



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



Doctoral Programme in Process and Food Engineering

Course Layout

Minimum Credit Requirements

Sr. No.	Subject	Minimum credit(s)
1	Major Courses	15
2	Minor Courses	08
3	Supporting Courses	05
4	Seminar	02
5	Research	45
	Total	75

Sr. No.	Course Number	Course Title	Credits
A) Major Subjects (Min. 15 Credits)			
1	PFE 601*	Textural & Rheological Characteristics Of Food Materials	3(2+1)
2	PFE 602 *	Advances in Food Processing	3(3+0)
3	PFE 603	Mathematical Models in Food Processing	2(2+0)
4	PFE 604	Advances in Drying of Food Materials	3(2+1)
5	PFE 605	Waste and By –Products Utilization	3(2+1)
6	PFE 606	Food Quality Systems & Management	3(2+1)
7	PFE 607	Nutraceuticals and Health Foods	3(2+1)
8	PFE 608	Enzymes in Food Processing	3(2+1)
9	PFE 609	Plant Utilities and Plant Safety	3(2+1)
10	PFE 615	Food Supply Chain Management	2(1+1)

11	PFE 693*	Special Problem	1(0+1)
12	PFE 694	Case Study	1(0+1)
B) Minor Subjects (Min. 8 Credits)			
1	PFE 610	Techniques in Food Analysis	3(1+2)
2	PFE 611	Bakery and Confectionary Technology	3(2+1)
3	PFE 612	Sensory Evaluation	2(1+1)
4	PFE 613	Automation in Food Processing	3(2+1)
5	PFE 614	Cold Chain Management	2(2+0)
6	PFE 617	Industrial Pollution And Control	3(2+1)
7	PFE 618	Solid-Fluid Operations	2(1+1)
8	RES 605	Fuels and Combustion	3(2+1)
9	RES 623	Energy Management & Planning	3(2+1)
C) Supporting Courses (Min. 5 Credits)			
1	PFE 620	Computer Applications in Food Industry	3(1+2)
2	PFE 621	Current Topics in Food Processing	2(2+0)
3	STAT 531	Data Analysis using Statistical Packages	3(2+1)
4	STAT 609	Operations Research	3(2+1)
5	STAT 612	Regression Analysis	3(2+1)
D) Seminar (02 credits)			
1.	PFE 691	Doctoral Seminar I	1(0+1)
2.	PFE 692	Doctoral Seminar II	1(0+1)
E) Doctoral Studies Research (45 Credits)			
1	PFE 699	Doctoral Research	45
F) Non Credit Compulsory Courses			
1	PGS 501	Library And Information Services	1(0+1)
2	PGS 502	Technical Writing and Communications Skills	1(0+1)
3	PGS 503 (e-Course)	Intellectual Property and Its Management In Agriculture	1(1+0)
4	PGS 504	Basic Concepts in Laboratory Techniques	1(0+1)
5	PGS 505 (e-Course)	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)
6	PGS 506 (e-Course)	Disaster Management	1(1+0)

* Compulsory

#Minimum of three weeks

Course Content

A) Major Subjects

PFE 601*	Textural & Rheological Characteristics of Food Materials	3 (2+1)
-----------------	---	----------------

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 Books

1. Bourne MC. 2002. Food Texture and Viscosity: Concept and Measurement. Academic Press
2. Deman JM. et al. 1976. Rheology and Texture in Food Quality. AVI Publ.
3. Journal of Food Science and Technology
4. Journal of Texture Studies
5. Mohsanin NN.1989. Physical Properties of Plant and Animal Material. Vol. I, II. Gordon and Breach Science Publ.
6. Steffe JF. 1992. Rheology and Texture in Food Quality. AVI Publ.

PFE 602*	Advances in Food Processing	3 (3+0)
-----------------	------------------------------------	----------------

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 Books

1. Heldman R Dennis and Lund B Daryl. 1992. Hand Book of Food Engineering. Marcel Dekker.
2. Goldblith SA, Rey I & Rothmayr WW. 1975. Freeze Drying and Advanced Food Technology. Academic Press.
3. Gould GW (Ed.).1996. New Methods of Food Preservation. Blackie Academic & Professional.
4. Leniger HA & Beverloo WA. 1975. Food Process Engineering. D. Reidel Publishing Co.
5. Rao MA & Rizvi SSH.. 1986. Engineering Properties of Foods. Marcel Dekker.
6. Ronald Jowitt. 1984. Extrusion Cooking Technology. Elsevier.

PFE 603	Mathematical Models in Food Processing	2 (2+0)
----------------	---	----------------

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 modeling 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 modeling food processing operations.

Suggested Books

1. Bailey NTJ, Sendov B & Tsanev R. 1974. Mathematical Models in Biology and Medicine. Elsevier.
2. Fischer M, Scholten HJ & Unwin D. 1996. Spatial Analytical Perspectives on GIS. Taylor & Francis.
3. Fish NM & Fox RI. 1989. Computer Application in Fermentation Technology: Modelling and Control of Biotechnological Processes. Elsevier.
4. Getz WM. 1979. Mathematical Modeling in Biology Processes. Elsevier.
5. Gold HJ. 1977. Mathematical Modelling of Biological Systems – An Introductory Guidebook. John Wiley & Sons.
6. Hunt DR. 1986. Engineering Models for Agricultural Production. The AVI Publ.
7. Kapur JN. 1989. Mathematical Modeling. Wiley Eastern.
8. Koeing HE, Tokad Y, Kesacan HK & Hedgers HG. 1967. Analysis of Discrete Physical Systems. Mc Graw Hill.
9. Meyer JW. 2004. Concepts of Mathematical Modeling. Mc Graw Hill.
10. Peart RM & Curry RB. 1998. Agricultural Systems, Modelling and Simulation. Marcel Dekker.
11. Tijms HC. 1984. Modelling & Analysis. A Congrtational Approach. Wiley Publ.
12. Ver Planck & Teare BR 1954. General Engineering Analysis – An Introduction to Professional Methods. John Wiley & Sons.

