Department of Agricultural Process Engineering
Mahatma Phule Krishi Vidyapeeth
Rahuri-413 722, Dist. Ahmednagar (MS)

Master's Programme in Process and Food Engineering

Course Layout

Minimum Credit Requirements

Sr. No.	Subject	Minimum credit(s)
1	Major Courses	20
2	Minor Courses	09
3	Supporting Courses	05
4	Seminar	01
5	Research	20
	Total	**55**

Sr. No.	Course Number	Course Title	Credits
A) Major Subjects (Min. 20 Credits)			
1	PFE 501*	Transport Phenomena in Food Processing	3(2+1)
2	PFE 502*	Engineering Properties of Food Materials	3(2+1)
3	PFE 503*	Advanced Food Process Engineering	3(2+1)
4	PFE 504*	Unit Operations in Food Process Engineering	2(1+1)
5	PFE 506	Processing of Cereals	2(1+1)
6	PFE 508	Fruits and Vegetables Process Engineering	3(2+1)
7	PFE 511	Food Quality and Safety Engineering	3(2+1)
8	PFE 513	Storage Engineering and Handling of Agricultural Products	2(1+1)
9	PFE 519	Processing of Pulses and Oilseeds	2(1+1)
10	PFE 509	Meat Processing	3(2+1)
11	PFE 516	Design of Bins and Silos	2(2+0)
12	PFE 518	Food Plant Design and Layout	2(1+1)
13	PFE 592*	Special Problem	1(0+1)
14	PFE 595#	Industry/Institute Training	NC

B) Minor Subjects (Min. 9 Credits)			
1	PFE 507	Food Process and Material Handling Equipment Design	3(2+1)
2	PFE 510	Food Packaging	3(2+1)
3	PFE 512	Farm Structures and Environmental Control	2(2+0)
4	PFE 514	Seed Drying, Processing and Storage	3(2+1)
5	PFE 515	Biochemical and Process Engineering	3(2+1)
6	RES 506	Design and Analysis of Renewable Energy Conversion Systems	3(3+0)
7	RES 507	Agricultural Waste and By-Products Utilization	3(2+1)
8	RES 521	Energy Management in Food Processing Industries	3(1+2)
9	FMPE 510	Ergonomics and Safety in Farm Operations	3(2+1)
C) Supporting Courses (Min. 5 Credits)			
1	STAT 501	Statistical Methods	3(2+1)
2	MATH 502	Methods of Numerical Analysis	2(1+1)
3	FMPE 505	Instrumentation Stress Analysis	3(2+1)
4	AE 502	Simulation and Modeling	3(3+0)
5	FMPE 521	Computer Aided System Design	2(0+2)
6	PFE 520	Applied Food Chemistry	2(1+1)
7	PFE 521	Applied Food Microbiology	2(1+1)
D) Seminar (1 Credit)			
1	PFE 591	Masters Seminar	0+1
E) Master's Research (20 Credit)			
1	PFE 599	Masters Research	20 (0+20)
F) Non Credit Compulsory Courses			
1	PGS 501	Library and Information Services	0+1
2	PGS 502	Technical Writing and Communications Skills	0+1
3	PGS 503 (e-Course)	Intellectual Property and its Management in Agriculture	1+0
4	PGS 504	Basic Concepts in Laboratory Techniques	0+1
5	PGS 505 (e-Course)	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
6	PGS 506 (e-Course)	Disaster Management	1+0

* Compulsory

#Minimum of three weeks

Course Content

A) Major Subjects		
PFE 501	**Transport Phenomena in Food Processing**	**3 (2+1)**

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.
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 state conduction, Solving problems on unsteady state conduction; numerical analysis; Numerical on natural convection; Numerical on forced convection; Numerical on radiation heat transfer; Numerical on mass transfer; Experiments on heat conduction, convection and radiation heat transfer.

Suggested Books

1. Benjamin G. 1971. Heat Transfer. 2nd Ed. Tata McGraw Hill.
2. Coulson JM & Richardson JF. 1999. Chemical Engineering. Vol. II, IV. The Pergamon Press.
3. Earle RL. 1985. Unit Operations in Food Processing. Pergamon Press.
4. EcKert ERG & Draker McRobert 1975. Heat and Mass Transfer. McGraw Hill.
5. Geankoplis J Christie 1999. Transport Process and Unit Operations. Allyn & Bacon.
6. Holman JP. 1992. Heat Transfer. McGraw Hill.
7. Kreith Frank 1976. Principles of Heat Transfer. 3rd Ed. Harper & Row.
8. McCabe WL & Smith JC. 1999. Unit Operations of Chemical Engineering. McGraw Hill.
9. Treybal RE. 1981. Mass Transfer Operations. McGraw Hill.
10. Warren Gredt H. 1987. Principles of Engineering Heat Transfer. Affiliated East-West Press.

