FE 202: Process Thermodynamics & Reaction Kinetics

L3 T1 P0 CR4

Course outcomes:

CO1: Ability to explain the concepts of process thermodynamics related to foods, processing operations and associated systems in food manufacturing facilities.
CO2: Ability to apply the concepts of systems, system properties, and thermodynamic processes for estimating heat and work exchange and system efficiency.
CO3: Ability to explain the concept of phase equilibria in two-component and multi-component systems and apply them for predicting behavior of the systems.
CO4: Ability to apply the concepts of chemical kinetics, reaction rates, and temperature dependence to food processing systems.

Course content:

Basic Concepts: Continuum and macroscopic approach; thermodynamic systems (closed and open); thermodynamic properties and equilibrium; state of a system, state postulate for simple compressible substances, state diagrams, paths and processes on state diagrams; concepts of heat and work, different modes of work; zeroth law of thermodynamics; concept of temperature.

Ideal Gas Mixtures: Dalton's and Amagat's laws, properties of ideal gas mixtures, air-water vapor mixtures and simple thermodynamic processes involving them; specific and relative humidities, dew point and wet bulb temperature, adiabatic saturation temperature, psychrometric chart.

Laws of Thermodynamics: First law: Concept of energy and various forms of energy; internal energy, enthalpy; specific heats; first law applied to elementary processes, closed systems and control volumes, steady and unsteady flow analysis.

Second Law: Limitations of the first law of thermodynamics, concepts of heat engines and heat pumps/refrigerators, Kelvin-Planck and Clausius statements and their equivalence; reversible and irreversible processes; Carnot cycle and Carnot principles/theorems; thermodynamic temperature scale; Clausius
inequality and concept of entropy; microscopic interpretation of entropy, the principle of increase of entropy, T-s diagrams; second law analysis of control volume; availability and irreversibility; third law of thermodynamics and its application in food system.

Properties of pure substances: Thermodynamic properties of pure substances in solid, liquid and vapor phases; P-v- T behaviour of simple compressible substances, phase rule, thermodynamic property tables and
charts, ideal and real gases, ideal gas equation of state and van der Waals equation of state; law of corresponding states, compressibility factor and generalized compressibility chart.

Thermodynamic relations: T-ds relations, Helmholtz and Gibbs functions, Gibbs relations, Maxwell relations, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron and Clapeyron-Clausius equations. Concept of phase equilibrium and chemical equilibrium in food processing.

Thermodynamic cycles: Carnot vapor cycle, ideal Rankine cycle, Rankine reheat cycle, air-standard Otto cycle, air-standard Diesel cycle, air-standard Brayton cycle, vapor-compression refrigeration cycle.

Reaction kinetics: Kinetics of chemical process, Molecularity and order of a reaction, rate laws for elementary reactions of different orders, competing reactions, Mechanisms of composite reactions, steady state and rate determining step approximations, homogeneous (acid-base catalysis and enzyme catalysis) and
heterogeneous catalysis (Langmuir adsorption isotherm), Temperature dependence of rate constant, Maxwell-Boltzman distribution of molecular speeds.

Texts books:

1. Engineering thermodynamics. P. K. Nag, Tata McGraw-Hill, New Delhi, 3rd Edition, 2005.
2. Fundamentals of Thermodynamics. R. E. Sonntag, and C. Borgnakke, John Wiley & Sons, 7th Edition, 2008.

Suggested readings:

1. Thermodynamics, an Engineering Approach. Y. A. Cengel and M. A. Boles, McGraw Hill, 7th Edition, 2010.
2. Fundamentals of Engineering Thermodynamics. J. P. Howell and P. O. Buckius, McGraw Hill,2nd Edition, 1992

FE 203: Fluid Mechanics **L2 T1 P1 CR4**

Course outcome:

CO1: State the mechanics of fluids at static and dynamic conditions.

CO2: Ability to compute force of buoyancy and stability of a floating body.

CO3: Ability to apply various equations related to motion of fluid for designing of fluid transmitting system.

CO4: Ability to evaluate pressure drop and energy losses in pipe transition systems of food industry.

Course content:

Definition and properties of fluids: Units of measurements; fluid statics, pressure at a point and its measurement; fluid static force on submerged surfaces, buoyancy, condition of floatation and stability of submerged and floating bodies.

Kinematics of fluids: Lagrangian and Eulerian description of fluid motion, stream lines, path lines, streak lines, types of fluid flow: translation, rotation, circulation and vorticity stream function, velocity potential and flow net; discharge: system, control volume and cross section; stress-strain rate relationship, linear and angular momentum theorems and applications; some exact solutions of Navier-Stokes equations.

Dynamics of fluid: Transport theorem, conservation laws, equation of continuity, Euler'sequation of motion, Bernoulli's equation, viscous flow. Raleigh's method and Buckingham's π theorem, types of similarities, dimensional analysis, dimensionless numbers.

Internal flow: laminar and turbulent flow in pipes, general equation for head loss – Darcy-Weisbach and Fanning's equations, Moody's diagram, energy losses through pipe fittings, flow through network of pipes.

Boundary layer flow-Introduction, Prandtl's boundary layer equation and Boundary layer separation. Flow around submerged bodies: Drag force, lift and drag coefficient, drag on flat plate circular cylinder and sphere.

Flow measurements and pumps: Orifice and venturi meter, pitot tube, rotameter and other flow measuring devices, positive displacement and centrifugal pumps.

Text books:

1. A Textbook of Fluid Mechanics. R.K. Bansal, Laxmi Publ., 1stedition, 2008.
2. Introduction to Fluid Mechanics. R. W. Fox, A. T. McDonald, and P. J. Pritchard, John Wiley and Sons, 6th edition, 2003.

Suggested readings:

1. Introduction to Fluid Mechanics. F. Kreith, CRC Press, London, 1stedition, 2000.
2. Hydraulics and Fluid mechanics, E. H. Lewitt, Issac Pitman and Sons, London, 10th Edition, 2001. Chemical Engineering (Vol. I & II), J. M. Coulson & J. F. Richardson, Butterworth Heinemann, 4th Edition, 2002.
3. Hydraulics and Fluid Mechanics, JagdishLal, Metropolitan Book Co., 9th edition, 2005.

FE 206: Transport Phenomena in Food Engineering

L2 T1 P1 CR4

Course Outcome:

CO1: State and define the basic laws of transport processes and their mechanisms.
CO2: Ability to analyze heat, mass and momentum transfer in food processing operations.
CO3: Ability to analyze heat and mass transfer industrial problems along with appropriate approximations and boundary conditions.
CO4: Ability to solve problems related to heat conduction, convection and radiation in simple geometries.
CO5: Ability to explain the mechanism of different mass transfer operations (diffusional mass transfer, drying, distillation, crystallization and absorption).

Course content:

Introduction to engineering principles: Classification of unit operations and transport processes; Conservation of mass and material balances; Conservation of energy and heat balances.