Theory**UNIT I**

Importance of drying, principles of drying, moisture determination, equilibrium moisture content, determination of EMC, methods and isotherm models, psychometric, psychometric terms, use of psychometric 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 Books

1. Bala BK. 1998. Drying and Storage of Cereal Grains. Oxford & IBH.
2. Brooker DB, Bakker Arkema FW & Hall CW. 1974. Drying Cereal Grains. The AVI Publ.
3. Chakraverty A & De DS. 1999. Post-harvest Technology of Cereals, Pulses and Oilseeds. Oxford & IBH.
4. Hall CW. 1970. Drying of Farm Crops. Lyall Book Depot.
5. Tadsenz Kudra & Majumdar AS. 2002. Advanced Drying Technologies. Marcel Dekker.
6. Wallace B Van Arsdel & Michael J Copley. 1963. Food Dehydration. AVI Publ.

PFE 605	Waste and By-Products Utilization	3 (2+1)
----------------	--	----------------

Theory
UNIT I
Generation of by-products, agricultural and agro industrial byproducts/ wastes, properties, on site handling, storage and processing.
UNIT II
Collection of wastes, utilization pattern as fuel, agricultural waste fired furnaces: Mechanism, construction and efficiency, suitability of wastes as fuel, fuel briquettes, briquetting process, equipment, factors affecting briquetting.
UNIT III
Utilization of wastes for paper production, production of particle board, utilization, by-products from rice mill, rice husk, rice bran, utilization.
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 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 Technologies for Utilisation of Biomass/ Agricultural Wastes. Oxford & IBH.
5. David C Wilson. 1981. Waste Management - Planning, Evaluation, Technologies. Oxford.
6. Donald L Klass & Emert H George 1981. Fuels from Biomass and Wastes. Ann. Arbor. Science Publ.
7. Srivastava P K, Maheswari R C & Ohja T P. 1995. Biomass Briquetting and Utilization. Jain Bros.
8. USDA 1992. Agricultural Waste Management Field Handbook. USDA. Wilfred A Cote.1983. Biomass Utilization. Plenum Press.

PFE 606	Food Quality Systems & Management	2 (1+1)
----------------	--	----------------

Theory
UNIT I
Concept of quality: Quality attributes- physical, chemical, nutritional, microbial, and sensory; their measurement and evaluation; Sensory vis-à-vis instrumental methods for testing quality.
UNIT II
Concepts of quality management: Objectives, importance and functions of quality control; Quality management systems in India; Sampling procedures and plans; Food Safety and Standards Act, 2006; Domestic regulations; Global Food safety Initiative; Various organizations dealing with inspection, traceability and authentication, certification and quality assurance (PFA, FPO, MMPO, MPO, AGMARK, BIS); Labeling issues; International scenario, International food standards.
UNIT III
Quality assurance, Total Quality Management; GMP/GHP; GLP, GAP; Sanitary and hygienic practices; HACCP; Quality manuals, documentation and audits; Indian & International quality systems and standards like ISO and Food Codex; Export import policy, export documentation; Laboratory quality procedures and assessment of laboratory performance; Applications in different food industries; Food adulteration and food safety. IPR and Patent.
Practical
Testing and evaluation of quality attributes of raw and processed foods; Detection and estimation of food additives and adulterants; Quality assurance procedure, GMP, GAP documentation; Preparation of quality policy & documentation, Application of HACCP to products, Preparation of HACCP chart; Preparation of documentation & records, Visit to Units with ISO systems; Visit to Units with HACCP certification; Visit to Units implementing GMP, GAP; Mini-project on preparation of a model laboratory manual.

Suggested Books

1. Amerine MA, Pangborn RM & Rosslos EB. 1965. Principles of Sensory Evaluation of Food. Academic Press.
2. Early R. 1995. Guide to Quality Management Systems for Food Industries. Blackie Academic.
3. Furia TE. 1980. Regulatory status of Direct Food Additives. CRC Press.
4. Jellinek G. 1985. Sensory Evaluation of Food - Theory and Practice. Ellis Horwood.
5. Krammer A & Twigg BA. 1973. Quality Control in Food Industry. Vol. I, II. AVI Publ.
6. Macrae R, Roloson R & Sadlu MJ. 1994. Encyclopedia of Food Science & Technology & Nutrition. Vol. XVI. Academic Press.
7. Piggot J.R. 1984. Sensory Evaluation of Foods. Elbview Applied Science.
8. Ranganna S. 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill.