PFE 502	**Engineering Properties of Food Materials**	**3 (2+1)**

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 standards, 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 theory, 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 and hydrodynamics of agricultural products, drag coefficients, terminal velocity.
UNIT III
Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination. Electrical properties; Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high frequency electric field. Optical properties.

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 of food materials , surface area, bulk density, true density, porosity, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods. Determination of terminal velocity, lift and drag force for food grains, thermal conductivity, 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 Books

1. Mohesenin NN. 1980. Physical Properties of Plant and Animal Materials.Gordon & Breach Science Publ.
2. Mohesenin NN. 1980. Thermal Properties of Foods and AgriculturalMaterials. Gordon & Breach Science Publ.
3. Lewis M. J. 1987. Physical Properties of Foods and Food Processing Systems. VCH Publishers, Deerfield Beach, Florida .
4. Peleg M & Bagelay EB. 1983. Physical Properties of Foods. AVI Publ.
5. Rao MA & Rizvi SSH. (Eds.). 1986. Engineering Properties of Foods.Marcel Dekker.
6. Ronal Jowitt, Felix Escher, Bengt Hallsrram, Hans F, Th. Meffert, WalterEC Spices, Gilbert Vox. 1983. Physical Properties of Foods.Applied Science Publ.
7. Singhal OP & Samuel DVK. 2003. Engineering Properties of BiologicalMaterials. Saroj Prakasan.

PFE 503	**Advanced Food Process Engineering**	**3 (2+1)**

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: water activity, 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, cryogenic processing equipments, freeze drying, principle, equipments.
UNIT IV
Extrusion: Theory, equipments, applications. Distillation and leaching: Phase equilibria, multistage calculations, equipments, solvent extraction, high pressure technology

Practical
Numerical 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 Books

1. Brennan JG, Butters JR, Cowell ND & Lilly AEI. 1990. Food Engineering Operations. Elsevier.
2. Toledo R.T., 1991. Fundamentals of food process engineering (Second Edn.), Van Nostrant Reinhold, New York.
3. Coulson JM & Richardson JF. 1999. Chemical Engineering. VolS. II, IV. The Pergamon Press.
4. Earle RL. 1985. Unit Operations in Food Processing. Pergamon Press.
5. Fellows P. 1988. Food Processing Technology: Principle and Practice. VCH Publ.
6. Geankoplis J Christie. 1999. Transport Process and Unit Operations. Allyn & Bacon.
7. Henderson S & Perry SM. 1976. Agricultural Process Engineering. 5th Ed. AVI Publ.
8. McCabe WL & Smith JC. 1999. Unit Operations of Chemical Engineering. McGraw Hill.
9. Sahay KM & Singh KK. 1994. Unit Operation of Agricultural Processing. Vikas Publ. House.
10. Singh RP & Heldman DR. 1993. Introduction to Food Engineering. Academic Press.
11. Singh RP. 1991. Fundamentals of Food Process Engineering. AVI PubL.

PFE 504 Unit Operations in Food Process Engineering	**2 (1+1)**

Theory
UNIT I
Units and dimensions; Mass and energy balance. Methods of heat transfer, types of heat exchangers and their application in food processing.
UNIT II
Thermal processing operations; Evaporation, dehydration/drying, types of food dryers, blanching, pasteurization, distillation, steam requirements in food processing.
UNIT III
Psychrometry (review), Refrigeration principles and Food freezing. Mechanical separation techniques, size separation equipments; Filtration, sieving, centrifugation, sedimentation. Types material handling equipment, conveyors and elevators; Size reduction processes; Grinding and milling.
UNIT IV
Homogenization; Mixing- mixers, kneaders and blenders. Extrusion. Membrane technology. Non- thermal processing techniques.

Practical
Study of heat exchangers (numericals), Study of food dryers, Size reduction equipments, Cleaning and sorting equipments, Mixing equipments, Sieve analysis, Kinetics of liquid food dehydration

Suggested Books

1. Brennan JG, Butters JR, Cowell ND & Lilly AEI. 1990. Food Engineering Operations. Elsevier.
2. Earle RL. 1985. Unit Operations in Food Processing. Pergamon Press.
3. Fellows P. 1988. Food Processing Technology: Principle and Practice. VCH Publ.
4. McCabe WL & Smith JC. 1999. Unit Operations of Chemical Engineering. McGraw Hill.
5. Sahay KM & Singh KK. 1994. Unit Operation of Agricultural Processing. Vikas Publ. House.
6. Singh RP & Heldman DR. 1993. Introduction to Food Engineering. Academic Press.

PFE 506	Processing of Cereals	2 (1+1)

Theory
UNIT I
Production and utilization of cereals, grain structure of major cereals and their milling fractions; grain quality standards.
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, millets, pulses.
UNIT III
Packaging of processed products, design characteristics of milling equipments; selection, installation and their performance, BIS standards for various processed products. physico-chemical methods for evaluation of quality of processed products.

