Department of Post Harvest Engineering

M.Tech. Programme

Course No.	Course Title	Credit
	1st Semester	
PHE-501	Unit Operation in Agricultural Processing	2+1
PHE-502	Engineering Properties of Biological Materials	2+1
PHE-503	Transport Process in Food Engineering	3+0
PHE-504	Post Harvest Engineering of Cereals, Pulses and Oil Seeds	2+1
	2nd Semester	
PHE-551	Storage and Handling Crops	2+1
PHE-552	Agricultural Waste and By-product Utilization	2+1
PHE-553	Process Equipment Design	2+1
PHE-554	Food Handling and Packaging	2+1
	3rd Semester	
PHE-601	Computer Application in Numerical Analysis	3+1
PHE-602	Food Processing Operations	3+1
PHE-649	Seminar-I	1+0
	4th Semester	
PHE-699	Seminar-II	0+1
PHE-700	Master's Research	0+20

Ph.D programme

Course No.	Title of the course	Credits
1st Semester		
PHE-701	Advances in Post Harvest Engineering and Food Engineering	3+1
PHE-702	Biomass and Agricultural By-product Utilization	3+1
2nd Semester		
PHE 751	Instrumentation and Process Control	2+1
PHE -752	Advanced Process Equipment Design	2+1
PHE-799	Seminar-I	1+0
3rd Semester		
PHE-801	Advances In drying and Dehydrations	2+1
PHJE-802	Advanced Storage Engineering	2+1
PHE-849	Seminar-II	1+0
4th Semester		
PHE-851	Advances in Packaging Technology of Food	3+0
PHE-852	Computational Methods in Process Engineering	3+0
	Nil	
5th Semester		
	Nil	
6th Semester		
PHE-999	Seminar-III	1+0
PHE-1000	Doctoral Research	0+45

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PHE- 501   Unit Operations in Agricultural Processing   2+1 (3)

Theory

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

UNIT II: Principles of fluid flow, methods of heat transfer, heat exchangers and their designs.

UNIT III: Psychrometry, dehydration:- theory and process, type of dryers, EMC, Thermal processing operations; Evaporation, dehydration/drying, types of dryers, blanching, pasteurization, distillation, steam requirements in food processing.

UNIT IV: Refrigeration principles and Food freezing. Mechanical separation techniques, size separation equipments; Filtration, sieving, centrifugation, sedimentation. Material handling equipment, conveyors and elevators; Size reduction processes and equipment; Grinding and milling. Agitation and mixing of liquid, powder and paste.

Practical

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

PHE- 502   Engineering Properties of Biological Materials   2+1 (3)

Theory

UNIT I: Physical characteristics of different food grains, fruits and vegetables; Shape and size, description of shape and size, volume and density, porosity, surface area. Rheology; ASTM standard, terms, physic al states of materials, classical ideal material, rheological models and quations, visco-elasticity,creep-stress relaxation, Non-Newtonian fluid and viscometry, rheological properties, force, deformation, stress, strain, elastic, plastic behaviour.

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

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

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

Practical

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

PHE- 503   Transport Process in Food Engineering   3+0 (3)
Theory
UNIT I: Introduction to heat and mass transfer and their analogous behaviour, steady and unsteady state heat conduction, analytical and numerical solution of unsteady state heat conduction equations, use of Gurnie-Lurie and Heisler Charts in solving heat conduction problems. Applications in food processing including freezing and thawing of foods.
UNIT II: Convective heat transfer in food processing systems involving laminar and turbulent flow heat transfer in boiling liquids, heat transfer between fluids and solid foods. Functional design of heat exchangers: Shell and tube, plate and scraped surface heat exchangers, Jacketed vessels.
UNIT III: Radiation heat transfer and its governing laws, its applications in food processing.
UNIT IV: Molecular diffusion in gases, liquids and solids; molecular diffusion in biological solutions and suspensions molecular diffusion in solids, unsteady state mass transfer and mass transfer coefficients, molecular diffusion with convection and chemical reaction, diffusion of gases in porous solids and capillaries, mass transfer applications in food processing.
Practical
Solving problems on steady and unsteady state conduction with or without generation; numerical analysis; problems in natural and forced convection; radiation; design of heat exchangers; performing experiments on heat conduction, convection and radiation heat transfer.

PHE- 504   Post Harvest Engineering of Cereals, pulses and Oil Seeds   2+1 (3)

Theory
UNIT I: Production and utilization of cereals and pulses, grain structure of major cereals, pulses and oilseeds and their milling fractions; grain quality standards and physico-chemical methods for evaluation of quality of flours.
UNIT II: Pre-milling treatments and their effects on milling quality; parboiling and drying, conventional, modern and integrated rice milling operations; wheat roller flour milling; processes for milling of corn, oats, barley, gram, pulses, paddy and flour milling equipments.
UNIT III: Dal mills, handling and storage of by-products and their utilization. Storage of milled products, Expeller and solvent extraction processing, assessment of processed product quality.
UNIT IV

Oilseed processing, Extraction and refining of oil from coconut, soyabean, sunflower and rice bran. Packaging of processed products, design characteristics of milling equipments; selection, installation and their performance, BIS standards for various processed products.