PFE 607	Nutraceuticals and Health Foods	3 (2+1)
----------------	--	----------------

Theory
UNIT I
Introduction to nutraceuticals: definitions, synonymous terms, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals including CODEX.
UNIT II
Concept of angiogenesis and the role of nutraceuticals/functional foods; Nutraceuticals for cardiovascular diseases, cancer, diabetes, cholesterol management, obesity, joint pain, immune enhancement, age-related macular degeneration, endurance performance and mood disorders – compounds and their mechanisms of action, dosage levels, contraindications if any etc.
UNIT III
Manufacturing aspects of selected nutraceuticals such as lycopene, isoflavonoids, prebiotics and probiotics, glucosamine, phytosterols etc.; formulation of functional foods containing nutraceuticals – stability and analytical issues, labelling issues.
UNIT IV
Clinical testing of nutraceuticals and health foods; interactions of prescription drugs and nutraceuticals; adverse effects and toxicity of nutraceuticals; nutrigenomics – an introduction and its relation to nutraceuticals.
Practical
Market survey of existing health foods; identification and estimation of selected nutraceuticals; production and quality evaluation of foods containing nutraceuticals; development of labels for health foods; visit to relevant processing Units.

Suggested Readings

1. Brigelius-Flohé, J & Joost HG. 2006. Nutritional Genomics: Impact on Health and Disease. Wiley VCH.
2. Cupp J & Tracy TS. 2003. Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press.
3. Gibson GR & William CM. 2000. Functional Foods - Concept to Product .
4. Goldberg I. 1994. Functional Foods: Designer Foods, Pharma Foods.
5. Losso JN. 2007. Anti-angiogenic Functional and Medicinal Foods. CRC Press.
6. Manson P. 2001. Dietary Supplements. 2nd Ed. Pharmaceutical Press.
7. Campbell JE & Summers JL. 2004. Dietary Supplement Labeling Compliance.
8. Neeser JR & German BJ. 2004. Bioprocesses and Biotechnology for Nutraceuticals. Chapman & Hall.
9. Robert EC. 2006. Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman.
10. Shi J. (Ed.). 2006. Functional Food Ingredients and Nutraceuticals: Processing Technologies. CRC Press.
11. Webb GP. 2006. Dietary Supplements and Functional Foods. Blackwell Publ.

PFE 608	Enzymes in Food Processing	3 (2+1)
----------------	-----------------------------------	----------------

Theory
UNIT I
Enzymes– classification, properties, characterization, kinetics and immobilization; fermentative production of enzymes (amylases, proteases, cellulases, pectinases, xylanases, lipases) used in food industry and their downstream processing.
UNIT II
Enzymes for production of protein hydrolysates and bioactive peptides, maltodextrins and corn syrup solids (liquefaction, saccharification, dextrinization, isomerization for production of high-fructose-corn-syrup), fructose and fructo-oligosaccharides.
UNIT III
Enzymes as processing aids: Role of enzymes in cheese making and whey processing; fruit juices (cell wall degrading enzymes for liquefaction, clarification, peeling, debittering, decolourization of very dark coloured juices such as anthocyanases); baking (fungal α -amylase for bread making; maltogenic α -amylases for anti-staling; xylanases and pentosanases as dough conditioners; lipases or dough conditioning; oxidases as replacers of chemical oxidants; synergistic effect of enzymes); meat and meat processing (meat tenderization); egg processing.
UNIT IV
Enzyme processing for flavours (enzyme-aided extraction of plant materials for production of flavours, production of flavour enhancers such as nucleotides; flavours from hydrolyzed vegetable/animal protein); enzymatic approach to tailor- made fats.

Practical
Assay of enzymes for activity, specific activity, kinetics, stability temperature, pH and storage); Extraction and clarification of juices using enzymes; Applications of enzymes in baking, starch and protein hydrolysis, meat tenderization, cheese making.

Suggested Readings

1. Flickinger MC & Drew SW. 1999. Encyclopedia of Bioprocess Technology. A Wiley-Inter Science Publ.
2. Kruger JE. et al. 1987. Enzymes and their Role in Cereal Technology. American Association of Cereal Chemists Inc.
3. Nagodawithana T & Reed G. 1993. Enzymes in Food Processing. Academic Press.
4. Tucker GA & Woods LFJ. 1991. Enzymes in Food Processing.
5. Whitehurst R & Law B. 2002. Enzymes in Food Technology. Blackwell Publ.

PFE 609	Plant Utilities and Plant Safety	3 (2+1)
----------------	---	----------------

Theory
UNIT I
Identification of common plant utilities, water, Compressed air, Steam, Vacuum Refrigeration, Venting, Flaring and pollution abating, Water and its quality
UNIT II
Storage and distribution for cooling and fire fighting. Compressed air from blowers and compressor. Production of dust free air by filtration.
UNIT III
Steam generation by boilers. Types of boilers and their operation. Steam generation by utilizing process waste heat using thermic fluids. Regenerators and recuperators. Distribution of steam in a plant.
UNIT IV
Principles of refrigeration. Creation of low temperature using various refrigerants.
Creation of low pressures/vacuum by pump and ejectors. Flaring and venting. A different type of vents flares.
UNIT V
Concept and definition, safety culture. Storage of dangerous materials. Plant layout. Safety systems. Technology and process selection. Scale of disaster. Vapour Cloud Explosions. Relief Systems. Risk and hazard management.
UNIT VI
Safety versus production. Risk assessment and analysis. Hazard models and risk data. Identification, minimization and analysis of routine hazard. Tackling disasters. Plan for emergency. Risks management routines. Emergency shutdown systems.