Practical
Raw and milled products quality evaluations; parboiling and drying; study of paddy, wheat, milling equipments; planning and layout of cereal, processing units, visit to related processing industry.

Suggested Readings

1. Chakraverty A. 1995. Post-harvest Technology of Cereals, Pulses and Oilseeds. Oxford & IBH.
2. Pandey PH. 1994. Principles of Agricultural Processing. Kalyani.
3. Sahay KM & Singh KK. 1994. Unit Operations in Agricultural Processing. Vikas Publ. House.
4. Morris Lieberman. 1983. Post-harvest Physiology and Crop Preservation. Plenum Press.
5. Pillaiyar P. 1988. Rice - Post Production Manual. Wiley Eastern.
6. Asiedu JJ.1990. Processing Tropical Crops. ELBS/MacMillan.

PFE 50	**Fruits and Vegetables Process Engineering**	**3 (2+1)**

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
Washing and cleaning, pack house, pre-cooling, preservation of fruits and vegetables: blanching, canning of fruits and vegetables, minimal processing of fruits and vegetables. Juice extraction and concentration.
UNIT III
Cold storage of fruits and vegetables, modified/ controlled atmosphere storage of fruits and vegetables, effect of storage on quality.
UNIT IV
Dehydration of fruits and vegetables, methods: osmotic dehydration, foam-mat drying, freeze drying, microwave heating, radiation and irradiation.
UNIT V
Intermediate moisture foods, importance of water activity in fruits and vegetables, sensory evaluation of fruit and vegetable products, packaging of fruits, vegetables and their products, general principles of quality standards and control, FPO, HACCP, food safety and 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 dehydration of fruits and vegetables, controlled atmosphere storage and quality evaluation.

Suggested Books

1. Cruesss WV. 2000. Commercial Fruit and Vegetable Products. Agrobios.
2. Mircea Enachesca Danthy. 1997. Fruit and Vegetable Processing. International Book Publ.
3. Srivastava RP & Sanjeev Kumar. 1994. Fruit and Vegetable Preservation. Principles and Practices. International Book Distr.
4. Sumanbhatti & Uma Varma. 1995. Fruit and Vegetable Processing. CBS.
5. Thompson AK. 1996. Post Harvest Technology of Fruits and Vegetables. Blackwell.
6. Vegetables. Vols. I-II. Indus Publ.
7. Verma LR & Joshi VK. 2000. Post Harvest Technology of Fruits and vegetables.

PFE 511	**Food Quality and Safety Engineering**	**3 (2+1)**

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 anddisinfesting 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,FSA-2006, ISO-22000, 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. Visits to food industries to study the various quality and safety aspects adopted.

Suggested Books

1. Chesworth N. 1997. Food Hygiene Auditing. Blackie Academic Professional, Chapman & Hall.
2. David A Shapton & Norah F Shapton. 1991. Principles and Practices for the Safe Processing of Foods. Butterworth-Heinemann.
3. Jacob M 2004. Safe Food Handling. CBS.
4. Jose M Concon. 1988. Food Toxicology, Part A. Principles and Concepts,Part B. Contaminants and Additives. Marcel Dekker.
5. Sara Mortimore & Carol Wallace. 1997. HACCP - A Practical Approach.l.

PFE 513 Storage Engineering and Handling of Agricultural Products	**2 (1+1)**

Theory
UNIT I
Food spoilage and preservation, Storage of grains, biochemical changes during storage, storage losses, storage requirements.
UNIT II
Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, Properties of stored products, function, Design of storage structures, Aeration system.
UNIT III
Cold storage, controlled and modified atmosphere storage, Effects of nitrogen, oxygen, and carbon dioxide on storage of durable and perishable commodities, Storage of dehydrated products, BIS standards.

UNIT IV
Physical factors influencing flow characteristics of grains, mechanics of bulk solids, flow through hoppers, openings and ducts; Types and selection of belt, chain, screw, roller, pneumatic conveyors and bucket elevators.

Practical
Quality evaluation of stored products. Design of storage structures, Pressure drop through grain beds. Design of aeration systems. Maintenance of storage structures. Study of controlled atmosphere storage system, Study of modified atmosphere storage system, Estimation of storage loss, and quality of stored products.

Suggested Books

1. FAO. 1984. Design and Operation of Cold Stores in Developing Countries.FAO.
2. Hall CW. 1970. Handling and Storage of Food Grains in Tropical and Sub-tropical Areas. FAO Publ. Oxford & IBH.
3. Henderson S & Perry SM. 1976. Agricultural Process Engineering. 5th Ed. AVI Publ.
4. McFarlane Ian. 1983. Automatic Control of Food Manufacturing Processes. Applied Science Publ.
5. Multon JL. (Ed). 1989. Preservation and Storage of Grains, Seeds andtheir By-products. CBS.
6. Ripp BE. 1984. Controlled Atmosphere and Fumigation in Grain Storage. Elsevier.
7. Shefelt RL & Prussi SE. 1992. Post Harvest Handling – A System Approach.Academic Press.
8. Shejbal J. (Ed). 1980. Controlled Atmosphere Storage of Grains. Elsevier.
9. Vijayaraghavan S. 1993. Grain Storage Engineering and Technology. BatraBook Service.

