and grading machines. Lazer guided leveler with global positioning system.
UNIT IV
Boring machines. Different methods of boring.

Suggested Readings
Dutta SK. 1987. *Soil Conservation and Land Management*. International Distributors, Dehradun.
Eric C Orlem.1997. *Earth-Moving Machines*. Motorbooks International.
Kuhar JE. 1977. *The Precision Farming Guide for Agriculturalist*. Lori J. Dhabalt, USA.
Nichols HL & Day DH.1998. *Moving the Earth. The Work Book of Excavation*. McGraw Hill.
Peurifoy RL. 1956. *Construction, Planning, Equipment and Methods*.McGraw Hill.
Roger V Amato & Donald J Heimburger 2003. *Classic Vintage Crawlers and Dozers*. B Heimburger House Publ.
Singh G.1991. *Manual of Soil and Water Conservation Engineering*. Oxford & IBH.

SWE 601 ADVANCED HYDROLOGY 3+0

Objective
To acquaint and equip the students with advanced hydrological process, analysis of hydrological data and their application for modeling.

Theory

UNIT I

Hydrologic models, processes and systems. Uncertainty in hydrological event. Statistical homogeneity.

UNIT II

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

UNIT III

Time series analysis. Markov processes.

UNIT IV

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

Suggested Readings

Garg SK.1987. *Hydrology and Water Resources Engineering.* Khanna Publ.
Hann CT. *Advanced Hydrology*. Oxford Publ. House.
Linseley RK Jr., Kohler MA & Paulhus JLH. 1975. *Applied Hydrology*. McGraw Hill.
Mutreja KN.1986. *Applied Hydrology*. Tata McGraw Hill.

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

Objective

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

Theory

UNIT I

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

UNIT II

Rainfall-runoff models - Infiltration models, Simulation methods, structure of a water balance model.

UNIT III

Channel flow simulation - parameters and calibration - Streamflow statistics, surface water storage requirements.

UNIT IV

Flood control storage capacity; total reservoir capacity - surface water allocations. Ground water models.

UNIT V

Design of nodal network, General systems frame work – Description of the model; Irregular boundaries, General –Numerical approaches.

Practical

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

Suggested Readings

Biswas AK. 1976. *Systems Approach to Water Management*. McGrawHill.
Cox DR & Mille HD. 1965.*The Theory of Stochastic Processes*. John Wiley & Sons.
Eagleson PS. 1970. *Dynamic Hydrology*. McGraw Hill.
Himmel Blau DM & Bischoff KB. 1968. *Process Analysis and Simulation Deterministic Systems*. John Wiley & Sons.
Linsley RK, Kohler MA & Paulhus JLH. 1949. *Applied Hydrology.*McGraw Hill.
Schwar RS & Friedland B. 1965. *Linear Systems*. McGraw Hill.
Ven Te Chow, David R Maidment & Mays LW. 1998. *Applied Hydrology*. McGraw Hill.

SWE 603 MODELING SOIL EROSION PROCESSES 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

Water and wind erosion control measures.

UNIT IV

Universal soil loss equation; stochastic models and dynamic models.

Practical

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

Suggested Readings

Garde RJ & Ranga Raju KG. 1977. *Mechanics of Sediment Transport and Alluvial Stream Problems*. Wiley Eastern Ltd.
Morgan RPC. (Ed. D. A. Davidson). 1986. *Soil Erosion and Conservation*. ELBS,Longman.
USDA. 1969. *A Manual on Conservation of Soil and Water*. Oxford & IBH.

SWE 604 ADVANCED HYDO-MECHANICS IN SOIL AQUIFER SYSTEMS 3+0

Objective

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

Theory

UNIT I

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

UNIT II

Determination of unsaturated hydraulic conductivity and models for its estimation.

UNIT III

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

UNIT IV

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

Suggested Readings

Kirkham & Powers.1972. *Advanced Soil Physics*. John Wiley & Sons.
Muskut M.1937. *The Flow of Homogeneous Fluid through Porous Media*. McGraw Hill.

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

Objective

To acquaint and equip the students with the hydrodynamics of fluid and pollutant flow and the impact analysis of contaminant transport through modeling.

Theory

UNIT I

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

UNIT II

Analytical and numerical models of contaminant transport in unsaturated soil profile and ground water.

UNIT III

Water quality management in lakes and reservoirs; physical characteristics; hydrologic and chemical budgets; bio-geochemical processes of pollutants; assessment methods.

UNIT IV

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

UNIT V

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

Suggested Readings

Larry W Mays 1996. *Water Resources Handbook*. McGraw Hill.
Metcalf and Eddey 1994. *Wastewater Treatment Engineering and Reuse*. John Wiley.
Soli J Arceivala 1998. *Wastewater Treatment for Pollution Control*. Tata McGraw-Hill.

SWE 606 PLANT GROWTH MODELING AND SIMULATION 3+0

Objective

To acquaint and equip the students with the simulation and modeling techniques in the soil, plant and water environment for crop growth.

Theory

UNIT I

Introduction to crop growth modeling. Simulation and simulation techniques. Types of models and modeling approaches.

UNIT II

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

UNIT III

Input environment and techniques of monitoring plant environment, process and aspect of growth and development. Input yield models.

UNIT IV

Quantitative analysis of plant processes light photo-syntheses, respiration, growth, water uptake etc. and their mathematical modeling.

Suggested Readings

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

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

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

SWE 607 ADVANCES IN IRRIGATION AND DRAINAGE 2+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Suggested Readings

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

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

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

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

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

SOIL AND WATER ENGINEERING

List of Journals

- Ground Water
- Journal of Hydrology
- Journal of Soil Conservation
- Journal of Water Management
- Transactions of ASAE
- Transactions of ASCE
- Water Resource Research

Suggested Broad Topics for Master's and Doctoral Research

- Groundwater Modeling
- Hydrologic 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

FARM MACHINERY AND POWER ENGINEERING

Course Structure - at a Glance

CODE	COURSE TITLE	CREDIT
FMPE 501*	DESIGN OF FARM POWER AND MACHINERY SYSTEMS	3+1
FMPE 502*	SOIL DYNAMICS IN TILLAGE AND TRACTION	2+1
FMPE 503*	TESTING AND EVALUATION OF TRACTORS AND FARM EQUIPMENT	2+1
FMPE 504*	SYSTEM SIMULATION AND COMPUTER AIDED PROBLEM SOLVING IN ENGINEERING	1+1
FMPE 505	APPLIED INSTRUMENTATION IN FARM MACHINERY AND STRESS ANALYSIS	2+1
FMPE 506	SYSTEM ENGINEERING AND PRODUCTIVITY	2+1
FMPE 507	FARM MACHINERY DYNAMICS NOISE & VIBRATIONS	3+1
FMPE 508	TRACTOR DESIGN	2+1
FMPE 509	OPERATIONS RESEARCH IN FARM POWER & MACHINERY MANAGEMENT	2+1
FMPE 510	ERGONOMICS AND SAFETY IN FARM OPERATIONS	2+1
FMPE 511/ PFE 502	ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS	2+1
FMPE 512	AGRO-ENERGY AUDIT AND MANAGEMENT	2+0
FMPE 513	DESIGN AND ANALYSIS OF RENEWABLE ENERGY CONVERSION SYSTEMS	3+0
FMPE 514	RESEARCH METHODOLOGY	0+1
FMPE 591	MASTER'S SEMINAR	1+0
FMPE 592	SPECIAL PROBLEM	0+1
FMPE 595#	INDUSTRY/ INSTITUTE TRAINING	NC
FMPE 599	MASTER'S RESEARCH	20

FMPE 601**	ADVANCES IN FARM MACHINERY AND POWER ENGINEERING	3+1
FMPE 602**	SIMULATION MODELING IN FARM MACHINERY AND POWER ENGINEERING	2+0
FMPE 603	ENERGY CONSERVATION AND MANAGEMENT IN FARM MACHINERY AND POWER ENGINEERING	2+0
FMPE 604	COMPUTER AIDED ANALYSIS AND DESIGN OF FARM MACHINERY	2+1
FMPE 605	MACHINERY FOR NATURAL RESOURCE MANAGEMENT AND PRECISION FARMING	3+1
FMPE 606	ADVANCES IN HYDRAULICS AND ELECTRO PNEUMATIC CONTROLS	2+0
FMPE 691	DOCTORAL SEMINAR I	1+0
FMPE 692	DOCTORAL SEMINAR II	1+0
FMPE 693	SPECIAL PROBLEM	0+1
FMPE 694	CASE STUDY	0+1
FMPE 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; ** Compulsory for Doctoral programme
FPM 595 – Minimum of Three Weeks Training

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

FARM MACHINERY AND POWER ENGINEERING

Course Contents

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Design and selection of matching power unit.