Suggested Books:

1. D.A Crawl, "Chemical Process Safety: Fundamental with Applications", 2nd Ed. - New Jersey: Prentices - Hall - 2001
2. O. P. Kharbanda and E.A. Stallworthy, "Management of Disasters and How to Prevent them", Gower - 1986
3. F. P. Lees, " Loss Prevention in process Industries", Vol - I & II, Butterworth - 1983
4. W.L. McCabe Smith, J.C. Smith and P. Harriot, "Unit Operations of Chemical Engineering", 5th Ed. McGraw Hill-1995
5. Dossat, Roy J., "Principles of Refrigeration ", 3rd Ed. New Jersey; Prentices Hall Career and technology -1991

Theory
UNIT I
Building blocks of supply chain network, performance measures, decisions in supply world and models.
UNIT II
Supply chain inventory management, economic order quantity models, recorder point models, multi echelon inventory systems.
UNIT III
Use of stochastic models and combinatorial optimization in SC planning, layout, capacity planning, inventory optimization, dynamic routing and scheduling.
UNIT IV
Internet technologies and electronic commerce in SCM related to ERP, Qprocurement, e-logistics, internet auctions, e-market, electronic, business process optimization.

Practical
Problems, games and case studies related SCM, Demonstration of various models in decision making, case studies for SCM in processing of fruits/vegetable/milk, case study for export of one perishable and one non perishable food.

Suggested Books

1. Chopra S & Meindel P. 2002. Supply Chain Management: Strategy, Planning and Operation. Prentice Hall.
2. Handfield RB & Nochols EL.1999. Introduction to Supply Chain Management. Prentice Hall.
3. Hopp WJ & Spearman ML. 1996. Factory Physics: Foundations of Manufacturing Management. McGraw Hill.
4. Levi DS, Kaminsky P & Levi ES. 2000. Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies. Mc Graw Hill.
5. Shapiro JF. 2001. Modeling the Supply Chain. Duxbury Thomson Learning.
6. Tayur S, Ganeshan R & Magazine M.1999. Quantitative Models for Supply Chain Management. Kluwer Academic Publ.
7. Viswanadham N. 2000. Analysis of Manufacturing Enterprises. Kluwer.
8. Viswanadham N & Narahari Y. 1998. Performance Modeling of Automated Manufacturing Systems. Prentice Hall.

PFE 693	Special Problem	1 (0+1)
----------------	------------------------	----------------

PFE 694	Case Study	1 (0+1)
----------------	-------------------	----------------

B) Minor Subjects		
PFE 610	Techniques in Food Analysis	3 (1+2)

Theory
UNIT I
Sampling techniques; Water activity, its measurements and significance in food quality; Calibration and standardization of different instruments.
UNIT II
Spectroscopic techniques using UV/Vis, fluorescence, IR, FTIR, NIR, NMR, atomic absorption, ICP, polarimetry, refractometry, microscopic techniques in food analysis (light microscopy, SEM, TEM, XRD, particle size analysis, image analysis etc.).
UNIT III
Chromatographic techniques: Adsorption, column, partition, affinity, ion exchange, size exclusion, GC, GLC, HPLC, HPTLC, GCMS, LCMS.
UNIT IV
Separation techniques: Gel filtration, dialysis, electrophoresis, sedimentation, ultrafiltration and ultracentrifugation, solid phase extraction, supercritical fluid extraction, isoelectric focusing, isotopic techniques, manometric techniques.
UNIT V
Special techniques: Immunoassay techniques; Isotopic, non-isotopic and enzyme immunoassays; surface tension; enzymatic methods of food analysis; thermal methods in food analysis (Differential scanning colorimetry and others).

Practical
Sorption isotherms by measuring water activity in any hygroscopic food material (for instance - biscuits/potato chips/coffee powder); Estimation of tannin/phytic acid by spectrometric method, Separation of amino acids/coal tar dyes by two dimensional paper chromatography; Separation and identification of sugars in fruit juices; Separation of proteins by ion-exchange chromatography; Separation and identification of carotenoids by column chromatography; Identification and determination of organic acids by HPLC; Analysis of dietary fibre/glucose by enzymatic method; Heavy metal analysis using atomic absorption spectrometry; Residue testing

Suggested Books

1. AOAC International. 2003. Official methods of analysis of AOAC International. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities.
2. Kirk RS & Sawyer R. 1991. Pearson's Chemical Analysis of Foods. 9th Ed. Longman Scientific & Technical.
3. Leo ML. 2004. Handbook of Food Analysis. 2nd Ed. Vols. I-III.
4. Linden G. 1996. Analytical Techniques for Foods and Agricultural Products. VCH.
5. Macleod AJ. 1973. Instrumental Methods of Food Analysis. Elek Sci. Marcel Dekker.
6. Nielsen S. (Eds.). 1994. Introduction to Chemical Analysis of Foods. Jones & Bartlett.
7. Pomrenz Y & Meloan CE. 1996. Food Analysis - Theory and Practice. 3rd Ed. CBS.
8. Ranganna S. 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill.
9. Robinson JW. 1970. Undergraduate Instrumental Analysis. Marcel Dekker.

PFE 611	Bakery and Confectionary Technology	3 (2+1)
----------------	--	----------------

Theory
UNIT I
Bakery and confectionary industry; raw materials and quality parameters; dough development; methods of dough mixing; dough chemistry; rheological testing of dough-Farinograph, Mixograph, Extensograph, Amylograph / Rapid Visco Analyzer, Falling number, Hosney's dough stickiness tester and interpretation of the data.
UNIT II
Technology for the manufacture of bakery products-bread, biscuits, cakes and the effect of variations in formulation and process parameters on the quality of the finished product; quality consideration and parameters; Staling and losses in baking; machineries used in bakery industry.
UNIT III
Quality characteristics of confectionery ingredients; technology for manufacture of flour, fruit, milk, sugar, chocolate, and special confectionary products; colour, flavor and texture of confectionary; standards and regulations; machineries used in confectionery industry.