Momentum transfer: General molecular transport equation for momentum, heat and mass transfer; Viscosity and mechanism of momentum transport: Newton's law of viscosity, Pressure and temperature dependency of viscosity; Types of fluid flow and Reynolds number, Overall mass balance and continuity equation, Overall energy balance, overall momentum balance; velocity profile in laminar flow, Design equations for laminar and turbulent flow in pipes; Flow past immersed object and packed and fluidised bed, measurement of flow of fluids, Non-Newtonian fluids: simple models.

Heat transfer: Steady state heat transfer in conduction, Fouriers law of heat conduction, Thermal conductivity of solids and liquids, Effective thermal conductivity of solids; Convection: Forced convection, Free convection; heat transfer coefficient, Boiling and condensation; Heat exchangers, Heat exchanger effectiveness; Unsteady heat conduction in solids; Energy transport by Radiation, spectrum of electromagnetic radiation, Absorption and emission on solid surfaces, Planck's distribution law, Wien's displacement law and Stefan-Boltzmann's law, Black body.

Mass transfer: Molecular diffusion and Fick's Law; Steady state mass transfer in equimolar counter diffusion and diffusion through stagnant medium; Diffusion through varying cross sectional area; Convective mass transfer coefficient; Unsteady state mass transfer in plate, cylinder and spherical bodies. Analogy between momentum, heat and mass transfer.

Text books:

1. Transport Phenomena in Food Processing Engineering. A.K. Datta, Himalaya Publishing House, 1st edition, 2001.
2. Transport Processes and Unit Operations. C.J. Geankoplis, Prentice Hall publ., New Delhi, 3rd edition, 2000.

Suggested readings:

1. Fundamentals of Heat and Mass Transfer, R.C. Sachdeva, Wiley Eastern Limited, 3rdedition, 2001.
2. Fundamental of Food Process Engineering, R.T. Toledo, CBS publishers, 3rdedition, 1980.
3. Engineering Heat Transfer, C.P. Gupta and R. Prakash Nemchand and Brothers, 4th edition, 1994.

FE 207: Principles of Food Processing & Preservation

L2 T0 P0 CR2

Course outcomes:
CO1: Ability to describe the basic concept of food preservation techniques.
CO2: Ability to describe the various operations involved in industrial processing of foods.
CO3: Ability to identify the processing parameters for implementation on any given food material.
CO4: Ability to determine preservation techniques required to improve the shelf life of foods.
CO5: Ability to analyze the causes of spoilage of foods.

Course content:

Introduction: Definition and scope of Food Science and Technology, historical development of food processing and preservation, general principles of food preservation.

Preservation of food by low temperatures: Chilling; considerations relating to storage of foods at chilling temperature, applications and procedures, controlled and modified atmosphere storage of foods. Freezing temperature: Freezing process, slow and fast freezing of foods and its consequences, other occurrences associated with freezing of foods. Technological aspects of pre-freezing, freezing, frozen storage and thawing of foods. Calculation of freezing time.

Preservation of foods by high temperature: Basic concepts in thermal inactivation of microorganisms-D, z, F values. Heat resistance of microorganisms. Cooking, blanching, pasteurization and sterilization of foods. Extrusion, baking, roasting, frying, dielectric heating, Ohmic, microwave, infrared and radiowave heating. Assessing adequacy of thermal processing of foods, general process of canning of foods, spoilages in canned foods.

Preservation by water removal: Drying of various foods, water activity and its effect on the keeping quality, sorption isotherms and their use. Characteristics of food substances related to their dehydration behaviour, drying phenomenon, factors affecting rate of drying, methods of drying of various food products, type of driers and their suitability for different foods; intermediate moisture foods.

Preservation by irradiations: isotopes and electron based radiations, units and doses, effect on microorganisms and different nutrients; dose requirements for radiation preservation of foods, safe limits, irradiation mechanism and survival curve, irradiation of packaging materials.

Chemical preservations: Principles, technological aspects and applications of sugar and salt, antimicrobial agents, biological agent.

Hurdle technology: definition and applications.
Effects of various food processing operations on the nutritive value of foods.

Text books:

1. Food Processing Technology: Principles and Practices. P.J. Fellows, Woodhead Publishing, Oxford, 3rd edition, 2009.
2. Introduction to Food Process Engineering. Smith, P.G., Springer publ., 2nd edition, 2011.

Suggested readings:

1. Food Processing: Principles and Applications. H.S. Ramaswamy and M.Marcotte,Taylor and Francis publ., 1st edition, 2005.
2. Industrial Drying of Foods.C.G.J.Baker,Blackie Academic and Professional, 1997.

Food science. B. Srilakshmi, New Age International, 2003.

FE 208: Mechanical Operations & Material Handling

L2 T0 P1 CR3

Course Outcome:

CO1: Ability to identify the various mechanical operations of food industry and understand the basic principles of the unit operations.
CO2: Select the basic operations that will be appropriate for the development of a process
CO3: Ability to identify size reduction methods for various applications in food industry and calculate power requirements.
CO4: Ability to demonstrate skills to relate the design aspects of filtration and separation techniques and apply for mechanical operations involved in food industries.

Course content:

Introduction: Geometrical, physical, functional and growth property of foods.

Post-harvest operations: Cleaning, sorting and grading of foods. Peeling, decortication, deseeding of fruits, dehulling of grains, blanching of vegetables.

Size reduction: Principles and types of size reduction equipment, disintegration of fibrous materials. Mechanical expression of edible oil.

Size growth: agglomeration, coating and encapsulation: concept and applications.

Mixing: Mixing of liquids and solids (powder), mixing equipment, mixing index and mixing time, Agitation and blending, types of agitators, power consumption in mixing.

Filtration: Principle and types of filtration equipment, Settling classifiers and Flotation Screening, types of screen.

Centrifugation: Principle of settling and centrifugation, devices for centrifugal separation.
Material handling: material handling systems and their design, material handling equipment-conveyors and chutes.

Text books:

1. Unit Operation of Chemical Engineering, W. McCabe, J. Smith & P. Harriot, McGraw Hill Co., 7th edition, 2005.
2. Food Process Engineering, D.R. Heldman, and R.P. Singh. Academic Press, 4th edition, 2004.

Suggested readings:

1. Chemical Engineering (Vol. I& II), J. M. Coulson & J. F. Richardson, Butterworth Heinemann, 4th edition,2002.
2. Food Engineering Operation, J. G. Brennan, J. R. Butters, N. D. Cowell and A. E. V. Lilly, Elsevier Publ. 1st edition, 1985.
3. Conventional and Advanced Food Processing Technologies. S. Bhattacharya, Willey-Blackwell, 2015.

FE 209: Food Process Calculations

L1 T1 P0 CR2

Course outcomes:

CO1: Solve the materials and energy balances involved in different food processing operations.
CO2: Ability to develop skills in defining problems, collecting data and analyzing the data related to various food processes.
CO3: Ability to apply computer applications as required in solving food engineering problems.
CO4: Ability to calculate the raw material requirement, energy requirement, volume of the product and wastes during industrial food processing operations.

Course content:

Introduction to process engineering calculations: Units and dimensions, the mole unit, conventions in methods of analysis and measurement, basis, temperature, pressure, the chemical equation and stoichiometry.