UNIT V

Safety devices for tractors & farm implements.

Practical

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

Suggested Readings

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

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*.

ElsevierSharma 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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Introduction of traction devices, tyres-types, function & size, their selection; mechanics of traction devices. Deflection between traction devices and soil, slippage and sinkage of wheels, evaluation and prediction of traction performance, design of traction and transport devices. Soil compaction by agricultural vehicles 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.
Gill & Vandenberg.1968. *Soil Dynamics in Tillage and Traction*. Supdt. of Documents, U.S. Govt. Printing Office, Washington, D.C.
Sineokov GN. 1965. *Design of Soil Tillage Machines*. INSDOC, New Delhi.
Terzaghi K & Peck Ralph B.1967.*Soil Mechanics in Engineering Practices*. John Wiley & Sons.

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Tractor performance testing, evaluation and interpretation of results.

UNIT V

Review and interpretation of test reports. Case studies.

Practical

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

Suggested Readings

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

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

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

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

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

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

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

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

FMPE 504 SYSTEM SIMULATION AND COMPUTER AIDED PROBLEM SOLVING IN ENGINEERING 1+1

Objective

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

Theory

UNIT I

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

UNIT II

Mathematical modeling and engineering problem solving.

UNIT III

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

UNIT IV

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

UNIT V

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

Suggested Readings

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

Balagurusamy E. 2000. *Numerical Methods*. Tata McGraw Hill.

Buckingham E. 1914. *On Physical Similar System*. Physical Reviews 4:345.

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

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

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

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

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

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

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

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

FMPE 505 APPLIED INSTRUMENTATION IN FARM MACHINER AND STRESS ANALYSIS 2+1

Objective

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

Theory

UNIT I

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

FMPE 506 SYSTEM ENGINEERING AND PRODUCTIVITY 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical
Extensive practice on the packages mentioned in theory.

Suggested Readings
Danovan SS. 2000. *System Programming*. Tata McGraw.
Gillett G. 2001. *Introduction to Operations Research*. Tata McGraw Hill.
Grawham WJ & Vincent TL. 1993. *Modern Control System Analysis and Design*. John Wiley & Sons.
Lewis FL & Syrmos VL. 1995. *Optimum Control*. 2nd Ed. John Wiley & Sons.
Loomba D. 2000. *Linear Programming*. Tata McGraw.
Puttaswamaiah K. 2001. *Cost Benefits Analysis*. Oxford & IBH.

FMPE 507 FARM MACHINERY DYNAMICS, NOISE & VIBRATIONS 3+1

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

Theory
UNIT I
Principles of soil working tools: shares, discs, shovels, sweeps and blades, rota-tillers and puddlers.
UNIT II
Metering of seeds and granular fertilizers with various mechanism, effect of various parameters on distribution of seed and fertilizer in seed cum fertilizer drills and planters, flow of seeds and fertilizers through tubes and boots. Kinematics of transplanters.
UNIT III
Theory of atomization, specific energy for atomization, electrostatic spraying and dusting, spray distribution patterns. Kinematics of reapers/harvesting machines. Theory of mechanical separation of grains from ear heads/pods. Parameters affecting performance of threshers aerodynamic properties of straw and grain mixture, theory of root crop harvesters, power requirement of various components of field machines.
UNIT IV
Noise and vibration theory- Definition, units and parameters of measurement importance. Types of vibrations- free and forced, in damped and without damped analy , two and multiple degree of freedom systems and their solution using Newton's motic method, longitudinal, transverse and torsional vibrations, Raleigh's methods, Lagrange
UNIT V
Introduction of transient vibration in systems, vibration of continuous media. Balancing of single rotating weight and number of weights in same plane and different planes. Complete balancing of reciprocating parts of engine.

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

Suggested Readings

Ballaney PL. 1974. *Theory of Machines*. Khanna Publ.
Bosoi ESO, Verniaev V, Smirnov & Sultan-Shakh EG. 1990.*Theory, Construction and Calculations of Agricultural Machinery*. Vol. I. Oxonian Press Pvt. Ltd. No.56.
Getzlaff GE. 1993.*Comparative Studies on Standard Plough Body*. *Engineering Principles of Agricultural Machines.* ASAE Text Book No. 6.
Grover GK. 1996. *Mechanical Vibrations*. New Chand & Bros., Roorkee.
Harris CM & Crede CE. 1976. *Shock and Vibration Hand Book*. McGraw Hill.
Holowenko AR. 1967. *Dynamics of Machinery*. McGraw Hill.
Kelly SG. 2000. *Fundamental of Mechanical Vibration*. 2nd Ed. McGraw Hill.
Kepner RA, Bainer R & Berger EL. 1978. *Principles of Farm Machinery*. AVI Publ. Co.
Klenin NI, Popov IF & Sakoon VA. 1987. *Agricultural Machines. Theory of Operations, Computing and Controlling Parameters and the Condition of Operation*. Amrind Publ. Co.
Marples.1969. *Dynamics of Machines*. McGraw Hill.
Meirovitch L. 1986. *Elements of Vibration Analysis*. 2nd Ed. McGraw Hill.
Nartov PS. 1985.*Disc Soil Working Implements*. A. A. Balkema, Rotterdam.
Srivastav AC. 2001*. Elements of Farm Machinery*. Oxford & IBH.
Steidal.1986. *Introduction to Mechanical Vibrations*. Wiley International & ELBS Ed.
William T Thomson. 1993. *Theory of Vibration with Application.* Prentice Hall

FMPE 508 TRACTOR DESIGN 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Practical

Extensive practices on the packages mentioned in the theory

Suggested Readings

Arther W Judge 1967. *High Speed Diesel Engines*. Chapman & Hall.
Barger EL, Liljedahl JB & McKibben EC. 1967. *Tractors and their Power Units*. Wiley Eastern.
Macmillan RH.*The Mechanics of Tractor - Implement Performance, Theory and Worked Example*. University of Melbourne.
Maleev VL. 1945. *Internal Combustion Engines*. McGraw Hill.
Ralph Alcock 1986. *Tractor Implements System*. AVI Publ. Co

FMPE 509 OPERATIONS RESEARCH IN FARM POWER & MACHINERY MANAGEMENT 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

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

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

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

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

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 operator's seat for tractors and agricultural equipment.

Practical

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

Suggested Readings

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

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

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

Kromer KHE. 2001. *Ergonomics*. Prentice Hall. Mathews J & Knight AA.1971. *Ergonomics in Agricultural Design*. National Institute of Agric. Engineering, Wrest Park Silsoe, Bedford.

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

William D McArdle. 1991. *Exercise Physiology*.1991. Lea & Febiger. Zander J. 1972. *Principles of Ergonomics*. Elsevier.

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

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

Suggested Readings

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

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

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

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

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

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

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

FMPE 512 AGRO-ENERGY AUDIT AND MANAGEMENT 2+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

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

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.

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

Practical

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

Suggested Readings

Hamdy A Taha. 2001. *Operations Research*. Prentice Hall of India.

Holman JP 1996. *Experimental Methods for Engineers*. 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)

Objective

To expose the students to the industry

Theory

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

FMPE 601 ADVANCES IN FARM MACHINERY AND POWER ENGINEERING 3+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

Suggested Readings

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

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

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

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

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

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

FMPE 602 SIMULATION MODELING IN FARM MACHINERY AND POWER ENGINEERING 2+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Practical

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

Suggested Readings

Langhaar HL.1954. *Dimensional Analysis and Similitude*. McGraw Hill.