Practical
Determination of dough relaxation constants and their interpretation; Effect of mixing method on the quality of baked product; Effect of mixing time on the rheological characteristics of dough; Effect of mixing time on the crispness and firmness of biscuits; Effect of additives on the quality and textural characteristics of bakery products; Development and quality evaluation of baked products based on composite flour; Preparation and quality evaluation of cakes, croissant, doughnuts, and pizza base; Effect of syrup consistency and temperature on the quality characteristics of hardboiled sweets; Preparation and quality evaluation of chocolate; Visit to bakery and confectionery industries.

Suggested Books

1. Dubey SC. 2002. Basic Baking. The Society of Indian Bakers, New Delhi.
2. Francis FJ. 2000. Wiley Encyclopedia of Food Science & Technology. John Wiley & Sons.
3. Manley D. 2000. Technology of Biscuits, Crackers & Cookies. 2nd Ed. CRC Press.
4. Pyler EJ. Bakery Science & Technology. 3rd Ed. Vols. I, II. Sosland Publ.
5. Qarooni J. 1996. Flat Bread Technology. Chapman & Hall.

PFE 612	Sensory Evaluation	2 (1+1)
----------------	---------------------------	----------------

Theory
UNIT I
Introduction to sensory analysis; general testing conditions, Requirements of sensory laboratory; organizing sensory evaluation programme.
UNIT II
Selection of sensory panelists; Factors influencing sensory measurements; Sensory quality parameters -Size and shape, texture, aroma, taste, color and gloss; Detection, threshold and dilution tests.
UNIT III
Different tests for sensory evaluation– discrimination, descriptive, affective; Flavour profile and tests; Ranking tests; Methods of sensory evaluation of different food products.
UNIT IV
Computer-aided sensory evaluation of food & beverage, statistical analysis of sensory data.

Practical
Selection and training of sensory panel; Detection and threshold tests; Ranking tests for taste, aroma colour and texture; Sensory evaluation of various food products using different scales, score cards and tests; Estimation of color and texture; Relationship between objective and subjective methods.

Suggested Readings

1. Amerine MA, Pangborn RM & Rossles EB. 1965. Principles of Sensory Evaluation of Food. Academic Press.
2. Early R.1995. Guide to Quality Management Systems for Food Industries. Blackie Academic.
3. Jellinek G. 1985. Sensory Evaluation of Food - Theory and Practice. Ellis Horwood.
4. Lawless HT & Klein BP. 1991. Sensory Science Theory and Applications in Foods. Marcel Dekker.

5. Macrae R, Rolonson Roles & Sadlu MJ.1994. Encyclopedia of FoodScience & Technology & Nutrition. Vol. XI. Academic Press.
6. Maslowitz H. 2000. Applied Sensory Analysis of Foods. Vols. I, II. CRC Press.
7. Piggot JR. 1984. Sensory Evaluation of Foods. Elbview Applied Science Publ.
8. Potter NN & Hotchleiss JH. 1997. Food Science. 5th ed. CBS.
9. Rai SC & Bhatia VK. 1988. Sensory Evaluation of Agricultural Products.
10. Stone H & Sidel JL. 1985. Sensory Evaluation Practices. Academic Press.
11. Watts CM, Ylimaki CL, Jaffery LE & Elias LG. 1989. Basic Sensory Methods for Food Evaluation. Int. Dev. Res. Centre, Canada.

PFE 613	Automation in Food Processing	3 (2+1)
----------------	--------------------------------------	----------------

Theory
UNIT I
Introduction: Food quality evaluation, indication variables, Data acquisition, elastography, electronic nose and tongue, ultrasonic, Data analysis, intramuscular fat, wavelet, marbled meat, statistical textural feature extraction from, elastography, Sampling, concept and system for data acquisition, image acquisition, ultrasonic B- mode imaging. Data Analysis – Data processing, Dynamic data analysis, Image processing.
UNIT II
Modeling system identification, Modeling strategy, linear statistical modeling, ANN Modeling, F statistic, null hypothesis Prediction Levenberg Marquardt algorithm, recurrent neural networks, gradient descent.
UNIT III
Control objective function, neuro-fuzzy, membership functions Systems integration assembly language, high-level programming language.
UNIT IV
System integration, Robotics, Application of robotics and basic components of robotics, Features of II and II generation robots.
UNIT V
Bottle Washing Machine Automaton, Bottling Plant Drive System, Demineralization Plant Control System, Labeling Machine Control system, Charger level automation, Reverse Osmosis plant automation, Thermal plant automation, Dehydration and freezing pant automation.
UNIT VI
Automation in different units of food processing, preparation of raw food and materials, sorting, grading, size reduction, mixing an agitation, thermal processing, dehydration, packaging, CIP, quality control.

Practical

Food odor measurement, Continuous snack food frying quality, Sampling for detection peanut off flavours, Snack food frying data acquisition for process control, Elastographic imaging for meat quality evaluation. Linear . statistical dynamic modeling for snack food modeling, Study of automatic food dehydration plant, Study automatic extrusion plant, Study automatic evaporation and puree processing plants. Study automatic CIP systems.

Suggested Readings

1. Considine 2001. *Process Control*. AVI Publ.
2. Huang Y & Lacey RE. 2003. *Principles of Robotics*. CRC.
3. Huang Y, Whittaker AD & Lacey RE. 2001. *Automation for Food Engineering*. CRC.