Practical

Physical properties of cereals and pulses, raw and milled products quality evaluations; parboiling and drying; terminal velocities of grains and their fractions; study of paddy, wheat, pulses and oilseeds milling equipments; planning and layout of various milling plants, visit to related agro-processing industry.

PHE- 551   Storage and Handling of Crops   2+1 (3)

Theory

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

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

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

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

Practical

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

PHE 552 Agricultural Waste and By-products Utilizations   2+1 (3)

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.

PHE- 553   Process Equipment Design   2+1 (3)

Theory
UNIT I: Design considerations of processing agricultural and food products.
UNIT II: Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation.
UNIT III: Human factors in design, selection of materials of construction and standard component, design standards and testing standards. Plant design concepts and general design considerations: plant location, location factors and their interaction with plant location, location theory models, computer aided selection of the location.

UNIT IV: Feasibility analysis and preparation of feasibility report: plant size, factors affecting plant size and their interactions, estimation of break-even and economic plant size; Product and process design, process selection, process flow charts, computer aided development of flow charts.
Practical
Detailed design and drawing of mechanical dryers, milling equipment, separators, evaporators, mixers and separators. Each individual student will be asked to select a food processing plant system and develop a plant design report which shall include product identification and selection, site selection, estimation of plant size, process and equipment selection, process flow-sheeting, plant layout, and its evaluation and profitability analysis.

PHE-554   Food Handling & Packaging   2+1 (3)
Theory
UNIT I:Introduction of packaging: Package, functions and design. Principle in the development of protective packaging. Deteriorative changes in foodstuff and packaging methods of prevention.
UNIT II: Food containers: Rigid containers, glass, wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks, corrosion of containers (tin plate); Flexible packaging materials and their properties; Aluminium as packaging material; Evaluation of packaging material and package performance.
UNIT III: Packaging equipments: Food packages, bags, types of pouches, wrappers, carton and other traditional package; Reportable pouches; Shelf life of packaged foodstuff.
UNIT IV: Methods to extend shelf life; Packaging of perishables and processed foods; Special problems in packaging of food stuff.

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

Practical

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

PHE-601 Computer Application and Numerical Analysis   3+1 (4)

Review of algorithm and methods of successive bisection, Newton-Rapson iterative method. Solution of simultaneous algebraic equations: Gauss elimination method, refinement of its solution, Gauss Seidel iterative method, Algorithm to implement the Gauss-Seidel method. Linear regression algorithm for linear regression, polynomial regression, fitting exponential and trigonometric functions. Formulae for mumerical differentiations, numerical integration, Simpson's numerical solution to differential equation. Raunge-Kutta method, Raunge-Kutta 4th order formulae, Higher order differential equations.

Practical

Practice on developing programs for solutions of higher order algebraic equations, Simultaneous equations, Interpolation, Least square approximation, differentiation, integration and numerical solution t differential equation and testing them on computer.

FE-602   Food Processing Operations   3+1 (4)

Overview of thermal operations carried out in dairy and food processing, Role of water and water activity in foods, Control of water activity by addition of solutes and moisture removal. Different isotherms, their limitations and applicability. Irradiation and microwave processing of foods. Crystallization and freezing. Estimation of freezing time of foods, Equipments used for freezing water in food and for production of crystalline foods i.e. sucrose and lactose. Freeze concentration of liquid foods, concentration of liquid foods in batch and continuous type evaporators, Energy saving by use of multi effect evaporators with mechanical and thermal vapour compression. Mechanism of moisture removal in solid and liquid foods during drying: spray, freeze, roller and tray drying operations. Overview of contact equilibrium based separation techniques in dairy and food processing. Heat and mass transfer analogy, Estimation of mass transfer coefficients, Balance in equilibrium stage operations. Distillation in aroma and solvent recovery in fruit concentration alcoholic beverages and oil processing, Gas-liquid and liquid-

liquid extraction and principles and operations. Leaching and extraction for production of edible oil. Ultra filtration and reverse osmosis in liquid food concentration. Osmotic drying of fruits.

Practical

Estimation of degree of sterilization of food during in-can stabilization. Moisture sorption isotherms from water activity measurement and its modeling, Determination of elevation of boiling point and depression of freezing point of some liquid foods (milk/ fruit juices), Determination of flow pattern, porting arrangement and flow rate pressure drop relationship in plate heat exchanger, Estimation and measurement of freezing time in a freezer, Concentration of liquid foods in evaporator.