Sedov LI. 1991. *Similarity and Dimensional Methods in Mechanics*. Mir Publ., Moscow

FMPE 603 ENERGY CONSERVATION AND MANAGEMENT IN FARM POWER AND MACHINERY 2+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Suggested Readings

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

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

FMPE 604 COMPUTER AIDED ANALYSIS AND DESIGN OF FARM MACHINERY 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Practical

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

Suggested Readings

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

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

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

Rao PN. 2002. *CAD/CAM Principles and Applications*. Tata McGraw Hill.

Zeid Ibrahim.1998. *CAD/CAM Theory and Practice*. Tata McGraw Hill.

FMPE 605 MACHINERY FOR NATURAL RESOURCE MANAGEMENT AND PRECISION FARMING 3+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

Practical

Introduction to GIS and GPS, study of models vis-à-vis farm machinery usage. Precision farming using GIS and GPS – case study. Study the mechanism of power shovels, drag lines, earth diggers, clamshells etc. earth work estimation, unit cost of operation, work scheduling, machinery maintenance, entrepreneurship

Suggested Readings

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

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

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

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

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

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

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

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

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

FMPE 606 ADVANCES IN HYDRAULICS AND ELECTRO PNEUMATIC CONTROLS 2+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Suggested Readings

Anthony Esposito. 2003. *Fluid Power with Applications*. Pearsons Edu.
Krutz G.1984.*Design of Agricultural Machines*. John Wiley & Sons.
Merritt HE. 1991. *Hydraulic Control System*. John Wiley a& Sons.
Majumdar SR. 2003. *Oil Hydraulic System*. Tata McGraw Hill.

FARM MACHINERY AND POWER ENGINEERING

List of Journals

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

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 vegetable crops
- Cotton pickers- for picking cotton balls
- Crop harvesters – for berseem
- 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

RENEWABLE ENERGY ENGINEERING

Course Structure at a Glance

CODE	COUSE TITLE	CREDITS
REN 501*	SOLAR ENERGY SYSTEMS	3 (2+1)
REN 502*	WIND ENERGY TECHNOLOGY	3 (2+1)
REN 503*	BIOMASS ENERGY ENGINEERING	3 (2+1)
REN 504*	BIOGAS TECHNOLOGY & MECHANISM	3 (2+1)
REN 505	DIRECT ENERGY CONVERSION SYSTEM	2 (2+0)
REN 506	ALTERNATE FUEL TECHNOLOGY & APPLICATIONS	3 (2+1)
REN 507 / FMPE 504	SYSTEM SIMULATION AND COMPUTER AIDED PROBLEMS SOLVING IN ENGINEERING	2(1+1)
REN 508	GREENHOUSE TECHNOLOGY & MANAGEMENT	3 (2+1)
REN 509	INTEGRATED RURAL ENERGY PLANNING & ORGANIZATION	3 (3+0)
REN 510	HEAT TRANSFER IN SOLAR ENERGY	3 (2+1)
REN 511	ENERGY & ENVIRONMENTAL ENGINEERING	3 (3+0)
REN 512 /FMPE 512	AGRO ENERGY & AUDIT MANAGEMENT	2 (2+0)
REN 513/ FMPE 513	DESIGN & ANALYSIS OF RENEWABLE ENERGY CONVERSION SYSTEMS	3 (3+0)
REN 514	ENGINEERING INSTRUMENTATION & CONTROL	3 (2+1)
REN 515	STATISTICAL METHODS	3 (3+0)
REN 591	MASTER'S SEMINAR	1 (1+0)
REN 592	SPECIAL PROBLEM	1 (0+1)
REN 595#	INDUSTRY / INSTITUTE TRAINING	NC
REN 519	MASTER'S RESEARCH	20
REN 601*	ADVANCED ENERGY SYSTEMS FOR INDUSTRIAL APPLICATIONS	3 (2+1)
REN 602*	COMPUTER AIDED ANALYSIS AND DESIGN OF RENEWABLE ENERGY SYSTEMS	3 (2+1)
REN 603	ENERGY LAB	3 (0+3)
REN 604	NUMERICAL ANALYSIS	3 (2+1)
REN 605	AGRICULTURAL WASTE & BY-PRODUCTS UTILIZATION	3 (2+1)
REN 691	DOCTORAL SEMINAR-I	1 (1+0)
REN 692	DOCTORAL SEMINAR-II	1 (1+0)
REN 693	SPECIAL PROBLEM	1 (0+1)
REN 694	CASE STUDY	1 (0+1)
REN 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme
# Minimum three weeks training

Note: some of the identified minor/supporting fields are Mechanical Engineering, Processing & Food Engineering, Farm Machinery & Power Engineering, Civil Engineering, Computer Science, Mathematics & Statistics, soil & water engineering. The content of some of the identified minor /supporting courses have been given.

RENEWABLE ENERGY ENGINEERING

Course Contents

REN 501 SOLAR ENERGY SYSTEM 3(2 + 1)

Theory

UNIT I

Importance of solar energy and its application in crops drying, air and water heating, cooking, lighting, seed treatment and preservation.

UNIT II

Principles and design criteria of solar water heaters, solar crop dryers, solar cookers and solar absorption refrigeration systems, storage of energy by rock, water and phase change medium .

UNIT III

Measurement of solar radiation, reflectivity, absorptivity, transmissivity and thermal conductivity.

UNIT IV

Design of photovolatic cells. Economics of various solar energy systems. Operation and maintenance of solar operated appliances systems and equipments

Practicals.

1. Study of the environmental parameters measuring instruments.
2. Measurement and estimation of solar radiation availability.
3. Determination of LAT, day length
4. Estimation of thermal losses, overall heat loss co-efficient of FPC.
5. Testing and performance evaluation of solar air heater.
6. Testing and performance evaluation of the solar water heater.
7. Testing and performance evaluation of the solar dryers
8. Study of the selective coatings.
9. Performance study of solar still.
10. Design and Performance evaluation of solar PV systems.
11. Visit of Solar Energy Application & Testing Centers

Suggested Readings

1. Sukhatme S.P. Solar Energy. Tata McGraw-Hill Publishing company ltd., New Delhi.
2. Grag H.P. and Prakash J. solar energy fundamentals and applications. Tata McGraw-Hill publishing company Ltd.,New Delhi.
3. J A Duffie and W.A.Beckman. Solar Engineering of Thermal processes. John Wiley.
4. F Kreith and J.F.Kreider, Principles of solar Engineering McGraw-Hill , 1978.
5. Garg H.P. Treatise on solar Energy , Wiley Inter science Publication , New York.
6. Hall. C.W. Drying Farm Crops. AVI publishing co. west port connecticut.

REN 502 WIND ENERGY TECHNOLOGY 3(2 + 1)

Theory

UNIT I

Wind machine types, classification, parameters. wind resource assessment-measurement, prediction and wind mapping, Wind velocity and power from the wind, Concept of wind energy and its use in water power generation.

UNIT II

Wind turbine aerodynamics, momentum theories, basic aerodynamics, airfoils and their characteristics, Horizontal Axis Wind Turbine (HAWT) - Blade Element Theory, wake analysis, Vertical Axis Wind Turbine (VAWT) aerodynamics. HAWT rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, yaw system, tower.

UNIT III

Wind turbine loads, aerodynamic loads in steady operation, wind turbulence, static, WECS control system, requirements and strategies. Wind Energy Conversion System (WECS) siting, rotor selection, Annual Energy Output (AEO). Synchronous and asynchronous generators and loads, integration of wind energy converters to electrical networks, inverters. Testing of WECS. Noise. Miscellaneous topics. Mechanical and electrical applications, wind farms, Interfacing, Maintenance, Management of crops irrigated by wind pumps. Management of power generated by wind mill .