PFE 519 Processing of Pulses and Oilseeds 2 (1+1)
Theory
UNIT I
Production and utilization of pulses and oilseeds, grain structure of major pulses and oilseeds and their milling fractions; grain quality standards.
UNIT II
Processes of milling of pulses - Dal mills, handling and storage of by-products and their utilization. Assessment of processed product quality.

UNIT III
Processingof oilseeds 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. physico-chemical methods for evaluation of quality of processed products.

Practical
Study of pulses and oilseeds milling equipments; planning and layout of pulses and oilseed processing units, visit to related processing industry

Suggested Readings

1. Chakraverty A. 1995. Post-harvest Technology of Cereals, Pulses and Oilseeds. Oxford & IBH.
2. Pandey PH. 1994. Principles of Agricultural Processing. Kalyani.
3. Sahay KM & Singh KK. 1994. Unit Operations in Agricultural Processing. Vikas Publ. House.
4. Kent Cereal Technology .....
5. Morris Lieberman. 1983. Post-harvest Physiology and Crop Preservation. Plenum Press.
6. Pillaiyar P. 1988. Rice - Post Production Manual. Wiley Eastern.
7. Asiedu JJ.1990. Processing Tropical Crops. ELBS/MacMillan.

PFE 509	**Meat Processing**	**3 (2+1)**

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 products: different methods, stuffed products, frozen, products, poultry product concentrates.
UNIT IV
Different preservation methods of meat: Smoking, curing and freezing, chilling of meat and its' methods, freezing of meat and different methods of freezing of meat, physical and chemical changes during chilling and freezing, packaging of meat, meat products and it's 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 slaughter house, meat and fish processing units.

Suggested Books

1. Chooksey MK & Basu S. 2003. Practical Manual on Fish Processing and Quality Control. CIFE, Kochi.
2. Chooksey MK. 2003. Fish Processing and Product Development. CIFE, Kochi.
3. Hall GM. 1997. Fish Processing Technology. Blabie Academic & Professional.
4. Lawrie RS. 1985. Developments in Meat Sciences. Vol. III. Applied Science Publ.
5. Mead GC. 1989. Processing of Poultry. Elsevier.
6. Pearson AM & Tauber FW. 1984. Processed Meats. AVI Publ.
7. Stadelman WJ & Cotterill OJ. 1980. Egg Science and Technology. AVI Publ.

PFE 516	Design of Bins and Silos	2 (2+0)

Theory
UNIT I
Rankine's and Coulomb's theories of active and passive pressures. Janssen's and Airy's grain pressure theories for design of deep and Sallow silos. Reimbert's theory of silo design.
UNIT II
Types and classification of silos. Flow behaviour of grains through small openings. Flow through hoppers, openings and ducts.
UNIT III
Cad for silos and bins. Selection of Aeration and ventilation systems. Codes and standards.

Suggested Books

1. Reimbert, M. and Reimbert, A. 1980. Design of Bins.
2. BS-5061. 1974. Specifiactions for cylindrical storage tower silos and recommendations for their use. BIS relevant standards.
3. Rajgopalan, K. 1989. Storage Structures. Oxford & IBH.
4. Multon JL. (Ed). 1989. Preservation and Storage of Grains, Seeds and their By-products. CBS.
5. Ripp BE. 1984. Controlled Atmosphere and Fumigation in Grain Storage.Elsevier.
6. Shejbal J. (Ed). 1980. Controlled Atmosphere Storage of Grains. Elsevier.
7. Vijayaraghavan S. 1993. Grain Storage Engineering and Technology. BatraBook Service.

PFE 518	**Food Plant Design and Layout**	**2 (1+1)**

Theory
UNIT I
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 II
Feasibility analysis and preparation of feasibility report: plant size, factors affecting plant size and their interactions, estimation of break-even and 37 economic plant size; Product and process design, process selection, process flow charts, computer aided development of flow charts.
UNIT III
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
Each individual student will be asked to select a food processing plant system and develop a plant design report which shall include product identification and selection, site selection, estimation of plant size, process and equipment selection, process flow-sheeting, plant layout, and its evaluation and profitability analysis.

Suggested Readings

1. Ahmed T. 1997. Dairy Plant Engineering and Management. 4th Ed. Kitab Mahal.
2. Johnson AJ. 1986. Process Control Instrumentation Technology. 2nd Ed. Wiley International & ELBS.
3. Rao T. 1986. Optimization: Theory and Applications. 2nd Ed. Wiley Eastern.
4. Richey CB. (Ed.). 1961. Agricultural Engineers' Hand Book. McGraw Hill.
5. Romeo T Toledo. 1997. Fundamentals of Food Process Engineering. CBS.
6. Slade FH. 1967. Food Processing Plant. Vol. I. Leonard Hill Books.