Gases, vapours, liquids and solids: Ideal gas law calculations, real gas relationships, vapour pressure and liquids, saturation, partial saturation and humidity, introduction to vapour-liquid equilibria for multicomponent systems, material balances involving condensation and vaporization.

Material balances: Material balance of physical processes with and without chemical reactions, including recycle, purge and bypass, Unsteady-state material balances.

Energy balances: Concept and Units, calculation of enthalpy changes, general balance with reactions, heats of solution and mixing with, Unsteady-state energy balances. Computer application for problem solving.

Text books:

1. Basic Principles and Calculations in Chemical Engineering. D.M. Himmelblau, Prentice- Hall of India, 6th edition, 1997.
2. Computer Application in Food Technology. R.P. Singh, Academic Press, 1st edition, 2005.

Suggested readings:

1. Solving Problems in Food Engineering. S. Yanniotis, Springer, 1st edition, 2008.
2. MATLAB manual, Mathworks.
3. Stoichiometry. B. Bhatt and S. Vora, Tata McGraw Hill, New Delhi, 5th edition,2010.
4. Food Process Engineering, D.R. Heldman and R.P. Singh. Academic Press, 5th edition, 2014.
5. Food Engineering in Computer Climate, Institution of Chemical Engineers, Great Britain, 1st edition, 2008.

FE 210: Food Material Science and Engineering

L3 T0 P0 CR3

Course Outcomes:

CO1: Describe qualitatively the bonding scheme, structure and general physical properties of a given food, as well as possible applications in food design.

CO2: Ability to describe the physical origin, as well as the strength of the polymer and colloids based upon type of bond, structure, and other physical properties.

CO3: Ability to describe a polymer's viscoelastic behavior above and below the glass transition.

CO4: Ability to correlate the mechanical properties qualitatively in relevance to food engineering.

Course content:

Strength of materials: Stress and strain, analysis of deformation and strain components. Bending moment and shear force diagram, principal stresses and strains.

Food materials science and engineering- An overview: Introduction: Molecular basis of food materials, observation of materials at various size ranges and size-property relationship, amorphous and crystalline structures of materials, gel structures of food materials, interfacial properties of the food materials, application of materials science in food design and development of engineered food materials.

Food polymers and colloids: Interactions of Food Biopolymers in molecular and colloidal dispersions, functional properties of polymers and colloids, incompatibility of polymers and colloids, phase diagram of food polymers.

Crystalline, glassy and rubbery state of food: introduction, thermodynamics principles, factors affecting and their application in food systems, water plasticization.

Textural and rheological aspect of solid, semi-solid and liquid food: texture measurement of foods, texture measuring instruments, ISO standards of texture measurement, rheological properties of semi-solid and liquid food in connection with the food material science: flow behavior, viscoelastic behavior, extension flow and mechanical models.

Micro and macro structures of food materials and their analysis: measurement of microstructures/nanostructures, the relationship between structure and quality, microstructure and emulsions, structure and sensory perception, process to control the structure of food materials, measurement techniques for micro and macro structures.

Material Science approaches towards food design: State diagram and its interpretation in food design

Text books:

1. Schaum's Outline of Strength of Materials. William Nash McGraw-Hill Education 6th edition 2013 2. Food Materials Science and Engineering. Bhesh Bhandari and Yrjö H. Roos, Wiley-Blackwell 2012.

Suggested readings:

1. Food Materials Science Principles and Practices, José Miguel Aguilera and Peter J. Lillford, Springer Publishers, 2007.
2. Microstructural Principles of Food Processing and Engineering. José Miguel Aguilera, David W. Stanley, Aspen Publication, 2nd edition. 1999.
3. Materials Science and Engineering: An Introduction, William D. Callister, David G. Rethwisch Wiley, 9th edition 2013

FE 301: Instrumentation and Process Control in Food Industry

L3 T0 P1 CR4

Course outcomes:

CO1: Ability to apply sensors for measurement of common food process parameters like pressure, temperature, strain, pH, etc.

CO2: Ability to analyze the system behavior of instrumentation systems for measurement of common food process parameters

CO3: Ability to quantify the performance characteristics of measuring systems.

CO4: Ability to develop mathematical models of physical systems and processes. CO5: Ability to conduct stability analysis.

Course content:

Unit-I: Concept of instrumentation systems, Functional elements, measuring and controlling devices, role of transducers in food processing, classification of transducers, self-generating transducers, variable parameter type, digital transducers, selection of transducers, actuating and controlling devices.

Unit-II: Measurements in Food Processing: Instruments for Moisture measurement, Humidity measurement, Turbidity and Colour measurement, Food flow metering, Viscosity, pH values, Enzymes, Flavour, Texture, Particle size.

Unit-III: Performance characteristics of instrumentation systems- static and dynamic characteristics, first and second order systems and their responses.

Unit IV: Models of physical systems, differential equations, transfer functions in Laplacetransform and ztransform, block diagrams of open and closed loop systems, stability criterions and stability analysis of systems.

Unit V-Controllers (ON/OFF and PID) and indicators in food industries: temperature control in drying and dehydration, flow ratio controller in food pickling, atmosphere control in food preservation, Food sorting and grading control, discrete controllers, adaptive and intelligent controllers, digital controller and PLC.

Text books:

1. Measurement Systems: Applications and Design. E O Doeblin and D N Manik, Tata McGraw Hill, 5th edition, 2003.
2. Industrial Instrumentation, D. Patranabis, McGraw Hill, 2nd edition, 2001.

Suggested readings:

1. Modern Electronic Instrumentation and Measurement Techniques, D. Helfric and W. D. Cooper, PHI, Revised edition, 1990.
2. Modern Control Engineering, K. Ogata K, Prentice Hall of India, 5th edition, 2005.
3. Automatic Control Systems. B C Kuo, Prentice Hall, 7th edition, 2002.

FE 302: Thermal Operations in Food Processing

L2 T1 P1 CR4

Course outcomes:

CO1: Ability to identify different thermal operations and their applications in food industry.
CO2: Ability to explain the effect of thermal processing on the constituents of food.
CO3: Ability to calculate the thermal process lethality and kinetics for various food constituents.
CO4: Ability to evaluate the performance of different thermal processing equipments and accessories
CO5: Ability to estimate commercial sterility of the product.

Course content:

Introduction: Food Properties pertaining to thermal Operations: Thermal; electrical; electromagnetic properties of food. Shrinkage and expansion. Overview of thermal operations carried out in dairy and food processing.

Thermal processing: The kinetics of thermal inactivation of microorganisms and enzymes; D- Value; Effect of the temperature on the rate of thermal destruction/inactivation; Lethality of thermal processes; Optimization of thermal processes with respect to quality; Heat transfer considerations in thermal processing; In-package thermal processing; In-flow thermal processing. Thermal processes, methods and equipment- Thermal processing in hermetically closed containers; Thermal processing in bulk, before packaging; Indirect and direct methods of Pasteurization; Sterilization & UHT processing; Aseptic processing.