PFE 614**Cold Chain Management****2 (2+0)****Theory****UNIT I**

Introduction, scope and importance of cold chain in food processing industry and retail chain, components of cold chain and integration.

UNIT II

Products going in cold chain, their temperature and humidity requirements, packaging needs and their compatibility in cold chain.

UNIT III

Stages and points of control in cold storages and structures, functions in cold storages, pallet layout and stacking options, flexibility storage systems cold chain transportation in land and export, retail & supermarket cold chain & display systems.

UNIT IV

Temperature recording devices used during transport, documentation and traceability, Risk management problem diagnosis, cost benefit studies for type of transport, loading & unloading, storage duration.

Suggested Books

There are no books on cold chain management but there are chapters in supply chain management books shown in next course.

PFE 617	Industrial Pollution and Control	3 (2+1)
----------------	---	----------------

Theory
UNIT I
Types of environments, and their pollutants, Classification of pollutants. Legislative aspects including water (Prevention and control) Act, 1974, Air (Prevention and Control) act, 1981, and Effluent standards.
UNIT II
Removal/recovery/destruction method for the pollution like SO ₂ , NO, CL, F, mercury, H ₂ S and organic vapours and particulate matter from gaseous effluents
UNIT III
Preliminary methods of separation, Cyclone separators, fabric filters, liquid scrubbers, Electrostatic precipitators, adsorption, and incineration of vapours.
UNIT IV
Method of Physico-chemical and biological treatment for industrial effluents from fertilizer, petrochemical, pulp and paper, caustic soda, tanning and sugar industries.
UNIT V
Treatment of medical waste, common effluent Treatment Plant and concept of zero effluent treatment.
UNIT VI
Alternate routes of manufacture and/or sequencing of operations as means pollution control and recovery of chemicals. Alternate use of by products waste as means of by-product waste as means of pollution abatement.

Practical
Study of sampling techniques for collection of water sample
Determination of chlorine content
Determination of hardness of water
Determination of pH and conductivity of water sample
Determination of acidity
Determination of alkalinity
Determination of oil and grease.
Determination of dissolved oxygen
Determination of chemical oxygen demand.
Determination of biochemical oxygen demand.

Suggested Books

1. Metcalf & Eddy, "Waste Water Engineering: Treatment, Disposal, Reuse", 2nd Ed., McGraw-Hill, New York - 1979.

2. S. P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, New Delhi - 1996.
3. K. S. Peavy, "Environmental Engineering", McGraw-Hill, International Ed., New York - 1985.

PFE 618	Solid-Fluid Operations	2 (1+1)
----------------	-------------------------------	----------------

Theory
UNIT I
Particulate Solids - Particle Characterization, Particulate Solids in Bulk, Blending of Solid Particle, Classification of Solid Particles
Size Reduction of Solids - Mechanism of Size Reduction. Energy for Size Reduction, Methods of Operating Crushers, Nature of Material to be Crushed, Types of Crushing Equipments
UNIT II
Sedimentation - Gravitational Sedimentation, Centrifugal Separation, Flocculation.
UNIT III
Flow through Packed Columns - Flow of a Single Fluid through a Granular Bed, Dispersion, Packed Columns Fluidization - Characteristics of Fluidized Systems, Liquid-Solid and Gas-Solid Systems, Applications of the Fluidized Solids Technique. Pneumatic and Hydraulic Conveying - Theory and Industrial Applications.
UNIT IV
Filtration - The Theory of Filtration. Filtration Practices, Filtration Equipments, Filtration in a Centrifuge and Filtration Calculations
UNIT V
Gas Cleaning - Gas Cleaning Equipments such as Gravity Separators, Centrifugal Separators, Electrostatic Precipitators etc.
UNIT VI
Flow of particulate matter - Flow of solids through silos and hoppers. Storage and transport of powders. Size Enlargement - Principles of agglomeration palletizing (cone and disk), press and tabulating machines and extrusion and granulating machines.

Practical
Determination of screen effectiveness
Dry screen analysis
Wet screen analysis
Study of sedimentation
Study of air elutriation
Study of cyclone separator

Study of froth flotation
To verify laws of crushing and grinding using jaw crusher
To verify laws of crushing and grinding using ball mill
Study of Vacuum leaf filter
Study of Plate and frame filter press
Study of Conveyors
Study of Basket centrifuge

Suggested Books

1. J. M. Coulson and J. F. Richardson, Chemical Engineering, Vol. 2, 3rd Edn. Pergamon Press
2. W. L. McCabe, J. C. Smith and P. Harriot, Unit operations of Chemical Engineering, 4th ed. McGraw Hill, 1985
3. S. K. Gupta, Momentum transfer operations, Tata McGraw Hill, 1979.
4. A. S. Foust, L. A. Wenzel, C. W. Clump, L. B. Andersen, "Principles of Unit Operations", 2nd ed. Wiley, New York, 1980.

RES 605	Fuels and Combustion	2 (1+1)
----------------	-----------------------------	----------------

Theory
UNIT I
Introduction to energy sources Solid Fuels - Biomass, peat, lignite and brown coal, black lignite, anthracite, natural coke, origin of coal, composition of coal, oxidation and hydrogenation of coal, classification of coal.
UNIT II
Processing of Solid Fuels - Coal preparation and storage, coal carbonization, briquetting, liquefaction and gasification of solid fuels.
UNIT III
Liquid Fuels - Petroleum Processing, properties and testing of petroleum products, petroleum refining in India, liquid fuels from other sources, storage and handling of liquid fuels.
UNIT IV
Gaseous Fuels - Natural gas, methane from coal mines, producer gas, water gas, coal gas, blast furnace gas,
UNIT V
Gaseous Fuels - gases from biomass, refinery gases, LPG, Oil gasification, cleaning and purification of gaseous fuels.
UNIT VI
Combustion Stoichiometry: thermodynamics and kinetics. General appliances such as gas burners, oil burners and coal burning equipment.