PFE 592	Special Problem	1 (0+1)

PFE 595	Industrial / Institute Training	NC
Minimum three weeks training in Food Processing Industry or Institute.		

B) Minor Subjects

PFE 507	Food Process and Material Handling Equipment Design	3 (2+1)

Theory
UNIT I
Design considerations of processing agricultural and food products.
UNIT II
Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation.
UNIT III
Human factors in design, selection of materials of construction and standard component, design standards and testing standards.

Practical
Detailed design and drawing of mechanical dryers, milling equipment, separators, evaporators, mixers.

Suggested Books

1. Ahmed T. 1997. Dairy Plant Engineering and Management. 4th Ed. Kitab Mahal.
2. Chakraverty A & De DS. 1981. Post-harvest Technology of Cereals, Pulses and Oilseeds. Oxford & IBH.New Delhi

3. Gary Krutz, Lester Thompson & Paul Clear. 1984. Design of Agricultural Machinery. John Wiley & Sons.
4. Hall CW & Davis DC. 1979. Processing Equipment for Agricultural Products. AVI Publ.
5. Henderson S & Perry SM. 1976. Agricultural Process Engineering. 5th Ed. AVI Publ.
6. Johnson AJ. 1986. Process Control Instrumentation Technology. 2nd Ed. Wiley International & ELBS.
7. Rao T. 1986. Optimization: Theory and Applications. 2nd Ed. Wiley Eastern.
8. Richey CB. (Ed.). 1961. Agricultural Engineers' Hand Book. McGraw Hill.
9. Romeo T Toledo. 1997. Fundamentals of Food Process Engineering. CBS.
10. Slade FH. 1967. Food Processing Plant. Vol. I. Leonard Hill Books.

PFE 510	**Food Packaging**	**3 (2+1)**

Theory
UNIT I
Introduction of packaging. Deteriorative changes in foodstuff and packaging methods of prevention.
UNIT II
Food containers: Rigid containers, glass, wooden boxes, crates, corrugated and fibre board boxes, textile , corrosion of containers (tin plate); Flexible packaging materials and their properties; Aluminium as packaging material.
UNIT III
Packaging equipments: Food packages, bags, types of pouches, wrappers, carton package; Retortable pouches; Shelf life of packaged foodstuff.
UNIT IV
Methods to extend shelf life; Packaging of perishables (fruits and vegetables) and processed foods(Dairy products confectionary and snack foods.
UNIT V
Package standards and regulation; Shrink packaging; Aseptic packaging, CA and MAP, Active packaging; Biodegradable packaging.

UNIT VI
Packaging requirement of RTE and RTS foods. Intelligent and smart packaging with plastics, stretch wrapping, micro ovenable packages. Plastic for food packaging; national and international standards.

Practical
Packaging of fruits/vegetables; Estimation of shelf-life of packaged food stuff; Familiarization of types of packaging material

Suggested Books:

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

PFE 512 Farm Structures and Environmental Control 2 (2+0)

Theory
UNIT I
Farm structures, their design , constructional details. Heating, ventilating and exhaust systems, air distribution and air cleaning.
UNIT II
Thermodynamic properties of moist air, psychorometric chart. Humidification and dehumidification system, air-water contact operations and evaporation, Process and product air conditioning, energy efficient environmental control practices.
UNIT III
Instruments and measurements; Codes and Standards.

Suggested Books

1. Albright LD. 1990. Environmental Control for Animals and Plants. ASAE Textbooks.
2. Esmay ML & Dixon JE. 1986. Environmental Control for Agricultural Buildings. The AVI Corp.
3. Gaudy AF & Gaudy ET. 1988. Elements of Bioenvironmental Engineering. Engineering Press.
4. Moore FF. 1994. Environmental Control Systems: Heating, Cooling, Lighting. Chapman & Hall.
5. Threlkeld JL. 1970. Thermal Environmental Engineering. Prentice Hall.

PFE 514	**Seed Drying, Processing and Storage**	**3 (2+1)**

Theory
UNIT I
Principles and importance of seed processing.
UNIT II
Precleaning, grading, conveying, elevating, drying, treating, blending, packaging and storage, seed processing machines like scalper, debreader, draper belt, velvet roll separator, spiral separator, cleaner-cum-grader, specific gravity separator, indent cylinder, disc separator, and colour sorter, seed treaters : dry powder, slurry, most-o-matic, Automatic weighing and bagging machines, their operation and maintenance, installation and determination of their capacity, plant design and layout.
UNIT III
Seed drying principles and methods, theory of seed drying, introduction todifferent 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 seedstores, 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
Performance study of pre-cleaners, air screen cleaners, graders : specific gravity separator and indented cylinder separator, seed treating equipment, automatic weighing and bagging and sealing machine study. design and layout of seed processing plant, cost economics of seed processing plant. Study of dehumidified storage, AC/ LT storage, cry-o-storage

Suggested Books

1. Agarwal R. L. Seed Technology
2. Gregg et al. 1970. Seed Processing. NSC.
3. Justic and Bass. Principles and practices of seed processing and storage.
4. Sahay KM & Singh KK. 1994. Unit Operation of Agricultural Processing. Vikas Publ. House.
5. Seed Processing, NSC Publication.