Food freezing: Effect of temperature on food spoilage; slow and rapid, Plank's law and estimation of freezing time of foods; equipment used for freezing water in foods, production of crystalline foods, e.g. sucrose and lactose; Freeze drying (lyophilisation) and freeze concentration: Sublimation of water; Heat and mass transfer in freeze drying; Freeze drying, Freeze concentration: Basic principles, The process of freeze concentration.

Drying & dehydration: Thermodynamics of moist air; Convective drying (air drying)- The drying curve, drying rates; heat & mass transfer during drying; Drying under varying external conditions; Conductive (boiling) drying. prediction of drying time from drying data; Dryers in the food processing industry. Issues in food drying technology: Pre-drying treatments, Effect of drying conditions on quality, Post-drying treatments, Rehydration characteristics; Energy consumption in drying.

Concentration and Evaporation: Concentration of liquid foods in batch and continuous type evaporators; heat and energy balance in multiple effect evaporators; design of calendria in the evaporators, falling and rising film evaporators; mechanical and thermal vapour recompression systems. Extrusion cooking: The single-screw extruder; Twin-screw extruders; Advantages and shortcomings; Effect on foods Food applications of extrusion.

Text books:

1. Fundamental of Food Process Engineering. R.T. Toledo, CBS publishers, 3rd edition, 1980.
2. Introduction to Food Engineering By R Paul Singh, Dennis R. Heldman; Academic Press. 5th edition, 2013

Suggested readings:

1. Food Process Engineering and Technology. ZekiBerk, Academic Press. 5th edition, 2013.
2. Physicochemical Aspects of Food Engineering and Processing.SakamonDevahastin, CRC Press, 2011.

Handbook of Food Engineering Practice. Kenneth J. Valentas, Enrique Rotstein, R. Paul Singh, CRC Press, 1997.

FE 303: Separation Techniques in Food Processing

L2 T0 P1 CR3

Course outcomes:

CO1: Ability to describe the various separation process for food application.
CO2: Ability to understand the mass transfer principle and operation in food processing.
CO3: Ability to identify the various extraction and separation processing aspect of food processing.
CO4: Ability to evaluate the mechanism of various extraction and separation process in food processing.
CO5: Ability to recommend the design parameters and process of separation technique for food processing.

Course content:

Introduction: Separation Processes, Mechanism of separation, Separation techniques, separation from solid, liquid , gases and vapours

Gas liquid separation process: Single and multiple equilibrium contact stage, Mass transfer between phases, Continuous humidification process, Absorption in plate and packed tower.

Vapour liquid separation process: Vapour liquid equilibrium relation, Vapour liquid equlibria, boiling point diagram, relative volatility, enthalpy concentration diagram, flash vaporization, differential distillation, steam distillation, azeotropic distillation and extractive distillation for binary system. Continuous rectification, McCabe Thiele method, bubble cap distillation column.

Liquid-liquid and solid-liquid extraction process: Ternary liquid–liquid equilibrium and tie line data, choice of solvents, extraction equipment, leaching principle and equipment.

Gas Absorption: Equilibrium solubility of gases in liquids, ideal and non-ideal solutions. Gas absorption equipment: Gas dispersed- bubble columns, tray towers, liquid dispersed-venturi scrubbers, wetted wall towers, spray tower, packed towers. Concept of NTU, HTU and HEPT. Ideal stage and stage efficiency.

Membrane separation process: principle of membrane processes, types of membrane separation processes: reverse osmosis, ultrafiltration, microfiltration, electrodialysis and pervaporation. gaseous separation by membranes.

Adsorption: Types of Adsorption, nature of adsorbents, adsorption equilibrium, adsorption of a single component from a gas mixture/liquid solution.

Text books:

1. Unit Operation of Chemical Engineering. W. McCabe, J. Smith & P. Harriot, McGraw Hill Co., 7th edition, 2005.
2. Transport processes and separation process principles. C. J. Geankoplis, PHI, 4th edition, 2003.

Suggested readings:

1. Separation Processes in the Food and Biotechnology Industries: Principles. A.S. Grandison, Michael John Lewis, Elsevier publ., 1st edition, 1996.
2. Mass Transfer Operation. R. E. Treybal, McGraw Hill, 3rd edition, 1981.
3. Chemical Engineering (Vol. I& II). J.M. Coulson & J.F. Richardson, Butterworth Heinemann, 4th edition, 2002.

FE 304: Grains and Oilseeds Processing Technology

L2 T0

P1 CR3 Course Outcome:

CO1: Ability to explain physical and chemical properties of cereals, pulses, oilseed and their products.
CO2: Ability to specify different storage structures required for the storage of grains.
CO3: Ability to explain the milling principles and operations of different cereals and pulses. CO4: Ability to apply various unit operations required for processing of different cereals, pulses and oilseeds.
CO5: Ability to demonstrate in grain and oilseed processing based industries.

Course content:

Introduction: Post-harvest quality and quantity losses. Recommended pre-processing practices for handling of cereals, pulses and oilseeds for their safe storage, including control of infestation.

Wheat: Structure, types, composition, quality characteristics and physicochemical properties of wheat. cleaning, tempering and conditioning, and milling processes for different wheat's. Turbo-grinding &air classification. Blending of flours. milling equipment and milling products (Dalia, Atta, Semolina and flour). By-product utilization.

Rice: Structure, types, composition, quality characteristics and physicochemical properties of rice. milling and parboiling of paddy, curing and ageing of paddy and rice, assessment criteria of milling, cooking, nutritional and storage qualities of raw & parboiled rice. Processed rice products (flaked and expanded rice). By-product (husk and rice bran) utilization.

Other cereals and millets: Structure, types and composition of corn. Dry and wet milling of corn. Starch and its conversion products. Processed corn products (popped corn, corn flakes etc.) Structure and composition of barley, bajra, jowar and sorghum. Pearling of millets. Parched and snack products.

Cereal Malts: basic malting process, malting plant, malt storage, malt characteristics, malt extract, uses.

Pulses: Pulses production, types, chemical composition, toxic factors, milling of pulses, milling equipment, factors affecting pulses quality, secondary processing of pulses, processed products, fermented products, traditional products, by products utilization; effect of processing on nutritive value.

Oilseeds: Processing of oilseeds, oil extraction methods- mechanical (ghani and expellers) and chemical methods (solvent extraction), oil refining, processing of refined oils.

Text books:

1. Hand Book of Cereal Science and Technology. K. Kulp and J. G. Ponte. Jr., CRC, 2nd edition, 2000.
2. Cereals Processing Technology, G. Owens, Woodhead Publishing, 2nd edition, 2001.

Suggested readings:

1. Bailey's Industrial Oil & Fat Products. D. Swer, John Wiley & Sons, 5thedition, 2005.
2. Cereals and Cereal products: Chemistry and Technology, Vol. 4, D.A.V. Dendy and B.J.Dobraszczyk, Springer, 1st edition, 2001.
3. Rice: Chemistry and Technology.B.O.Juliano, AACC, 2nd edition, 1985.
4. Wheat: Chemistry and Technology.Y.Pomeranz, AACC, 3rd edition, 1988.
5. Oils and Fats manual. A. Karleskind, Lavoisier Publisher, Paris, 1st edition, 1996.