Practical

1. Study of wind measuring instruments.
2. Energy estimation from wind data.
3. Design study of wind mill rotor blades.
4. Studies on Wind power generators
5. Problems on forces on the blades and thrust on turbines.
6. Study of water wind pumps.
7. Design calculations of wind pump for drip irrigation
8. Studies on velocity and power duration curves.
9. Visit to wind farms and studies on wind farm economics.
10. Study on wind energy storage system

Suggested Readings

1. D.M.Simons, Wind Power, Noyes Data Corporations, 1975
2. T.N.Veziroglu (Ed), Alternative Energy Sources, Vol. 5, Mcgraw Hill, 1977.
3. Thomas Ackermann Wind Power in Power Systems

REN 503 BIOMASS ENERGY ENGINEERING 3(2 + 1)

Theory

UNIT I

Identification of various forms of biomass. biomass production and potential in India, Plantation for renewable energy i.e. wood as a fuel charcoal, producer gas. Different types of species for Energy plantation. clean development mechanism CDM

UNIT II

Thermo-chemical conversion of biomass, reactor configuration, gas conditioning systems, fast pyrolysis technologies, technologies for production of bio-liquids, standards of bio-oils, sizing/selection of gasifiers, open - top reburn down draft gasifier, performance evaluation of different gasifiers, furnaces, stores, briquetting plants. Biomass cogeneration, application of biomass for thermal applications, briquetting, water pumping, power generation , cooking. Technologies for conversion of biomass to electricity. Economics of various systems of biomass run plants, equipments, operation and maintenance. Design of rural base industries run on biomass

Practicals

1. Proximate analysis of solid fuels.
2. Ultimate analysis of solid fuels.
3. Calculation of High Heat Value of solid and liquid fuels.
4. Calculation of Low Heat Value of gaseous fuels.
5. Determination of stoichiometric air requirement and excess air.
6. Gravimetric analysis, volumetric analysis and conversion.
7. Study and use of Bomb calorimeter.
8. Study of Junker's gas calorimeter.
9. Study of Gas Chromatography.
10 Study of different types of furnaces.
11. Testing of down draft gasifier.
12. Testing of open core gasifier.
13 Study of briquetting machines and wood burning stoves.

Suggested Readings

1. D O Hall, G W Barnard, and P A Moss, Biomass for Energy in the Developing Countries, Current Roles, Potential, Problems, Propects. Pergamon Press Ltd, 1982.
2. L P White, L G Claskett, Biomass as Fuel. Academic Press, 1981.
3. T B Read, Biomass Gasification Principles and Technology. Energy Technology Review, No. 67, Noyes Data Corporation, USA, 1981.
4. V J Patel, A New Strategy for High Density Agroforestry. Jivraj Patel Agroforestry Centre, Gujarat, 1988.
5. A Kaupp and J R Goss, State of Art Report For Small Scale Gas Producer Engine Systems. Friedr Vieweg & Sohn Verlag Sgesellschaft mbh, Braunschweig, 1984.
6. D W Robinson and R C Mollan, Energy Management and Agriculture. Elsevier Science Publishers, 1982.

REN 504 BIOGAS TECHNOLOGY AND MECHANISM 3(2+1)

Theory

UNIT I

Biogas Technology: Introduction, historical background, digestion process, factors enhancing/ inhibiting biogas production.

Bio-chemical and Microbial Aspects: Biogas mechanism, enhancing the biogas production and its purification.

Biogas Plant: Systems, Types of biogas plants, classification, design of a biogas plant (cow dung and organic waste), structural strength, selection of site and size, construction technique material requirement, high rate digesters, night soil linked biogas plant.

UNIT II

Biogas Distribution and Utilization: Properties of biogas, different uses, design of biogas distribution system, pressure and flow measuring devices, safety devices, biogas fittings, principles of dual fuel biogas engines, its limitations, biogas appliances including thermal and cooking efficiency test.

Effluent: Handling of effluent of biogas plant (cow dung based, sanitary latrine attached and agro industrial wastes), effluent treatment and management effect of slurry on crop and fish production. Integrated recycling of organic wastes.

Alternate Feed Material: Study of biogas plant for distillery and sugar mills effluent, willow dust, agro-wastes, agro and processing industry wastes.

UNIT III

Repair and Maintenance: Repair and maintenance of biogas plants

Practical:

1. Study on fixed dom type biogas plants.
2. Study on floating drum type biogas plants.
3. Study on determination of calorific value of biogas.
4. Study on design calculation of floating drum type biogas plant.
5. Determination of N, P and K contents of the fresh and digested slurry by chemical analysis.
6. Study of constructional details of willow dust based biogas plants.
7. Testing of biogas burner for heat transfer, thermal and cooking efficiency.
8. Testing of biogas lamp
9. Determination of BOD/COD
10 Visit of biogas bottling plant

Suggested Readings

1. Khandelwal, K.C. and S.S Mahdi.; Biogas Technology: A Practical Hand Book, Tata McGraw Hill Pvt. Co.
2. Chawla, O.P., Advances in Biogas Technology, I.C.A.R., New Delhi
   Rathore N.S., Kurchania A.K., Biomethanation Technology, Apex Publications, Udaipur, 2006
3. Mathur, A.N. and N.S Rathore; Biogas production management and utilization-Himanshu Publication

REN 505 DIRECT ENERGY CONVERSION SYSTEM 2(2 + 0)

Theory

UNIT I

Basic science of energy conversion. Physics of semiconductor, fabrication and evaluation of various cells.

UNIT II

Solar energy and its utilization, solar cell, thermo-electric and thermonic devices, wind energy, fuel cell, magneto hydrodynamic energy conversion, biogas theory, design of energy converters with special reference to rural living.

UNIT III

Applications of solar cells in photovoltaic power

Suggested Readings

1. Non- conventional Energy sources by G. D. Rai, Khanna Publishers, 2-B, Nath Market, Nai Sarak, Delhi-110006
2. D.M.Simons, Wind Power, Noyes Data Corporations, 1975
3. T.N.Veziroglu (Ed), Alternative Energy Sources,Vol.5, Mcgraw Hill, 1977.
4. Thomas Ackermann Wind Power in Power Systems
5. Grag H.P. and Prakash J. solar energy fundamentals and applications. Tata McGraw-Hill publishing company Ltd., New Delhi.
6. Garg H.P. Treatise on solar Energy, Wiley Inter science Publication, New York.
7. Tony Burton, David Sharp and Nick Jenkins; Wind Energy: Handbook, John Wiley & Sons Ltd., West Sussex, England.2001

REN 506 ALTERNATE FUELS TECHNOLOGY & APPLICATIONS 3(2+1)

Theory

UNIT I

Bioconversion Techniques, direct combustion, Pyrolysis, Flash pyrolysis, Formulation and gasification.

UNIT II

Utilization of industrial waste such as Biogases, improved cook stoves. Industrial biomass combustion systems gasification sizing beneficiation of Fuels, various sources of biofuels, Processing of various agro products for biofuels combustion characteristics of biofuels, working process in IC engines. Fuels efficiency, Fuel blends dual Fuel operation, Bio - gas generation and purification technology, biogas as cooking and IC engine fuel, performance evaluation of biogas as vehicle fuel, environmental pollution with conventional and alternate fuels.

UNIT III

Current biofuels scenario in India. availability of raw material technology for production of biofuels and developments in the sector. standardization and specifications for biofuels, clean development mechanism and biofuels.

Practicals:

1. Proximate and ultimate analysis of solid fuels.
2. Calculation of High Heat Value of solid and liquid fuels.
3. Calculation of Low Heat Value of gaseous fuels.
4. Study of the Bio fuels characteristics – proximate analysis and ultimate analysis
5 Determination of calorific value of bio-fuels and biogas.
6. Design of fixed dome type and movable drum type biogas plants.
7. Study of the biogas purification
8. Study of the bio-fuels purification
9. Performance evaluation of biogas as IC engine fuel
10. Performance evaluation of biofuels as IC engine fuel

Suggested Readings

1 Pathak Q.S. and srivastva NSL. Biomass based Decentralized Power Generation, SPRERI.
2. Selected Web sites www.ybiofuels.org/bio-fuels/history-biofuels.html
3. Gerpen J. Van, Shanks, Pruszko R. Clements D and Knothe G 2004. Bio-diesel Production Technology August-2002-January 2004. National Renewable Energy Laboratory (www.nrel.gov),US

REN 507 SYSTEM SIMULATION AND COMPUTER AIDED PROBLEMS SOLVING IN ENGINEERING 2(2+0)

Objective

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

Theory

UNIT I

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

UNIT II

Mathematical modeling and engineering problem solving.