PFE 515	**Biochemical and Process Engineering**	**3 (2+1)**

Theory
UNIT I
Introduction of Bio-processing of Foods; 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.

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 Books

1. Aartz R. et al.(1993). Bioprocess design and control. Springer-verlag.
2. Brennan JG, Butters JR, Cavell ND & Lilly AEI. 1990. Food EngineeringOperations. Elsevier.
3. Coulson JM & Richadson JF. 1999. Chemical Engineering. Vols. II, IV.The Pergamon Press.
4. Greanoplis J Christie. 1999. Transport Process and Unit Operation. Allyn& Bacon.
5. Moses, A. (1988). Bioprocess technology: Kinetic& reactor. Springer-verlag.
6. Shules, M. and Karg, K. (1992). Bioprocess engineering : Basic concepts. Prentice Hall.

RES 506 Design and Analysis of Renewable Energy Conversion Systems 3 (3+0)

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

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 3) Beckman WA. 1991. Solar Engineering of Thermal Processes. John Wiley.
3. Garg HP & Prakash J.1997. Solar Energy - Fundamental and Application. Tata McGraw Hill.
4. Grewal NS, Ahluwalia S, Singh S & Singh G. 1997. Hand Book of Biogas Technology. Solar Energy Fundamentals and Applications. TMH New Delhi.
5. Mittal KM. 1985. Biomass Systems: Principles & Applications. New Age International.

RES 507 Agricultural Waste and By-Product Utilization 3 (2+1)

Theory
UNIT I
Status of By-products and agricultural wastes, their sources and availability; properties, characteristics and pollution potential, collection handling and storage.
UNIT II
Modes of utilization as a fuel, alcohol production, pulp and paper, particle and other boards, cattle and poultry feed. briquetting process, equipments, factor affecting briquetting.
UNIT III
Utilization of wastes by products of different agro-industries (rice milling, sugarcane, coconut, cashewnut, orange, banana, dhall mill waste).
UNIT IV
Thermo-chemical conversions, densification, combustion biological conversions, anaerobic digestion, biochemicaldigestion 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 Books

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 Technologiesfor 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 andUtilization. Jain Bros.
8. USDA 1992. Agricultural Waste Management Field Handbook. USDA.
9. Wilfred A Cote.1983. Biomass Utilization. Plenum Press.

RSE 521 Energy Management in Food Processing Industries 2 (1+2)
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, 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, Agro-processing food industries etc. Energy audit study and management strategies in food processing plants. Identification of energy efficient

processing machines. Measurement and assessment of overall energy consumption, production and its cost in food processing plants, visit to related food processing industry.

Suggested Books

1. Pimental D. 1980. Handbook of Energy Utilization in Agriculture. CRC Press.
2. Rai GD. 1998. Non-conventional Sources of Energy. Khanna Publ.
3. Twindal JW & Anthony D Wier 1986. Renewable Energy Sources. E & F. N. Spon Ltd.
4. Verma SR, Mittal JP & Surendra Singh. 1994. Energy Management and Conservation in Agricultural Production and Food Processing. USG Publ. & Distr., Ludhiana.

FMPE 510 Ergonomics and Safety in Farm Operation 3 (2+1)
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

1. Bridger RS. 1995. Introduction to Ergonomics. McGraw Hill.
2. Charles D Reese. 2001. Accident / Incident Prevention Techniques. Taylor & Francis.
3. Gavriel Salvendy. 1997. Hand Book of Human Factors and Ergonomics. John Wiley & Sons.
4. Kromer KHE. 2001. Ergonomics. Prentice Hall.
5. Mathews J & Knight AA.1971. Ergonomics in Agricultural Design. National Institute of Agric. Engineering, Wrest Park Silsoe, Bedford.
6. Mathews J Sanders, Cormicks MS & MCEj. 1976. Human Factors in Engineering and Design. 4th Ed. McGraw Hill.
7. William D McArdle. 1991. Exercise Physiology.1991. Lea & Febiger.
8. Zander J. 1972. Principles of Ergonomics. Elsevier.
9. Zander J.1972. Ergonomics in Machine Design. Elsevier.