Practical
Practical's on UNIT-II to UNIT-VI

Suggested Books

S. Sarkar, "Fuels and Combustion", 2nd Edition, Orient Longmans, Bombay, 1990

RES 623	Energy Management and Planning	3 (2+1)
----------------	---------------------------------------	----------------

Theory
Energy resources on the farm: conventional and non-conventional forms of energy and their use. Heat equivalents and energy coefficients for different agricultural inputs and products. Pattern of energy consumption and their constraints in production of agriculture. Direct and indirect energy. Energy audit of production agriculture, and rural living and scope of conservation. Identification of energy efficient machinery systems, energy losses and their management. Energy analysis techniques and methods: energy balance, output and input ratio, resource utilization, conservation of energy sources. Energy conservation planning and practices. Energy forecasting, Energy economics, Energy pricing and incentives for energy conservation, factors effecting energy economics. Energy modeling.

Practical
Practicals on above topics

Suggested Readings

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

C) Supporting Subjects

PFE 620

Computer Applications in Food Industry

3 (1+2)

Theory

UNIT I

Importance of Computerization and IT in Food Industries Computers, operating environments and information systems for various types of food industries; Principles of Communication.

UNIT II

Role of Computer in Optimization: Introduction to operation Research; A Computer Oriented Algorithmic approach; Queuing systems and waiting models; PERT, CPS and CPM.

UNIT III

Food Process Modeling and Simulation; CAD and CAM in Food Industry: instrumentation, process Control; inventory Control, Automation, Robotics, Expert system and artificial intelligence.

Practical

Applications of MS Excel to solve the problems of food technology: Statistical quality control, Sensory evaluation of food, and Chemical kinetics in food processing; Use of word processing software for creating reports and presentation; Familiarization with the application of computer in food industries -Milk plant, Bakery Units, Fruit & Vegetable processing Unit; Familiarization with software related to food industry; Ergonomics

Application in the same; Visit to Industry and case study problems on computer.

Suggested Readings

1. Gillett BE. *Introduction to Operation Research* (A Computer Oriented Algorithmic Approach).
2. Groover MP & Zimmers EW. 1987. *CAD/CAM: Computer Aided Design and Manufacturing*. Prentice Hall.
3. Singh RP. 1996. *Computer Applications in Food Technology*. Academic Press.

PFE 621

Current Topics in Food Processing

2 (2+0)

The teacher and students must select various important and relevant topics from reputed journals and other information sources and take them up for study, discussion, assignments and review writing.

Theory**UNIT I**

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, t and F statistics.

UNIT III

Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons.

UNIT IV

Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

UNIT V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data., Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample t -test, two sample t -test, paired t -test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, fixed effect models, random effect models, estimation of variance components; Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, and partial correlation, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Fitting of growth models - curve estimation models, Factor analysis. Principal component analysis - obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

Suggested Readings

1. Atkinson AC. 1985. Plots Transformations and Regression. Oxford University Press.
2. Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmont, California.
3. Chatfield C & Collins AJ. 1980. Introduction to Multivariate Analysis. Chapman & Hall.

4. Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall.
5. Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.
6. Cleveland WS. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
7. Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
8. Erickson BH & Nosanchuk TA. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.
9. Snell EJ & Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman & Hall.
10. Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.
11. Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
12. Velleman PF & Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.

STAT 601

Operations Research

3 (2+1)

Theory
UNIT I
Definition and scope of operations research. Management applications of operations research. Main characteristics of operations research
UNIT II
Linear programming, LP models, formulation of problems, limitations, simplex method, complications and their resolution, duality principle, application of LP
UNIT III
Transportation type problems, formulation, basic concepts, finding initial basis, feasible and optimal solutions, degeneracy, Transportation Problem with minimum time requirements, the unbalanced Transportation Problem. Assignment problem: formulation and solution.
UNIT IV
Dynamic programming: multistage problems, recursive equation approach.
UNIT V
Inventory control, economic lot size model, production planning, single and multi-period models.
UNIT VI
Replacement problems: models: basic concepts, replacement of items that fail completely, replacement of equipment deteriorating with time, staffing and other problems of replacement.
UNIT VII
Queuing Theory and applications. M/M/1, M/M/s type models

Practical
Numerical on formulation and solution of LP problems
Numerical on formulation and solution of Transportation problems
Numerical on formulation and solution of Assignment problems
Numerical on formulation and solution of DP problems
Numerical on Inventory control models
Numerical on Replacement problems
Numerical on Queuing models

Suggested Books

1. Rao, S.S. 1990. Optimization- Theory and Applications.
2. Sharma, S.D. 1999. Operations Research. Kedar Nath Ram Nath and Co. Publishers, Meerut.
3. Taha, H.A. 1989. Operations Research- An Introduction. Maxwell Macmillan, New York.
4. Vohra, N.D. 1990. Quantitative Techniques in Management. Tata McGraw-Hill Publishing Co. New Delhi.