FE 305: Food Analysis and Quality Control

L3 T0 P1 CR4

Course Outcomes:

CO1: Ability to explain the importance of nutrition labelling on food package and methods of sampling.

CO2: Ability to analyse the food for its physical and chemical characteristics including proximate analysis of food.

CO3: Ability to estimate the characteristics of food products thorough use of sensory evaluation and correlate with instrumental analysis.

CO4: Ability to implement food analysis skills for quality control in food industries.

Course content:

Introduction to food analysis: Introduction, nutrition labelling, evaluation of analytical data, sampling and sample preparation,good laboratory practices and data validation.

Physical, chemical and microbial analysis of foods: Physical characteristics of food: size, shape, porosity, density, drag coefficient, sphericity, surface area etc., proximate analysis of food, pH and titratable acidity, vitamins and minerals, characterization of oils and fats, total microbial count.

Instrumentation in Food Analysis: Principle and working of water activity meter, pH meter,refractometer, butyro refractometer; Spectroscopic methods of food analysis, General principles of colorimeters and spectrophotometers, hunter color lab; Basic principles of chromatography;paper, thin layer, gas liquid, ion exchange and affinity chromatography.Electrophoretic techniques: general principles, paper and gel electrophoresis. Polyacrylamide gel electrophoresis.Texture measurement: empirical, imitative and fundamental methods.

Sensory evaluation of food products

Sensory attributes, Selection of panel of judges, Prerequisite for sensory analysis, application of consumer tests; control of factors affecting of sensory verdict, sensory evaluation methods. Correlation between instrumental and Sensory analysis of food quality attributes, ISO methods.

Text books:

1. A First Course in Food Analysis.V. Sathe, New Age International Pvt. Ltd., 1st edition, 1999.
2. Food Analysis Laboratory Manual. S. S. Nielsen, Springer, 2nd edition, 2010.

Suggested readings:

1. Modern Electronic Instrumentation and Measurement Techniques, D. Helfric and W. D. Cooper, PHI, Revised edition, 1990.
2. Modern Control Engineering. K. Ogata K, Prentice Hall of India, 5th edition, 2005.
3. Hand Book of Analysis and Quality Control for Fruits and Vegetable Products. S. Ranganna, Tata McGraw Hill, 3rd edition, 2002.

FE 306: Food Packaging Technology

L2 T0 P1 CR3

Course Outcomes:

CO1: Ability to explain the functions and properties of various packaging materials and check their performance.

CO2: Ability to implement advance food packaging system for safety of food.

CO3: Ability to apply the packaging laws, regulations and appropriate packaging machineries for food industries.

CO4: Ability to demonstrate skills for selecting suitable packaging materials and technique for packaging of food items.

Course content:

Introduction: Basic concept of packaging, functions of a food package, package development factors, food package development, current status and trends in food packaging in India and abroad.

Packaging materials: Metalcontainers made up of tin-plate, tin free steel, aluminium etc., Protective lacquers and coatings for metal containers. Glass containers and closures. Paper and paper based packaging materials. Plastic polymers and plastic based flexible and rigid packaging materials.

Special packaging: Gas, vacuum and aseptic packaging, MAP, CAS, advances in food packaging: Smart packaging, Intelligent Packaging, Active Packaging and Antimicrobial packaging, Retortable pouches, biodegradable and edibles packaging materials and films.

Evaluation of packaging material: Destructive and non-destructive test, testing of rigid, semi rigid and flexible packaging material, shelf life study etc. corrosion and toxicity of packaging material.

Packaging laws and regulations: Printing techniques; Package labeling: functions and regulations; Environmental aspect of food packaging, Bar coding.

Packaging machinery: Types of packaging machineries, form fill and seal machine, liquid filling machine, vacuum packaging machinery and other advance machineries.

Food product characteristics and package requirements: Application in different food products.

Text books:

1. Food Packaging Principles and Practices. G. L. Robertson, Marcell Decker, 2nd edition, 2006.
2. Innovation in Food Packaging. J.H. Han (Ed), Elsevier Publications, 1st edition, 2005.

Suggested readings:

1. Food Packaging Technology. R. Coles, D. McDowell and M. J. Kirwan, CRC Press, 1st edition, 2003.
2. Novel Food Packaging Techniques. R. Ahvenainen (Ed), Woodhead Publishing, 1st edition, 2003.
3. Hand Book of Canning and Accepting Packaging, S. Ranganna, Tata McGraw Hill, 1st edition, 2000.

FE 307: Food Process Equipment Design

L2 T1 P0 CR3

Course Outcome:

CO1: Ability to identify the proper plant design and layout for the specific food industry
CO2: Ability to select appropriate material haling and flow system or the food processing.
CO3: Ability to calculate the financial analysis of any food processing plant
CO4: Ability to design plan layout for food processing plant

Course content:

Introduction to design: Fundamentals of material and energy balance calculations for preliminary estimation of plant capacity and equipment sizes. Preparation of flow sheets for material movement and utility consumption in food plant. Materials for construction for food processing machineries; Food-Metal Interactions, Material Properties; Mechanical Properties; Corrosion resistance; Plastics as materials of construction for plans Plants

Mechanical Design of Process Equipment: General design considerations: Pressure vessels design; The Design of Thin-Walled Vessels Under Internal Pressure, design of solid and liquid food conveying systems: pipe, fittings and valves. Performance characteristics and selection of fans, blowers, centrifugal and positive displacement pumps. Design of CIP system.

Design of heat exchange equipment: Plate, shell & tube. Design of evaporator.

Design of dryers: Batch and continuous types.

Text books:

1. Handbook of Food Processing Equipment. George Saravacos and Athanasios E. Kostaropoulos, Springer 2nd edition, 2016.
2. Chemical Engineering Design; Principles, Practice and Economics of Plant and Process Design. Gavin Towler& Ray Sinnott, Butterworth-Heinemann publ.,2nd edition,2012.

Suggested readings:

1. Process Equipment Design - Vessel Design. L. E. Brownell and E.H. Young, Wiley NewYork, 2nd edition, 1968.
2. Dairy Plant Engineering and Management. T Ahmad, KitabMahal, 8th edition, 2009.
3. Chemical Process Equipment: Selection and Design. J.R. Couper, W. R. Penney, J. R. Fair, S.M. Walas; Butterworth Heinemann series in Chemical Engineering, 3rd edition, 2009.

FE 308: Process Technologies of Fruits and Vegetables

L2 T0 P1 CR3

Course outcomes:

CO1: Ability to examine the pre and post-harvest physiology of fruit and vegetables and asses its quality.
CO2: Ability to identify the post-harvest handling methods for fruits and vegetables and their effects on shelf life.
CO3: Ability to analyse the effect of storage and processing conditions on the quality of fruit and vegetable products.
CO4: Ability to state the regulations and specifications related to fruit and vegetable-based products. CO5: Ability to demonstrate skills for preparation of fruits and vegetable based products following industrial practices.