PHE 701   Advances in Post Harvest Engineering and Food Enginnering   4(3+1)

Size reduction: principles, types of technique, application and energy requirement laws. Mixing: objectives, equipment for solid, liquid mixing energy requirement, mixing index. Thermal processing: Death rate kinetics, thermal process calculation, method of sterilization and equipments involved, latest trend in thermal processing. Evaporation: Properties of liquid, heat and mass balance in single effect and multiple effect evaporator, aroma recovery, equipments and applications. Drying: Rates, equipments for solid, liquid and semisolid material and their application, theories of drying, novel dehydration techniques, Freezing: Freezing curves, thermodynamics, freezing time calculations, equipment, freeze drying, principle, equipments. Separation: Mechanical filtration, membrane separation, centrifugation, principles, equipments and applications, latest development in separation and novel separations techniques. Extrusion: Thery, equipments, applications. Distillation and Leaching: Phase equilibra, multistage calculations, equipments, solvent extrusion.

PHE 702   Biomass and Agricultural By-product Utilization   4(3+1)

Classification, characteristics and conversion methods of biomass and solid wastes. Biomass combustion: Principle and mechanism furnace and their design, chemical conversion of biomass and agricultural waste into pulp, paper, various other products and chemicales. Conversion of agricultural waste into energy chemicals. Utilization of milling by-products of cereals, pulses and oil bearing materials for food, feed and chemicals production**.**

PHE 751   Instrumentation and Process Control   3(2+1)

Different types of measuring instruments their working principles, construction and operating features for measurement of temperature, pressure, moisture, humidity, flow, viscosity, concentration and composition of materials. Generalized static and dynamic performances characterstics of instruments: calibration, accuracy, precision, bias. Zero, first and second order instruments and their response to different input signals(steps, ramp etc). Chemical process control: Characteristics, modeling of static and dynamic behavior, state variables and state equations. Linear and non-linear systems. Transfer functions and input and output models.

Dynamic behavior of first and second order system. Introduction to feed back control Stability analysis and frequency response. Design of feed back control system using frequency response control system for multivariable processes and introduction to plant control.

PHE 752   Advanced Process Equipment Design   3(2+1)

Design of machine elements and their selections, designing of conveying, elevating, cleaning, separetion. Conditioning /parboiling, milling, grinding, drying and mixing equipment. Material and energy balance, calculation for estimation of plant capacity and equipment sizes, material of construction for process equipment, design of storage and pressure vessels. Selection of fans an blower, design consideration for location of food processing units.

PHE 801 Advances In Drying and Dehydrations   3(2+1)

Water activity and its relations with self life of grains and other biomaterials, equilibrium moisture content and latent heat of vaporization, equipments for movement and heating of air, resistance to air flow in granular bed. Drying characteristics of cereals, pulse, oil seeds, spices and other biomaterials . Advances in drying theory and simulations of drying process. Heated air dryers- heat requirement and thermal efficiency of drying systems. Aeration: tempering and dry aeration. Operations of dryers and their control, dehydration of crops by microwave and dielectric and irradiation- recent dehydration techniques, operations. Packaging of dried grain products and other biomaterials.

PHE 802   Advanced Storage Engineering   3(2+1)

Analysis of grain storage eco-system, climatograph and under aerated and non-aerated system, quality analysis and sensing of stored produce, warning systems, bag storage, warehouses, classification, stack arrangement for various capacities and commodities, warehouse managements. BIS standard storage system for fruits and vegetables. Ventilated, refrigerated, frozen and controlled atmosphere storage, pre-cooling, chilling and freezing time calculations, nutrition loss design of cold storages and measures of energy conservation.

PHE 851   Advances in Packaging Technology of Food   3(3+0)

Functions of package: packaging materials, their structural qualities and performances including moisture and gas transmission, methods of package testing and performances evaluation design of packaging systems for food products, aseptic processing of food. Continuous flow pasteurization plants for homogeneous food. Heating and cooling of particulate food-physical principles. Pasteurization of particulate food stuffs with liquid phase. Destruction kinetics of micro organism on packaging materials. Evaluation criteria for aseptic filling and packaging systems. Packaging materials for aseptic packaging. Carton laminates and plastic laminates for aseptic packaging. Aseptic packaging system. Aseptic processing and packaging of foods in cans.

PHE 852   Computational Methods in Process Engineering   3(3+0)

Mathematical Models: Mathematical classification of equations(linear, elliptic, parabolic and hyperbolic). Finite difference equations for nodes using Taylor's series. Boundary Conditions for conduction, convection and radiation heat transfer surfaces. Selection of grid. Discretization: control volume method, differential equation methods, solving of differential equations by explicit scheme, implicit scheme and Crank-Nicholson scheme, stability, analysis. SIMPLE algorithm SIMPLEc algorithm. Application of computational methods to different modes of heat transfer and different flow condition.