UNIT III

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

UNIT IV

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

UNIT V

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

Suggested Readings

1. Averill M. Law & W David Kelton.2000. *Simulation Modeling and Analysis*. McGraw Hill.
2. Balagurusamy E. 2000. *Numerical Methods*. Tata McGraw Hill. Buckingham E. 1914. *On Physical Similar System*. Physical Reviews 4:345.
3. Langhar H. 1951. *Dimensional Analysis and Theory of Models*. John Wiley & Sons. Murphy J. 1950. *Similitude in Engineering*.
4. The Roland Press Co. Robert J Schilling & Sandra L Harries. 2002. *Applied Numerical Methods for Engineers Using MATLAB and C*.
5. Thomson Asia. Simpson OJ. 2000. *Basic Statistics*. Oxford & IBH.Singh RP. 2000.
6. *Computer Application in Food Technology*. Academic Press.Steven Chopra & Raywond Canale. 1989.
7. *Introduction to Computing forEngineers*. McGraw Hill.
8. Veerarajan T & Ramachnadran T. 2004. *Numerical Methods withProgrammes in C and C++.* Tata McGraw Hill.
9. Wilks SS. 1962. *Mathematical Statistics*. John Wiley & Sons

REN 508 GREENHOUSE TECHNOLOGY AND MANAGEMENT 3(2 + 1)

Theory

UNIT I

Introduction: Importance, Scopes, types of greenhouses and economics.

UNIT II

Greenhouse construction: Orientation, selection of site, floor plan, and construction materials designs and layout of greenhouse, load calculation and construction metrology.

UNIT III

Greenhouse environment and controls: Constituents of greenhouse environment and their effect on crop growth, type of heat loss, and calculation of heat requirement, greenhouse heating systems, heat sources, conservation of energy in greenhouse, different types of greenhouse cooling system, design of greenhouse cooling systems, greenhouse lighting system and design considerations, greenhouse environment control systems and automation, mathematical modeling of greenhouse environment greenhouse environment control instrumentation.

UNIT IV

Root Substrate Management: Soil based and soil less substrates, soil solarization and soil temperature modeling hydroponics techniques, greenhouse irrigations systems and controls, fertigation programmes, nutrition management, insect and disease management in greenhouse Post Harvest

UNIT V

Technology & Marketing: Packaging, grades & standards, post harvest of fresh flowers, market system of greenhouse products.

Practicals:

1. Studies on greenhouse cooling system.
2. Performance evaluation of fan-pad cooling system.
3. Studies on greenhouse irrigation system.
4. Studies on greenhouse automation systems.
5. One week training/internships in greenhouse technology and management.
6. Studies on different root substrates and hydroponics cultivation.
7. Studies on greenhouse lighting system.

Suggested Readings

1. Paul V. Welson; Greenhouse operation & management prentice Hall, New Jersey.
2. Hauon, J.J., Holley, W.D. and Golds berry, K.L. Greenhouse Management, Springer- verlag, Berlin.
3. Robert MC Mohan; Introduction to greenhouse production, Ohio Agril. Edu. Curriculum materials Service.
4. Bailey, B.J. and Takakura, T. Editer: A. kauo, Greenhouse Environment Control and automation.
5. G.N.Tiwari, R.K.Goyal; Greenhouse Technology, Narosa Publication, Delhi.

REN 509 INTEGRATED RURAL ENERGY PLANNING AND ORGANIZATION 3(3+ 0)

Theory

UNIT I

Importance and scope of rural energy planning and organisation present status and future thrusts.

UNIT II

Objectives of integrated rural energy planning, conventional and non-conventional sources of energy, biomass, photosynthesis, efficiency of energy conversion by different plant species, plantation for energy, wood as a fuel, charcoal, producer gas, biogas, their production, equipment required and application, design of integrated systems using solar, biomass, biogas and wind for lighting, cooking, water pumping, power generation for various uses in Agriculture both for renewable sources of energy, development of pilot villages, industries run solely on integrated sources of renewable energy.

UNIT III

Operation and maintenance of industries and plant.

Suggested Readings

1. N.S. Rathore, A.N. Mathur and A.S. Solanki. Integrated Rural Energy Planning. Agrotech Publishing Academy, Udaipur.
2. Somasehhura N. Rural Energy. Sterling Publishers Pvt. Ltd., New Delhi.
3. R.A. Meyers, Hand Book of Energy Technology. Jhon Wileys Sons., New York, 1983.
4. Elmahgary Y. and Biswas, A.K., Integrated Rural Energy Planning, Butter Warth, U.K., 1985.

REN 510 HEAT TRANSFER IN SOLAR ENERGY 3(2+1)

Theory

UNIT I

Principles of heat transfer, theory of heat conduction, Mathematical and numerical analysis of heat conduction problems, transient and static heat conduction. Theory of convective heat transfer, heat transfer in duct flows. Boiling condensation and heat exchangers. Radiation heat transfer between black and gray bodies.

UNIT II

Heat transfer in solar air and water heaters. Energy balance equations and performance prediction analysis. Heat transfer and energy balance equations of solar distillation, soil solarization, solar drying and green house systems.

Practicals:

1. Computer programming and performance prediction of box type solar cooker
2. Computer programming and performance prediction of solar air heating system.
3. Computer programming and performance prediction of solar distillation system.
4. Computer programming and performance prediction of solar green house system.
5. Computer programming and performance prediction of soil solarization system.
6. Computer programming and performance prediction of water heating system
7. Computer programming and performance prediction of solar drying system

Suggested Readings

1. Duffie J.A. Beckman solar Engineering of Thermal processes. Wiley Inter Science.
2. Stine W.B., Harrigan R.W. Solar Energy Fundamentals and Design with computer applications.
3. Wong H.Y. Heat Transfer for Engineers Longman London & New York.

REN 511 ENERGY AND ENVIRONMENTAL ENGINEERING 3(3 +0)

Theory

UNIT I

Sources of energy impact of fossil fuels on environment new and improved energy technologies, energy consumption strategies to meet demands for energy and environment quality, renewable sources of energy, air, water and soil pollution and its control, environmental impact of current agricultural technologies and engineering systems for pollution control and conservation and utilization of natural resources.

UNIT II

Waste management in agro industries, handling, storage and processing of waste, reclamation of waste water, use of waste land for energy generation, role and application of renewable energy for clean environment. Case studies, Biofilters, Biodegradable plastics for mulching.

Suggested Readings

1. Twidell John W. and A. D. Weir; Renewable Energy Sources.
2. Dune, P. D.; Renewable Energies: Sources, Conversion and Applications.
3. Hopes G. Puppy; Energy and Environment, Mankind and Energy Needs, Elsevir Pub. Co., New York.
4. Rao C. S.; Environmental Pollution Control Engineering.
5. Rathore N.S., Kurchania A.K., Climatic Changes & Their Remedial Measures, Shubhi Publications, Gurgaon, 2001.
6. Mathur A. N., Rathore N. S. and V. K. Vijay; Environmental Awareness
7. David Coley. Energy and Climate Change. Jhon Wiley & Sons, Ltd.U.K.

REN 512 AGRO-ENERGY AUDIT AND MANAGEMENT 2(2+0)

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Suggested Readings

1. Kennedy WJ Jr. & Wayne C Turner.1984. Energy Management. Prentice Hall.
2. Pimental D. 1980. Handbook of Energy Utilization in Agriculture. CRC
3. Fluck RC & Baird CD.1984. Agricultural Energetics. AVI Publ.
4. Rai GD. 1998. Non-conventional Sources of Energy. Khanna Publ.
5. Twindal JW & Anthony D Wier 1986. Renewable Energy Sources. E & F.N. Spon Ltd.
6. Verma SR, Mittal JP & Surendra Singh 1994. Energy Management and Conservation in Agricultural Production and Food Processing. USG Publ. & Distr., Ludhiana

REN 513 DESIGN AND ANALYSIS OF RENEWABLE ENERGY CONVERSION SYSTEMS 3(3+0)

Objective

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

Theory

UNIT I

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

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

UNIT II

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.