Course content:

Fruits and vegetables as living products: Current status of production and processing of fruits and vegetables and vegetables. Chemical composition; pre harvest changes, maturity standards for storage, grading methods and desirable characteristics of fruits and vegetables of processing.

Post-harvest handling of Fresh Fruits and Vegetables: Post-harvest changes**,** role of plants growth regulators in relation to storage, respiration, transpiration; physical and chemical treatment to increase the shelf-life, conditions for transportation and storage, disease and injuries during marketing, flavour characteristics. Primary processing. **Minimally processed Fruits and Vegetables**: Factors affecting shelf life and the quality of minimally processed fruits and vegetables, hurdle technology approach for processing of fruits and vegetables, physiology of fresh cut fruits and vegetables.
Role of enzymes in fruits and vegetables processing, browning reactions in fruits and vegetables, inhibition and control of browning reactions. Blanching.

Preservation by chilling, freezing, canning and drying: Principles, methods and application for the manufacture of different food products.

Processing of Fruits and vegetable: Preparation of juice, syrups, squashes, cordials, and nectars; concentrations and drying of juice, packaging, storage, concentrations and powders; fortified soft drinks, tomato product and its quality control, Vinegar production and its uses and quality control. Preparation of various types of pickles- theory and practice; preparation of sauces and chutneys; problems relating to the shelf life of pickles and chutneys; quality control.

Food additives: Sources and uses of food additives. GRAS.

Text Books

1. Processing Fruits: Science and Technology, Vol. I, Biology Principles and Applications, L. Somogyi, Woodhead Publishing, 1st Edition, 1996.
2. Postharvest – An introduction to the Physiology and Handling of Fruit and Vegetables, R.B.H. Wills, W.B. McGlasson, D. Graham, T.H. Lee and E.G.Hall, CBS Publishers & Distributors PvtLdt

Suggested readings:

1. Hand Book of Analysis and Quality Control for Fruits and Vegetable Products, S. Ranganna, Tata McGraw Hill, 3rd Edition, 2002.
2. Processing Fruits: Science and Technology, Vol II: Major Processed Products. L. Somogyi, D. M. Barette and Y.H. Hui, Woodhead Publishing, 1st Edition, 1996.
3. Processing Fruits: Science and Technology, D.M. Barrett, L. Somogyi and H.S. Ramaswamy, Woodhead Publishing, 2nd Edition, 2004.

FSSAI Manual of Methods of Analysis of Foods – Fruits and Vegetable Products, 2016.

FE 309: Biochemical Engineering

L2 T0

P1 CR3 Course outcomes:

CO1: Ability to calculate the kinetics of growth of microorganisms and various chemical reactions occurring in biological systems and processes.
CO2: Ability to explain engineering principles involved in development and analysis of various biochemical processes.
CO3: Ability to explain the processing of various raw materials to useful products using biological agents such as enzymes, microorganisms, plant and animal cells.
CO4: Ability to develop the designing parameters of various types of bioreactors for biological processes.
CO5: Ability to identify the various downstream processes for purification of products.
CO6: Ability to analyze the principles of transport processes in biological systems and processes.

Course content:

Basic concepts: Historical development of bioprocess technology, an overview of traditional and modern applications of biotech process, Outline of integrated bioprocess and various (upstream and downstream) unit operations involved in biochemical engineering, generalized process flow sheets.
Kinetics of microbial growth and product formation. Phases of cell growth in batch cultures, Simple unstructured kinetic models for microbial growth, Monod model, Growth of filamentous organisms. Growth associated (primary) and non-growth associated (secondary) product formation kinetics.

Fermentation process: Overview of aerobic and anaerobic fermentation processes and their application in biotech industry, Solid substrate and submerged fermentation and its application.

Bioreactor Design: Basic design and construction of fermenter and ancillaries. Material of construction for fermentation process equipment. Main parameters to be monitored and controlled in fermentation processes. Design of spargers, aerators and agitators. Fermenter types. Modelling of batch, fed batch and continuous Fermenters.

Downstream processing operations; Cell disruption, Solid-liquid and liquid-liquid separation processes, Extraction, Microfiltration, membrane filtration and centrifugal separation techniques, Chromatographic techniques for separation, drying of products; Biochemical process control and instrumentation.

Immobilized enzyme technology: enzyme immobilization, industrial processes, utilization and regeneration of cofactors. Immobilized enzyme kinetics: effect of external mass transfer resistance, analysis of intraparticle diffusion and reaction.

Industrial production of important products; Production of enzymes- sub merged fermentation and semisolid fermentation techniques: Industrial production of fermented food products.

Text books:

1. Biochemical Engineering Fundamentals, J. E. Bailey, F. Oilis, Tata McGraw Hill, 3rd Edition, 2010.
Bioprocess Engineering- Basic Concepts, M. L. Shuller, F. Kargi, Matthew DeLisa, Prentice Hall, 3rd Edition, 2017.

Suggested readings:

1. Principles of Fermentation Technology, P.F. Stanbary, A. Whitaker, Hall, 3rd Edition, Elsevier Publ. 2016.

FE 401: Dairy Products Technology **L2 T0 P1 CR3**

Course Outcome:

CO1: Ability to interpret the chemistry underlying the properties and reactions of various milk constituents; the basics of physic-chemical changes in milk and milk products.
CO2: Ability to identify and aware of basic principles behind milk product development.
CO3: Ability to predict the processes involved in milk & milk product development.
CO4: Ability to display the practical skills related with quality aspects of milk and milk based products.
CO5: Ability to apply the skills related to processing, preservation of milk and its products at industrial scale.

Course content:

Milk production and consumption in India, white revolution, clean milk production.

Chemistry of milk: milk composition and structure, physical, chemical and microbiological changes in milk, **Milk components** – lactose, salts, lipids, proteins, enzymes, other components. Milk properties – solutiom properties, acidity, redox potential, flavour, density, optical properties, viscosity

Microbiology of milk: General aspects, undesirable microorganisms, source of contamination, hygiene measures.

Milk processing: General aspects of processing - Bulk cooling of milk, storage and transportation, milk collection and reception (RMRD), pilot test and payment method, standardization.

Cream separation: Principle of centrifugal separation, effectiveness, cut-off diameter and energy requirement, different types of centrifuges, application in dairy industry, clarifiers, tri-processors, cream separator, self dislodging, centrifugation, bactofugation.

Homogenization: Principle of homogenization, Classification of homogenization, single and two stage homogenizer pumps, power requirement, aseptic homogenizer.

Pasteurization and Sterilization: Process and equipment for milk pasteurization: Batch, flash and continuous (HTST) pasteurizers, flow diversion valve, pasteurizer control, direct and indirect sterilization; Ultra - High - Temperature (UHT) sterilization. Fouling of pasteurizers and sterilizers. Aseptic packaging. Technology and standards of commercial liquid milk products: toned, double toned products, reconstituted, recombined milk etc.

Heat desiccated products: Khoa: classification, standards methods of manufacture and preservation factors affecting yield of khoa, physicochemical changes during manufacture and storage of khoa, mechanization in manufacture of khoa, khoa based products.