C) Supporting Subjects

STAT 511	**Statistical Methods for Applied Science**	**3 (2+1)**

Theory
UNIT I
Measures of central tendency and dispersion Theory of probability: classical, empirical, axiomatic probability, random variable and mathematical expectation
UNIT II
Discrete and Continuous probability distribution: Binomial, Poisson, Normal, and their application. Concept of sampling distribution: Chi-square, t, and F distribution. Test of significance based on Normal, Chi-square, t and F distribution. Large sample theory (Z-test).
UNIT III
Correlation and regression: Simple and multiple linear regression models, Stepwise regression, Estimation of parameters, Correlation, Partial and multiple correlations. Rank correlation, Path analysis, Test of significance of correlation coefficients and regression coefficients, coefficient of multiple determinations. Polynomial regression model and their fitting, Estimation of parameters.
UNIT IV
Non-parametric tests: sign, Mann-Whitney U test, Run test, Median test.

Practical
Calculation of mean, median, mode, variance and standard deviation etc. Fitting of Binomial, Poisson and Normal distributions, Large sample test, t, F and Chi-square test, Correlation, Partial and multiple correlation, Rank correlation and linear, multiple and non-linear regression, Path analysis, Non- parametric tests.

Suggested Books

Snedecor G.W. & W.G. Cochran, (1967) Statistical Methods Sixth Edition, Oxford & IBH Publishing Company, Bombay, W.

Anderson TW 1984. An Introduction to Multivariate Statistical Analysis. 2nd Ed.

John Wiley.

Ostle B , (1967) Statistics in Research Oxford & IBH Publishing Company, Bombay,

Robert G. D. Steel and James H. Torrie (1971). Principles and Procedures of Statistics. Biometrical Approach, McGraw Hill International Book Company, New York

Gupta S. C, V.K. Kapoor (1991). Fundamental of mathematical statistics, Sultan

MATH 502	**Methods of Numerical Analysis**	**2 (1+1)**

Theory
UNIT-I
Numerical methods for systems of linear equations, eigen values, interpolation, differentiation.
UNIT-II
Least squares. 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 Books

1. Scarborough, G.(2000). Numerical Mathematical analysis. Oxford & IBH Pub.Co. Pvt.Ltd.
2. Chapra, C.(2000). Numerical Methods for Engineers. Tata McGraw-Hill, New Delhi.
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.

FMPE 505 Instrumentation and Stress Analysis 3 (2+1)

Theory
UNIT I
Strain and stress, strain relationship, strain gauges. Mechanical, optical, electrical acoustical and pneumatic etc. and their use. Various methods of determining srain/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 pickups, Speed measurement using optical devices, vibration measurement exercises , making of thermocouples and their testing- Basic electronic circuits and application of linear ICs.

Suggested readings

1. Ambrosius EE. 1966. Mechanical Measurement and Instruments. The Ronald Press.
2. BeckwithTG. 1996. Mechanical Measurements. Addison-Wesley.
3. Doeblin EO. 1966. Measurement System - Application and Design. McGraw Hill.
4. Ernest O Doebelin.1995. Measurement Systems - Application and Design. McGraw Hill.
5. Holman P 1996. Experimental Methods for Engineers. McGraw Hill.
6. Nachtigal CL. 1990. Instrumentation and Control. Fundamentals and Application. John Wiley & Sons.
7. Oliver FJ. 1971. Practical; Instrumentation Transducers. Hayden Book Co.
8. Perry CC & Lissner HR.1962. The Strain Gauge Primer. McGraw Hill.

AE 502	**Simulation and Modeling**	**3 (3+0)**

Theory
UNIT-I
Concept, advantages and limitations 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 Raleigh's methods, Buckingham's p theorem method and some other methods.
UNIT-II
Models - features of models, model types, theory of models, model laws, scales; true models; distorted models, different types of distortion in structural models; study of liquid flow models. Dissimilar models - analogies between two dissimilar systems.
UNIT-III
Curve fitting. Method of least squares, estimation of coefficients of simple determination and simple correlation, Properties of least square residuals. Computer simulation of agricultural engineering systems.

Suggested Books

1. Langhaar, H.L. (1951). Dimensional Analysis and Theory of Models. John Willey andSons.
2. Murphy, J. (1950). Similitude in Engineering. The Roland Press Company, New York.
3. Singh, R.P. (2000). Computer Application in Food Technology. Academic Press.
4. Simpson, O.J. (2000). Basic Statistics. Oxford & IBH Publishing Co. Pvt. Ltd.
5. Wilks, S. S. (1962). Mathematical Statistics. John Wiley and Sons, New York.

FMPE 521	Computer Aided System Design	2 (0+2)

Practical
Introduction to computer aided design, Geometric modeling and interactive graphics, Computer aided analysis and synthesis of common mechanical components. Application of numerical methods and optimal techniques to machine design problems. Computer aided selection of standard mechanical components. Introduction to FEM.
Preparation of engineering drawings of machine / implement components, design of plough share / furrow openers / plough discs, and other components of farm machinery, preparation of bill of material and costing.