STAT 612	Regression Analysis	3 (2+1)
-----------------	----------------------------	----------------

Theory
UNIT I
Introduction to correlation analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation.
UNIT II
Problem of correlated errors; Auto correlation; Removal of auto correlation by transformation; Analysis of collinear data; Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.
UNIT III
Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation; regression approach applied to analysis of variance in one way classification.
UNIT IV
Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose.

Practical
Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection; Handling of correlated errors, multicollinearity; Fitting of quadratic, exponential and power curves.

Suggested Books

1. Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
2. Ezekiel M. 1963. Methods of Correlation and Regression Analysis. John Wiley.
3. Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. Applied Regression Analysis and Multivariable Methods. Duxbury Press.
4. Koutsoyiannis A. 1978. Theory of Econometrics. MacMillan.
5. Kutner MH, Nachtsheim CJ & Neter J. 2004. Applied Linear Regression Models. 4th Ed. With Student CD. McGraw Hill

MATH 601	Mathematical Modeling and Software Applications	3 (2+1)
-----------------	--	----------------

Theory
UNIT I
Introduction, stages in mathematical modelling, importance of mathematical modelling.
UNIT II
Classification of mathematical models: Continuous and discrete models, linear models and its applications, quadratic models and its applications, exponential models and its applications, empirical models and its applications.
UNIT III
Introduction to MAT LAB, Desktop tools
UNIT IV
MAT LAB basics: variables and arrays, Initialization variables, Matrix manipulation, linear algebra, roots of polynomials, data analysis and statistics. Solution of the mathematical problems using MAT LAB and MAT LAB tools. Graph plotting: 2-D, 3-D, Contour.
UNIT V
Simulation of mathematical models using MAT LAB programming.

Practical
Hands on for UNIT III, IV and V.

Suggested Books

Dym, Clive L. Principles of Mathematical modeling.

Chapman, Stephen J. MAT LAB programming for Engineers

MATH 602	Optimization Techniques	2 (1+1)
-----------------	--------------------------------	----------------

Theory
UNIT I
Single-variable optimization algorithms: Optimal problem formulation, Optimization algorithms, Optimality criteria, Bracketing methods, Region-elimination methods, Point-estimation method, Gradient based methods, Root finding using optimization techniques.
UNIT II
Multi-variable optimization algorithms: Unidirectional search, Direct search methods, Gradient based methods.
UNIT III
Constrained optimization algorithms: Kuhn-Tucker conditions, Transformation methods,
UNIT IV
Sensitivity analysis, Direct search for constrained minimization, Linearized search techniques, Feasible direction method, Generalized reduced gradient method, Gradient projection method
UNIT V
Specialized algorithms: Integer programming, Geometric programming.
UNIT VI
Nontraditional optimization algorithms: Genetic algorithms, simulated annealing, Global optimization.

Practical
Hands on for UNIT-I to IV

Suggested Books

Deb K., Optimization for engineering design, Algorithms and examples, Prentice Hall of India, New Delhi 1996

AE 605	Project Planning and Implementation	3 (2+1)
---------------	--	----------------

Theory
UNIT I
An introduction to project management: An overview of project management. The differences between Product, Project and Program management, Industrial, R&D and social security projects.
UNIT II

Successful Initialization and Project Planning: Defining the project scope. Establishing the project scope and defining project deliverables. Defining and Sequencing of Project Deliverables. Project scheduling techniques, Market research and forecasting. GMP and HACCP.
UNIT III
Resource Planning: Determining resource requirements and acquiring those resources, Source of finance, Debt-equity ratio, Debt service coverage ratio, ROI, RONW, Process of soliciting and selecting vendors for material and services for the project. Cost Management. Establishing the project budget and analyzing budget variances, techno-economic feasibility analysis.
UNIT IV
Execution of the Project Plan and Evaluating Project Progress: Execution of the project plan and activities required to create the project team, monitor progress against the plan, and keep the project on track. Capacity utilization, Breakeven point.
UNIT V
Risk Identification and Analysis: Identify risky events, measure the element of risk, and develop responses to high-risk events. Establishing the Project Management Team Identifying project team members, and structuring a successful project team. Keeping the Project on Track The quality process, Project's quality standards and how performance to those standards will be measured. Managing Project Change Handling formal and informal change, how to identify and evaluate change, and incorporate change into the project plan.
Practical
Preparation of a model detailed project report for a small scale food processing unit and its power point presentation, Case studies of various food products, projections planning for sales target achievements, Risk analysis for financial and technical feasibilities of the projects, Project appraisal methods as applied to selected projects.

Suggested Books

1. Pavlyak MM.2000. *Systems Survival Guide*. Ruby Moon Press.
2. Thomsett TC.1990. *The Little Book of Project Management*. American Management Association.

D) Seminars		
PFE 691	Doctoral Seminar-I	1 (1+0)
Every student will be required to prepare and submit a seminar report based on experimental modeling and simulation work preferably a design problem given by Seminar Guide. Student must report the Guide at least once in a week on a specified day and report the progress of his work to the Project Guide. Every student has to deliver a Seminar before the examiners.		

PFE 692	Doctoral Seminar- II	1 (1+0)
----------------	-----------------------------	----------------

E) Doctoral Research		
PFE 699	Doctoral Research	45 (0+45)

F) Non Credit Compulsory Courses (Optional)		
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.		

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.

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. Erbis 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 vaccumets; 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 (e-Course) Agricultural Research, Research Ethics and Rural Development Programmes	1 (1+0)
--	----------------

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 (e-Course)	Disaster Management	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.