Cultured/Fermented milk products: Dahi and yoghurt: standard methods of manufacture, packaging and preservation, cheese, Traditional products: Srikhand, and lassi.

Heat-acid coagulated milk products: Chhana- product description, standard methods of manufacture, packaging and preservation, chhana based products. **Fat rich products**: Cream and butter, butter oil, ghee.

Dairy by-products: butter milk, whey and whey based products, ghee residues, lactose, caseinates etc.

Text Books:

1. Dairy Technology: Principles of Milk Properties and Processing, P. Walstra, T.J. Geurts, A. Noomen, and J.S. Van Boekel, Marcel Dekker, Illustrated Edition, 1999.
2. Outlines of Dairy Technology, Sukumar De, Oxford University Press, 3rd Edition, 2006

Suggested readings:

1. Dairy processing & Quality assurance, Chandan RC, Kilara A & Shah NP, Blackwell publishing, 2008
2. Milk processing and Quality management, Tamime AY, Blackwell publishing, 2009

FE 402: Plantation Products and Spices Processing Technology L2 T0 P1 CR3

Course Outcome:

CO1: Ability to explain processing and working of machineries involved in processing Tea, Coffee, Cocoa and different spices.

CO2: Ability to identify the changes takes place during processing and handling of plantation products.

CO3: Ability to utilize plantation crops for preparing various products like tea and coffee beverages, chocolates etc.

CO4: Ability to demonstrate the skills in tea, coffee and spices based manufacturing industries.

Course content:

Production and processing of Plantation products and spices in India, post-harvest technologies, challenges and scope in the market.

Tea: Production and processing of Tea leaves, Black tea, Green tea and Oolong tea. chemistry of tea manufacturing and tea quality; tea aroma precursors; tea flavour; tea grades; storing of tea Instant tea, tea concentrates, decaffeinated tea, flavoured tea; herbal tea.

Coffee: Production and processing of coffee cherries by wet and dry methods to obtain coffee beans, grinding, storage and preparation of brew, Soluble /Instant coffee, Use of chicory in coffee, decaffeinated coffee.

Cocoa: Production, processing and chemical composition of cocoa beans. Cocoa Processes: Cleaning, roasting, alkalization, cracking and fanning, Nib grinding for cocoa liquor, cocoa butter and cocoa powder. Manufacturing process for chocolate: Ingredients, Mixing, Refining, Conching, Tempering, Moulding etc.
to obtain chocolate slabs, chocolate bars. Enrobed and other confectionary products.

Nuts: Composition, structure and characteristics and stability of cashew nut, almond, walnut, pistachio etc. and product technology of dried nuts.

Spices: Types, classification, production, processing equipment, pre-harvest and post-harvest problems in processing, properties, drying, storage and packaging, health benefits; flavouring components; spice powder and paste: their processing, quality, storage; spice based food additives; volatiles, essential oils and oleoresins: their characteristics, extraction procedure, encapsulation of spice extracts and utilization.

Textbooks:

1. Banerjee, B. Tea Production and Processing, (Oxford & IBH Pub. Co., 1993)
2. Sivetz, M. Coffee Technology, (AVI publishing Co., 1979)

Suggested readings:

1. Purthi, J. S. Major Spices of India: Crop Management and Post Harvest Technology, (ICAR publication, 2003)
2. Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices by A. Chakraverty, A. S. Mujumdar, H. S. Ramaswamy
3. Handbook of Fruit Science and Technology: Production, Composition, Storage, and Processing. D. K. Salunkhe, S. S. Kadam, CRC Press, 1st Edition, 1995.
4. Handbook of Herbs and Spices by K. V. Peter, Woodhead Publishing, 2012

FE 421: Meat, fish and poultry processing **L3 T0 P0 CR3**

Course outcomes:

CO1: Ability to describe the composition and structure of the meat from different animals.
CO2: Outline the process involved in the antemortem and postmortem handling of animal.
CO3: Ability to identify critical factors involved in meat, fish and poultry processing industry.

CO4: Ability to describe the quality characteristics of the processed meat, poultry and fish products.

Course content:

Introduction: World production of fish, meat and poultry, consumption pattern and nutritive value

Meat: Characteristics and structure of meat muscle, abattoir design. Ante-mortem examination of meat animals, scientific techniques of stunning and slaughtering; carcass evaluation; muscle contraction, water holding capacity, post mortem changes, meat colour, meat tenderizer; Processing of meat and meat products: freezing, cooking, drying, curing, smoking; composition of smoke, carcinogenic contents, additives used; manufacture of sausages, comminuted meat products: ham, bacon, meat analogues; effect of processing on nutritive value; hygiene in meat processing, spoilage of meat, contaminants and naturally occurring toxicants; packaging of meat and meat products; by product utilization; waste from meat industry.

Poultry: characteristics and structure of poultry muscle, Pre-slaughter care and consideration; Operations in preparation of dressed poultry, its storage and marketing, processing of poultry. Egg: structure, composition, nutritive value, egg products, dehydrated egg powder. Effect of processing on nutritive value; additives used in poultry products; by product utilization; waste from poultry industry.

Fish: characteristics and structure of fish muscle, Effect of method of catching and handling on the quality of fish; handling fish from catching to transportation; post mortem changes, rigor mortis, autolytic changes, bacteriological changes, rancidity, physical changes; preservation of fish by different methods: chilling, freezing, modified atmosphere packaging, canning, curing, marinate; changes in fish proteins on storage; manufacture of fish protein concentrate, fish sauce, fermented fish: traditional products of the North East; packaging of fish; hygiene in fish processing spoilage of fish; effect of processing on nutritive value; contaminants and naturally occurring toxicants in fish; by product utilization; waste from fish industry.

Textbooks:

1. Poultry Meat Processing and Quality. G. C. Mead (Ed), Woodhead Publishing, 1st Edition, 2004.
2. Fish Inspection, Quality Control and HACCP. R. Martin, R. Collete and J. Slavin (Eds), Technomic Publishing Co., 1st Edition, 1997.

Suggested readings:

1. Meat Science and Applications. Y. H. Hui, W K. Nip and R. W. Rogers, O. A, Young, Marcel Dekker, 1st Edition, 2001.
2. Meat Products: Technology, Chemistry and Microbiology. A.H. Varnam and J.P. Sutherland, Food Products Series: Vol III, Chapman Hall,1st Edition,1995.

FE422: Bakery and Confectionery Technology L3 T0 P0 CR3

Course Outcome:

CO1: Ability to describe the role of ingredients involved in bakery and confectionery products.
CO2: Ability to identify the equipment involved in production of bakery and confectionery products.
CO3: Ability to assess the quality of bakery and confectionery products.
CO4: Ability to recall the standards and regulations of bakery and confectionery industries. CO5: Ability to demonstrate skills in bakery and confectionery industries.

Course content:

Status of bakery and confectionery industries in India, raw materials for bakery and confectionery products- essential and optional. quality parameters for bakery ingredients.