Suggested Books

1. Rammmurty, T. 2001. Computer Aided Mechanical Design and Analysis. Tata McGraw Hill, New Delhi.
2. Mukhopadhyay, M. 2000. Matrix, Finite Element, Computer and Structural analysis, Oxford & IBH Publishing Co. Pvt Ltd.
3. Krishnamooorty, G. 2001. Finite Element Analysis. Theory and Programming. Tata McGraw Hill, New Delhi.
4. Knudra, C.V. 2000. Numerical Control and Computer Aided Manufacturing. Tata McGraw Hill, New Delhi.
5. Zeid, K. 2000. CAD/CAM Theory and Pratice. Tata McGraw Hill, New Delhi.

PFE 520	Applied Food Chemistry	2 (1+1)

Theory
Nature of Food Chemistry, water in food, water activity and shelf life of food. Carbohydrates : chemical reactions, functional properties of sugars and polysaccharides in foods. Lipids : classification, role and use of lipids in foods , physical and chemical properties , effects of processing on functional properties and nutritive value. Protein and amino acids: physical and chemical properties, distribution, amount and functions of proteins in foods , functional properties , effect of processing. Losses of vitamins and minerals due to post harvest processing.

Practical
Determination of proteins, carbohydrates, sugars, amino acids , crude fibre, total minerals , crude fat and water in foods**.**

Suggested Books

1. Potter ,N.N. and Joseph,H.Hotchkiss . 1996. Food Science. CBS Publishers and distributers, New Delhi.
2. Swaminathan.M. 1999. Food Science, Chemistry and experimental foods. The Bangalore Printing and Publishing Co.Ltd., Bangalore – 560 018
3. Srilakshmi,B. 2001. Food Science. New Age International Publishers, Chennai.
4. Belitz.W.Grosch. 1986. Food chemistry. Springer Verley Berlin Heidelberg, New York
5. David S.Robinson. 1987. Food biochemistry and Nutritive Value. Longman Group, U.K.
6. Leslie Hat, F and Harry Johnstone Fisher. 1971. Modern Food Analysis. Spinger – Cerlag, New York.
7. Sadasivam,S and A.Manickam. 1996. Biochemical methods for Agricultural Sciences. New Age International Publishers.

PFE 521	**Applied Food Microbiology**	**2 (1+1)**

Theory
History of micro organism in food. Bacterial taxonomy, Primary sources of micro organisms found in foods. Food borne bacteria, molds and yeasts. Food parameters responsible for microbial growth. Incidence and types of microorganisms in foods. Food poisoning. Microbial toxins. Mycotoxins – aflatoxins, alternaria toxins, and Citrinin. Methods of Determination of micro organisms and their in products in foods – culture, microscopic, physical and chemical Microbial spoilage of fruits and vegetables, processed food, meats, poultry and sea foods. Microbial indicators of food safety and quality. HACCP - system, principles, flow diagram, limitations of HACCP. Microbial standards for foods .
Practical
Count of mould, yeasts and bacteria in food. Determination of micro organisms in food by standard plate counts (SPC) for viable cells. Determination of micro organisms in food by direct microscopic counts (DMC) for both viable and non viable cells. Microbial codes and standards for food.

Suggested Books

1. James M. Jay. 2005. Modern Food Microbiology. CBS Publishers and Distributors, 4596/1A, 11 Darya Ganj, New Delhi – 110 002.
2. Frazier W.C. 1987 Food Microbiology. McGraw Hill Publisher.

D) Seminar

PFE 591	**Master's Seminar**	**1 (0+1)**

E) Masters' Research

PFE 599	**Master's Research**

F) Non Credit Compulsory Courses

PGS 501	**Library and Information Services**	**1 (0+1)**

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; eresources access methods.

PGS 502	**Technical Writing and Communications Skills**	**1 (0+1)**

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 Books

1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
2. Collins' Cobuild English Dictionary. 1995. Harper Collins.
3. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed. Holt, Rinehart & Winston.
4. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
5. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
6. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
7. Mohan K. 2005. Speaking English Effectively. MacMillan India.
8. Richard WS. 1969. Technical Writing. Barnes & Noble.
9. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language. Abhishek.
10. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS 503	**Intellectual Property and its Management in Agriculture**	**1 (1+0)**
	(e-Course)	

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 biodiversity 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 Books

1. Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
7. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000;
8. Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout
9. Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504	**Basic Concepts in Laboratory Techniques**	**1 (0+1)**

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 Books

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

PGS 505	**Agricultural Research, Research Ethics and Rural Development**	**1 (1+0)**
	Programmes (e-Course)	

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 Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Books

1. Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

PGS 506	**Disaster Management**	**(e-Course)**	**1 (1+0)**

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 Books

1. Gupta HK. 2003. Disaster Management. Indian National Science Academy. Orient Blackswan.
2. Hodgkinson PE & Stewart M. 1991. Coping with Catastrophe: A Handbook of Disaster Management. Routledge.
3. Sharma VK. 2001. Disaster Management. National Centre for Disaster Management, India.