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

Suggested Readings

1. Boyle Godfrey. 1996. Renewable Energy: Power for Sustainable Future. Oxford Univ. Press.
2. Culp AW. 1991. Principles of Energy Conservation. Tata McGraw Hill. Duffle JA & Beckman WA. 1991. Solar Engineering of Thermal Processes. John Wiley.
3. Garg HP & Prakash J.1997. Solar Energy - Fundamental and Application.
4. Tata McGraw Hill.
5. Grewal NS, Ahluwalia S, Singh S & Singh G. 1997. Hand Book of Biogas Technology. Solar Energy Fundamentals and Applications. TMH New Delhi.
6. Mittal KM. 1985. Biomass Systems: Principles & Applications. New Age International.
7. Odum HT & Odum EC. 1976. Energy Basis for Man and Nature. Tata McGraw Hill.
8. Rao SS & Parulekar BB.1999. Non-conventional, Renewable and Conventional . Khanna Publ.
9. Sukhatme SP.1997. Solar Energy - Principles of Thermal Collection and Storage. 2nd Ed. Tata McGraw Hill.

REN 514 ENGINEERING INSTRUMENTATION & CONTROL 3(2 + 1)

Theory

UNIT I

Introduction to functional elements of an instrument, active and passive transducers, analog and digital modes, null and deflection methods, performance characteristics of instruments including static and dynamic characteristics.

UNIT II

Measuring devices for force, torque and shaft power, strain gauge type devices and their design and application in two and three dimensional force measurement, Design and analysis of strain gauge type tillage tool dynamometers, Devices for measurement of temperature, relative humidity, solar radiation, pressure, sound, vibration, flow etc. Measuring instruments for calorific values of solid, liquid and gaseous fuels, Measurement of gas composition using GLC. Recording devices and their type,

UNIT III

Data storage systems and their application

Practical

Calibration of instruments, measurement of strain, making of thermocouples and their testing, now measurement in a pipe, humidity measurement, data analysis and interpretation, signal conditioning circuits, testing of pressure transducers

Suggested Readings

1. Doeblin, E. O. (1966) Measurement Systems -Application and Design, McGraw-Hill, Book Company,
2. Ambrosius, E. E. (1966), Mechanical measurement and Instrumentation, The Ronald Press Company, New York.
3. Oliver, F. J. (1971), Practical Instrumentation Transducers, Hayden Book company Inc., New York,
4. Perry, C. C. and Lissner, H.R. (1962), The Strain Gauge Primer, McGraw-Hill Book Company, ,
5. Nachtigal, C.L. (1990), Instrumentation and Control: fundamentals and Applications, John Wiley and Sons.

REN 515 STATISTICAL METHODS 3(3 + 0)

Theory

UNIT I

Classical and recently developed statistical procedures, basic principles of statistical inference and the rationale underlying the choice of these procedures.

UNIT II

Problems of estimation, hypothesis testing, large sample theory, probability, regression.

Suggested Readings **:**

1. Kapur, K. (2000). Elements of Practical Statistics. Oxford & IBH Publishing Co. Pvt. Ltd.
2. Simpson, O.J. (2000). Basic Statistics. Oxford & lBH Publishing Co. Pvt. Ltd.
3. Milton, J. S. and Arnold, J. C. 1995). Introduction to Probability and Statistics: Principles and Applications for Engineering and Computing Sciences. McGraw Hill.

REN 592 SPECIAL PROBLEM 1(0 + 1)

REN 595 INDUSTRY / INSTITUTE TRAINING (NC)

Objective

To expose the students to the industry.

Theory

Institutional In-plant training in the relevant Renewable energy devices/process during manufacturing, assembly, testing and installation of equipments. 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.

REN 601 ADVANCED ENERGY SYSTEMS FOR INDUSTRIAL APPLICATIONS 3(3+0)

Theory

Gasification combined cycle (IGCC), Fuels for power generation, Advance energy storage systems, Hydrogen power clean coat technologies, Pressurized fluidised bed combustion, Natural gas cycles, Integrated generation, Fuel cells, Energy conservation in power plant. Power plants, Bio fuel technology plants, bio fuel purification and compression technology. Biogas bottling plant

Suggested Readings **:**

1. Nik Khartchenko, Advanced Energy Systems. Taylor & Francis; 1 edition.
2. Xianguo Li, Principles of Fuel Cells University of Waterloo, Ontario, Canada
3. Fuel Cell Technology Handbook, Editor(s): Gregor Hoogers, Trier University of Applied Sciences, Birkenfeld, Germany
4. Caye Drapcho, John Nghiem, Terry Walker Biofuels Engineering Process Technology, McGraw Hills.
5. Biofuel Technology Handbook, Free Download Book from http://artikel-software.com/blog/2008/06/16/biofuel-technology-handbook

REN 602 COMPUTER AIDED ANALYSIS AND DESIGN OF RENEWABLE ENERGY SYSTENS 3(2+1)

Theory

Introduction to computer-aided design,Autolips,Geometric modeling and interactive graphics, Computer-aided analysis and synthesis of common Renwable Energy systems. Application of numerical methods and optimal techniques to machine design, problems, Computer-aided selection of standard mechanical components, Introduction to FEM. Computer aided design of Renewable Energy Systems viz. solar air heating systems, solar dryers, Greenhouses, biomass gasifier and biogas plant. 3D rendering and animation. MATLAB programming language for the machine components

Practicals

Preparation of engineering drawings of equipment/machine, energy balance eequations and programming of solar air heating, solar drying, greenhouse. Design calculation and analysis of biomass gasifier and biogas systems. Estimating and costing of RE systems

Suggested Readings

1. Ramamurty, T. (2001). Computer Aided Mechanical Design and Analysis, Tata McG Hill, New Delhi.
2. Mukhopadhyay, M. (2000). Matrix, Finite Element, Computer and Structural Ana Oxford & IBH Publishing Co. Pvt. Ltd.
3. Krishnamoorty, G. (2001). Finite Element Analysis: Theory and Programming McGraw-Hill, New Delhi.
4. Kundra, C. V. (2000). Numerical Control and Computer Aided Manufacturing McGraw-Hill, New Delhi.
5. Zeid, K. (2000). CAD/CAM Theory and Practice, Tata McGraw-Hill, New Delhi.

REN 603 ENERGY LAB 3(0+3)

Practical

1. Study of Solar cell characteristic.
2. Study of Solar P. V. System
3. Study of Plank's constant by radiation law
4. Study of Solar Still and calculation of its efficiency
5. Study of agricultural wastes fired gasifier for power generation.
6. Study of Solar Powered Refrigeration system.
7. Study of Gas Chromatograph and determination of composition of biogas, producer gas and flue gases.
8. Development of solid and liquid fuel from biomass.
9. Study and testing of dual fuel engine running on biogas and diesel.
10. Development of biodiesel from Jatropha oil.
11. Study of Bomb Calorimeter and measurement of calorific value of different biomass.
12. Study of Proximate and Ultimate analysis of biomass
13. Testing of portable type of Improved Cook stoves
14. Study the harnessing the power from wind.
15. Study of Integrated Energy System

Suggested Readings

1. Rathore N.S., Kurchania A.K., Panwar N.L., Renewable Energy: Theory & Practice, Himanshu Publications, 2006
2. Khandelwal, K.C. & Mahdi, S.S. Biogas Technology, 1990.
3. Rai, G.D. Non-Conventional Energy Sources, Kh Publishers, New Delhi.

REN 604 NUMERICAL ANALYSIS 3(2 + 1)

Theory

UNIT I

Numerical methods for systems of linear equations, eigen values, interpolation, differentiation, least squares.

UNIT II

Numerical solution of differential equations and non-linear equations in several variables.

