Item No. 44.13

College of Agricultural Engineering and Technology
Anand Agricultural University
Godhra – 389001

Permission for starting Ph.D. programme in "Processing and Food Engineering" discipline under Agricultural Engineering faculty

Read : Resolution of 44th Meeting of Academic Council held on 13-12-2016, vide item no. 44.13

NOTIFICATION

It is hereby notified to all concerned that the Academic Council of the Anand Agricultural University has resolved vide item No. 44.13 in its 44th meeting held on 13-12-2016 as under;

"It is hereby resolved that Ph.D. programme in discipline of "Processing and Food Engineering" in the Faculty of Agricultural Engineering is post facto approved from academic year 2016-17 as per the syllabus approved by, Junagadh Agricultural University, Junagadh"

No:-AAU/CAET/Acad(PG)/3279-86/2017
Date:- 11 / 1 /2017

(Dr. R. Subbaiah)
Principal & Dean
College of Agril. Engg. & Tech.

Copy F.w.cs. to:

1. All the members of the Academic Council of this University
2. All officers of of this University
3. All Deans / Principals of of this University
4. The Registrar, Anand Agricultural University, Anand
5. Unit/Sub Unit Officers of this University

Copy to:

6. P.S. to Hon. Vice Chancellor, Anand Agricultural University, Anand
7. P.A. to Registrar, Anand Agricultural University, Anand
8. All the HODs of this college
9. Academic Branch of this college
10. Notification File

Annexure - I

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.

PROCESSING AND FOOD 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 ENGINEERING	2+1
PFE 511	FOOD QUALITY AND SAFETY ENGINEERING	2+1
PFE 512	FARM STRUCTURES AND E[illegible]IROMENTAL CONTROL	1+1
PFE 513	STORAGE ENGINEERING AND HANDLING OF AGRICULTURAL PRODUCTS	2+1
PFE 514	SEED DRYING, PROCESSING AND STORAGE	2+1
PFE 515	BIOCHEMCIAL AND PROCESS ENGINEERING	2+1
PFE 591	MASTER'S SEMINAR	1+0
PFE 592	SPECIAL PROBLEM	0+1
PFE 595#	INDUSTRY/ INSTITUE TRAINING	NC
PFE 599	MASTER'S RESEARCH	20
PFE 601**	TEXTURAL & RHEOLOGICAL CHARACTERISTICS OF FOOD MATERIALS	2+1
PFE 602**	ADVANCES IN FOOD PROCESSING	3+0
PFE 603	MATHEMATICAL MODELS IN FOOD PROCESSING	3+0
PFE 604	ADVANCES IN DRYING OF FOOD MATERIALS	2+1
PFE 605	AGRICULTURAL WASTE AND BY –PRODUCTS UTILIZATION	2+1
PFE 691	DOCTORAL SEMINAR I	1+0
PFE 692	DOCTORAL SEMINAR II	1+0
PFE 693	SPECIAL PROBLEM	0+1
PFE 694	CASE STUDY	0+1
PFE 699	DOCTORAL RESEARCH	45

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

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

PROCESSING AND FOOD ENGINEERING

Course Contents

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, nalytical 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 calculati... , 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 II

Principles of fluid flow, methods of heat transfer, heat exchangers and theirdesigns.

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 separationtechniques, size separation equipments; Filtration, sieving, centrifugation,sedimentation. Material handling equipment, conveyors and elevators; Sizereduction 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 disposalmethods, 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 udit study and management strategies in food processing plants. Identification of energy efficient processing macnines. 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 Control*. CIFE, Kochi.
Chooksey MK. 2003.*Fish Processing and Product Development*. CIFE, Kochi.
Hall GM. 1997.*Fish Processing Technology*. Blabie Academic & Professional.
Lawrie RS. 1985.*Developments in Meat Sciences*. Vol. III. Applied Science Publ.
Mead GC. 1989. *Processing of Poultry*. Elsevier.
Pearson AM & Tauber FW. 1984. *Processed Meats*. AVI Publ.
Stadelman WJ & Cotterill OJ. 1980. *Egg Science and Technology*. AVI Publ.

PFE 510 FOOD PACKAGING 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, packaging-principles, practices, materials and hermetic packaging, seed treatment methods and machines used, method of stacking and theirimpact, 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

Journal of Texture Studies

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

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

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.

UNIT II

Rosette analysis, Train gauge circuits, Strain measurements at high temperatures. Two dimensional & three dimensional photo elastic method of strain analysis.

UNIT III

Bifringent coatings and scattered light in photo elasticity, Brittle coating methods, Moire method of strain analysis, Grid Method of strain analysis, Photoelastic strain 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 dampling. Forced vibration with damping, Vibration isolation and force and motion transmissibility.

UNIT II

Two degree of freedom systems. Principal modes of vibration, co-ordinate coupling. Vibration absorbers, Free vibration equation of motion for 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

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 urvey, 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: rticipation 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

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.

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