***Practical* :**

Practice on matrix manipulation, Exercises on solution of the systems of linear and non-linear equations, solution of differential equations.

Suggested Readings:

1. Scarborough, G. (2000). Numerical Mathematical Analysis. Oxford & IBH Publishing -Co. Pvt. Ltd.
2. Chapra, C. (2000). Numerical Methods for Engineers. Tata McGraw-Hill, New Delh
3. Atkinson, K. (1993). Elementary Numerical Analysis. 2nd Ed. John Wiley
4. Epperson. J.F. (2002). An Introduction to Numerical Methods and Analysis. John Wiley

REN 605 AGRICULTURAL WASTE AND BY-PRODUCTS UTILIZATION 3(2+1)

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

Suggested Readings

1. ASAE Standards. 1984. *Manure Production and Characteristics*.
2. Bor S Luh (Ed.). 1980. *Rice: Production and Utilization*. AVI Publ.
3. Chahal DS.1991. *Food, Feed and Fuel from Biomass*. Oxford & IBH.
4. Chakraverty A. 1989. *Biotechnology and other Alternative Technologies for Utilisation of Biomass/ Agricultural Wastes*. Oxford & IBH.
5. David C Wilson. 1981. *Waste Management - Planning, Evaluation,Technologies*. Oxford.
6. Donald L Klass & Emert H George 1981. *Fuels from Biomass and Wastes*. Ann. Arbor. Science Publ.
7. Srivastava PK, Maheswari RC & Ohja TP. 1995. *Biomass Briquetting and Utilization*. Jain Bros.
8. USDA 1992. *Agricultural Waste Management Field Handbook*. USDA.
9. Wilfred A Cote.1983. *Biomass Utilization*. Plenum Press.

RENEWABLE ENERGY ENGINEERING

List of Journals

- Renewable Energy
- Journal of Renewable Energy & Sustainable Energy
- Journal of Renewable Energy Technology
- Solar Energy (ISES)
- Energy Conversion & Management
- Energy
- International Journal of Sustainable Energy
- International Journal of Energy Research
- Heat Recovery & CHP
- Applied Thermal Engineering
- Energy & Environmental Science
- International Journal of Green Energy
- Energy & Fuels
- Energy & Fuels

Suggested Broad Topics for Master's and Doctoral Research

- Solar Crop Drying
- Solar Thermal Energy Storage
- Solar Air Heating
- Biomass Gasification
- Bio fuel technology
- Greenhouse Technology
- Earth Tube Heat Exchanger
- Mathematical Modeling of Renewable Energy Systems
- Soil Solarization
- Bio Fuel Technology
- Solar Photovoltaic Applications
- Energy Conservation in Agro Industries

AGRICULTURAL PROCESS ENGINEERING

Course structure at a glance

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

* Compulsory for Master's programme; ** Compulsory for Doctoral programme
# PFE 595 – Minimum of Three Weeks Training

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

AGRICULTURAL PROCESS ENGINEERING

Course Contents

PFE 501 TRANSPORT PHENOMENA IN FOOD PROCESSING 2+1

Objective

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

Theory

UNIT I

Introduction to heat and mass transfer and their analogous behaviour, steady and unsteady state heat conduction, analytical and numerical solution of unsteady state heat conduction equations, use of Gurnie-Lurie and Heisler Charts in solving heat conduction problems. Applications in food processing including freezing and thawing 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 G. 1971. *Heat Transfer*. 2nd Ed. Tata McGraw Hill.

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

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

EcKert ERG & Draker 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 ENGINEERING PROPERTIES OF FOOD MATERIALS 2+1

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

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

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

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

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

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

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

Suggested Readings

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

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

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

Fellows P. 1988. *Food Processing Technology: Principle and Practice*. VCH Publ.

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

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

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

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

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

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

PFE 504 UNIT OPERATIONS IN FOODPROCESSENGINEERING 2+1

Objective

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

Theory

UNIT I

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

UNIT III

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

UNIT IV

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

UNIT V

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

UNIT VI

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

Practical

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

Suggested Readings

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

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

Fellows P. 1988. *Food Processing Technology: Principle and Practice*. VCH Publ.

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

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

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

PFE 505 ENERGY MANAGEMENT IN FOOD PROCESSING INDUSTRIES 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Practical

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

Suggested Readings

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

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, visit to related agro- processing industry

Suggested Readings

Asiedu JJ.1990. *Processing Tropical Crops*. ELBS/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

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

Practical

Detailed design and drawing of mechanical dryers, milling equipment, separators, evaporators, mixers and separators. Each individual student will be asked to elect 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.

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

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

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

Richey CB. (Ed.). 1961. *Agricultural Engineers' Hand Book*. McGraw Hill.

Romeo T Toledo. 1997. *Fundamentals of Food Process Engineering*. CBS.

Slade FH. 1967. *Food Processing Plant*. Vol. I. Leonard Hill Books

PFE 508 FRUITS AND VEGETABLES PROCESS ENGINEERING 2+1

Objective

To acquaint and equip the students with processing of fruits and egetables 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.

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

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

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

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

PFE 509 MEAT PROCESSING 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

UNIT VI

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

Practical

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

Suggested Readings

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

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

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

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

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

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

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

PFE 510 FOOD PACKAGING, FOOD QUALITY AND SAFETY ENGINEERING 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT V

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

Practical

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

Suggested Readings

Crosby NT. 1981. *Food Packaging Materials*. Applied Science Publ.
Mahadeviah M & Gowramma RV. 1996. *Food Packaging Materials*. Tata McGraw Hill.
Palling SJ. (Ed). 1980. *Developments in Food Packaging*. Applied Science Publ.
Sacharow S & Grittin RC. 1980. *Principles of Food Packaging*. AVI Publ

PFE 511 FOOD QUALITY AND SAFETY ENGINEERING 2+1

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 FARM STRUCTURES AND ENVIRONMENTAL CONTROL 1+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Instruments and measurements; codes and standards

Practical

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

Suggested Readings

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

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

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

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

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

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

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

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 SEED DRYING, PROCESSING AND STORAGE 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

Seed drying principles and methods, theory of seed drying, introduction to different types of heated air dryers, significance of moisture equilibrium, method of maintaining safe seed moisture, thumb rule and its relevance, importance of scientific seed storage, types of storage structures to reduce temperature and humidity; management and operation/cleanliness of seed stores,

UNIT IV

packaging-principles, practices, materials and hermetic packaging, seed treatment methods and machines used, method of stacking and their impact, design features of medium and long term seed storage building

Practical

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

Suggested Readings

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

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

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

PFE 515 BIOCHEMICAL AND PROCESS ENGINEERING 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

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

Treybal RE. 1981. *Mass Transfer Operations*. 3rd Ed. Harper & Row.

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

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

PFE 595 INDUSTRY/INSTITUTE TRAINING 0+1 (NC)

Objective

To expose the students to the industry

Theory

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

PFE 601 TEXTURAL & RHEOLOGICAL CHARACTERISTICS OF FOOD MATERIALS 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Practical

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

Suggested Readings

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

Deman JM. *et al.* 1976. *Rheology and Texture in Food Quality*. AVI Publ. Journal of Food Science and Technology

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

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

PFE 602 ADVANCES IN FOOD PROCESSING 3+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Suggested Readings

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

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

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

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

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

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

PFE 603 MATHEMATICAL MODELS IN FOOD PROCESSING 3+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

Applications of mathematical modelling techniques to food processing operations like parboiling, convective drying, pasteurization, dehydration, shelf-life prediction, 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

Suggested Readings

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

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

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

Getz WM.1979. *Mathematical Modeling in Biology Processes*. Elsevier.

Gold HJ.1977.*Mathematical Modelling of Biological Systems - An Introductory Guidebook*. John Wiley & Sons.

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

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

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

Meyer JW. 2004. *Concepts of Mathematical Modeling*. Mc Graw Hill.

Peart RM & Curry RB.1998.*Agricultural Systems, Modelling and Simulation*. Marcel Dekker.

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

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

PFE 604 ADVANCES IN DRYING OF FOOD MATERIALS 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

Suggested Readings

Bala BK. 1998. *Drying and Storage of Cereal Grains*. Oxford & IBH.

Brooker DB, Bakker Arkema FW & Hall CW. 1974. *Drying Cereal Grains*. The AVI Publ.

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

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

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

Wallace B Van Arsdel & Michael J Copley. 1963. *Food Dehydration*. AVI Publ

PFE 605 AGRICULTURAL WASTE AND BY-PRODUCTS UTILIZATION 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

Suggested Readings

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

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

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

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

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

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

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

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

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

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 and Doctoral 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

SUGGESTED MINOR/SUPPORTING COURSES

Some Identified Minor/Supporting Courses

Course code	Course Title	Credits
CE 501	OPEN CHANNEL FLOW	3+0
CE 502	DAMS & RESERVOIR OPERATIONS	3+1
CE 503	WATER QUALITY AND POLLUTION CONTROL	3+1
CE 504	FLUVIAL HYDRAULICS	2+1
CE 505	EXPERIMENTAL STRESS ANALYSIS	2+1
CE 506	SIMILITUDE IN ENGINEERING	2+1
CE 507	CONTROL OF POLLUTION FROM SOLID WASTES	2+0
CE 601	PROBABILISTIC APPROACH IN DESIGN	2+0
CE 602	RANDOM VIBRATIONS	2+0
CE 603	DESIGN OF BINS AND SILOS	2+1
CSE 501	COMPUTER GRAPHICS	2+1
CSE 502	NEURAL NETWORK AND ITS APPLICATIONS	2+1
EE 501	APPLIED INSTRUMENTATION	2+1
EE 502	PROCESS CONTROL SYSTEMS	2+1
ME 501	MECHANISM ANALYSIS AND SYNTHESES	3+0
ME 502	VIBRATIONS	3+0

Civil Engineering

CE 501 OPEN CHANNEL FLOW 3+0

Objective

To acquaint and equip with different techniques of Open Channel Flow and its importance in the engineering

Theory

UNIT I

Open channel and their properties. Energy and momentum principles. Critical flow computations and applications.

UNIT II

Uniform flow. Its development. Formula and design computation.

UNIT III

Boundary layer concept. Surface roughness. Velocity distribution and instability of uniform flow.

UNIT IV

Gradually varied flow theory and analysis. Method of computations.

UNIT V

Hydraulic jump and its use as levelling energy dissipation.

UNIT VI

Spatially varied flow. Unsteady flow. Rapidly varied flow.

Suggested Readings

Henderson FM.1966. *Open Channel Flow*. Macmillan.
Subramaninum 1960. *Open Channel Flow*. McGraw Hill.
Ven T Chow. 1959. *Open Channel Flow*. McGraw Hill

CE 502 DAMS & RESERVOIR OPERATIONS 3+1

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 & reservoirs. Survey & 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 & 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 above topics

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

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.* Vol. II. Khanna Publ.

Garg SK. 2004. *Environmental Engineering*. Vol. I. 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 and Eddy. 2003*. Waste Water Engineering Treatment and Reuse. Tata McGraw* Hill

CE 504 FLUVIAL HYDRAULICS 2+1

Objective

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

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 EXPERIMENTAL STRESS ANALYSIS 2+1

Objective

To acquaint and equip students with different techniques/methods of stress analysis and its importance in Engineering

Theory

UNIT I

Strain and stress, Strain relationship, Strain gauges mechanical, optical, electrical, acoustical and pneumatic etc and their use. Different types of electric strain gauges, Semiconductor gauges.

Practical
Measurement of strain with strain gauge. Photo elastic methods and Moire's apparatus

Suggested Readings
Srinath LS.1984. *Experimental Stress Analysis*. Tata McGraw Hill.
Singh Sadhu. 1982. *Experimental Stress Analysis*. Khanna Publ.
Dally J.W. & W.F. Riley, 1990. *Experimental Stress Analysis*. Tata McGraw Hill

CE 506 SIMILITUDE IN ENGINEERING 2+1

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 CONTROL OF POLLUTION FROM SOLID WASTES 2+0

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 601 PROBABILISTIC APPROACH IN DESIGN 2+0

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 non- stationary 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 602 RANDOM VIBRATIONS 2+0

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 land 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 603 DESIGN OF BINS AND SILOS 2+1

Objective

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

Theory

UNIT I

Computer aided design manuals. Rankine's and Coloumb's theories of active and passive pressures.

UNIT II

Janssen's and Airy's theories grain pressure theories for design of deep and shallow silos. Reimbert's 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*

Mechanical Engineering

ME 501 MECHANISM ANALYSIS AND SYNTHESIS 3+0

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, systematic of mechanisms deriving other mechanisms from linkages.

UNIT II

Relative motion, instantaneous center method, Kennedy's theorem. Graphical and analytical methods of displacement, velocity and acceleration analysis, Computer – 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, Freudenstein's 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 – follower system; standard follower motions and combinations, importance of follower acceleration in cam system dynamics, terms related to cam deisgn- their importance. Cam synthesis – 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 VIBRATIONS **3+0**

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 – viscous, solid, coulomb equivalent dampers. Viscosity damped free vibrations, Logarithmic decrement. Forced vibrations with harmonic excitation and rotating unbalance, Energy dissipated by damping. 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 multi- degree of freedom systems. Influence coefficients and Maxwell's 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

Computer Science & Electrical Engineering

EE 501 APPLIED INSTRUMENTATION 2+1

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 – 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 – 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 – Dry and Wet bulb, Hair hygrometer and Humister. Soil and Grain moisture transducers, pressure measurement – 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 – 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 SYSTEM 2+1

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 Publishers

CSE 501 COMPUTER GRAPHICS 2+1

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 Bresenham's 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
Practical problems on above topics

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

CSE 502 NEURAL NETWORK AND ITS APPLICATIONS 2+1

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

COMPULSORY NON-CREDIT COURSES
(Compulsory for Master's programme in all disciplines; Optional for Ph.D. scholars)

Course code	Course Title	Credits
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	0+1
PGS 503 (e-Course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-Course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-Course)	DISASTER MANAGEMENT	1+0

Course Contents

PGS 501 LIBRARY AND INFORMATION SERVICES 0+1

Objective
To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical
Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI
Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e- resources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 0+1

Objective
To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical
Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills **-**Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000.*Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively*. MacMillan India.

Richard WS. 1969. *Technical Writing*. Barnes & Noble.

Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.

Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.

Wren PC & Martin H. 2006.*High School English Grammar and Composition*. S. Chand & Co

PGS 503 (e-Course) INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE 1+0

Objective

The main objective of this course is to equip students and stakeholders with nowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement

Suggested Readings

Erbisch FH & Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001.*Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.
The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003

PGS 504 BASICCONCEPTS IN LABORATORYTECHNIQUES 0+1

Objective
To acquaint the students about the basics of commonly used techniques in laboratory

Practical
Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Readings
Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co

PGS 505 (e-Course) AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES 1+0

Objective
To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government

Theory
UNIT I
History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.
UNIT II
Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies /Non-Governmental Organizations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes

Suggested Readings

Bhalla GS & Singh G. 2001.*Indian Agriculture - Four Decades of Development*. Sage Publ.

Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.

Singh K. 1998.*Rural Development - Principles, Policies and Management.* Sage Publ

PGS 506 (e-Course) DISASTER MANAGEMENT 1+0

Objective

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building

Theory

UNIT I

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

UNIT II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations

Suggested Readings

Gupta HK. 2003.*Disaster Management*. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991.*Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.

Sharma VK. 2001.*Disaster Management*. National Centre for Disaster Management, India.

Annexure-III

ORGANIZATION OF COURSE CONTENTS & CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level. A Ph. D. student must take a minimum of two 600 series courses, but may also take 500-series courses if not studied during Master's programme.
- Credit seminar for Master's level is designated by code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

Course Contents

The contents of each course have been organized into

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Subject	Master's programme	Doctoral programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	**55**	**75**
Compulsory Non Credit Courses	See relevant section	

Major subject: The subject (department) in which the students takes admission.

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph. D. students may be exempted from these courses if already studied during Master's degree.