Bakery products technology: methods for dough quality measurements, dough rheology, bread making, methods, specification for various types of breads, manufacturing process for biscuit, cookies, crackers, cakes, buns, preservation of bakery products, spoilage in bread.

Bakery machinery and equipment: Bakery layout, weighing equipment- manual scale, automatic weigh,
liquid measuring. mixing- blenders, horizontal and vertical planetary, continuous mixers. make up equipment- divider, rounder, proofer, molder and other baking equipment.

Confectionery products: confectionery products- chocolate, fondant, caramels, fudge and toffee. equipment and process, quality parameters, standards and regulations for confectionary products.

Safety and sanitation: health and safety- food safety rules and regulations for bakery and confectionery products- safe practices in the work places- sanitation- duties of the sanitation equipment's- code for hygiene condition in bakery and confectionery manufacturing

Text Books

1. Bernard. W. Minifie., PhD "Chocolate, Cocoa, and confectionery" (Science and Technology), 3rd edition, CBS publishers and Distributors,New Delhi- 110002.

Suggested readings:

2. The complete technology book on bakery products" by NIIR Board.
3. DubeyS.C.,"Basic Baking", Science and craft "The prevention of food adulteration ACT", by Akalank publication, Delhi 1954.
4. Indian standards Glossary of terms relation to flour milling industry" by Indian standard institution, New Delhi.
5. Baking problems solved

FE 423: Oils and Fats Technology **L3 T0 P0 CR3**

Course Outcome:

CO1: Ability to describe the oil extraction technologies.
CO2: Ability to explain the processing technologies for fats.
CO3: Ability to describe the differences in quality of oils from different sources.
CO4: Ability to identify major chemical reactions that limit shelf life of foods. CO5: Ability to determine the quality of fats and oils.

Course content:

Sources, chemical composition, physical and chemical characteristics, functional and nutritional importance of edible oils and fats. Post-harvest handling, storage and processing of oilseeds for direct use and consumption, specification of edible oils and fats.
Extraction of oil by mechanical expelling and solvent extraction, Processing of other plant sources of edible oils and fats like coconut, cottonseed, rice bran, maize germ, groundnut etc.
Refining: Clarification, degumming, neutralization (alkali refining), bleaching, deodorization and desolventization techniques, Blending and enrichment of edible oils.
Processing of refined oils: Hydrogenation, fractionation, winterzation, inter-esterification etc. for obtaining tailor-made fats and oils.
Production of butter oil, lard, tallow, margarine, cocoa butter equivalents, shortenings, low fat spreads, peanut butter etc. Speciality fats and designer lipids for nutrition and dietetics.

Text Books:

1. Edible oil Processing. W. Hamm and R.J. Hamilton (Eds), CRC Press, 1st Edition, 2000.
2. Fats in Food Technology. K.K. Rajah, Sheffield Academic Press, 1st Edition, 2002.

Suggested readings:

1. Oilseed Processing for Small Scale Producers. J. Bachmann, ATTRA Publication, 1st Edition, 2004

FE 424: Functional Foods

L3 T0 P0 CR3

Course outcome:

CO1: Ability to describe the components of nutraceutical and functional foods

CO2: Ability to understand the evidence required for efficacy and safety assessment of nutraceutical and functional foods.

CO3: Understand how functional foods act as potential health benefits and what food sources they come from.

CO4: Ability to apply skills to critically evaluate the functionality and safety of foods in the context of human health.

Course content:

Scope, importance of functional foods for health, nutraceuticals, infant and baby foods, adolescent/ teen age foods, foods for pregnant women and nursing mothers, geriatric foods.
Food recommended and restricted in metabolic disorders and disturbances, gastrointestinal disorders; fever and infection; liver, gall bladder and pancreatic disturbances; blood, circulatory and cardiac diseases; urinary and musculoskeletal diseases; allergies.
Nutritional deficiencies and its correction trough fortification and supplementation of foods. Beneficial effect of spices, honey, spirulina etc.
Health benefits/ mode of action of PUFA/ gamma linolenic acids, antioxidants, dietary fiber, oligosaccharides, sugar alcohols, peptides and proteins, glycosides, alcohols, iso-prenoides and vitamins, choline, LAB, phenolics, flavonols, minerals and other miner food constitutes as reported in literature. Transgenic plant foods with health claims. Prebiotics and Probiotics.

Text Books:

1. Human nutrition: A textbook of nutrition in health and disease. B. T. Burton, McGraw Hill, 3rd Edition, 2002.
2. Nutrition and Dietetics. S. A. Joshi, Tata McGraw Hill Co. Ltd., 2nd Edition, 2003.

Suggested readings:

1. Dietetics. B. Shrilakshmi, New Age International (P) Ltd., New Delhi, 5th Edition, 2005.
2. Nutrition and Dietetic Foods, A. E. Bender, Chem. Pub. Co. New York, 2nd Edition, 2004.
   Basic Nutrition in Health and Disease. P. S. Howe, W. B. Saunders Company, London, 2nd Edition, 2003.

FE 425: Traditional Indian Foods

L3 T0 P0 CR3

Course Outcome:

CO1: Ability to classify the various types of tradition food product of India

CO2: Ability to identify the category of food product

CO3: Ability to explain the invention and processing aspect related to food product CO4: Ability to support the entrepreneur of traditional Indian food

Course content:

Introduction to traditional foods of India, composition and nutritive values, microbial and biochemical diversity, quality and food safety challenges

Processing & Preservation methods of Sweets & Desserts: Kulfi, Falooda, Kheer, khurchan, khoa/mawa, Rabri, jalebi, imarti, Gulabjamun, Peda, petha, rewdi, gajak, milk cake, balushahi, balmithai, singoni, Rasmalayi, Gulqand, ghevar, rasgolla, chamcham, son halwa, son papri, several varieties of halwa, laddu, barfi&rasgolla, chhanapoda and chhanajhilli

Traditional fermented foods: Idli, dosa, Vada, khammandhokla, Dahi (Curd), Srikhand

Processing & Preservation methods of Snacks: Gujiya, kachauri, samosa, mirchibada, kofta, potato chips, banana-chips, mathri, bhujiya, fried dhals, bhujia, shakarpara, pakora, vada.

Processing & Preservation methods of Baked Products: Toast, Candies, Cookies, Roti, Naan, Tandoori Roti, parotha, kulcha, puri, bhatura.

Processing & preservation methods of preserves & beverages: Murabba, sharbat, pana, aampapad, sharbat, coconut water, tea, milk (khas, rose), Alcoholic beverages

Puffed, popped and flaked rice

Jaggery and jaggery based products

Industrialization, socioeconomic conditions and sustainability of traditional foods.

Text Books:

1. Handbook of Indigenous Fermented Foods. K.H. Steinkrus (Ed), Marcel Dekkar Inc. 2nd Edition, 1998.
2. Outlines of Dairy Technology. Sukumar De, Oxford University Press, 1st Edition (PB), 2009.

Suggested readings:

1. The Food of India. P. Wickramasinghe, and C. Selva Rajah (Eds), Oberoi Group, Periplus, 1st Edition, 2001.
2. Technology of Indian Milk Products. R. P. Aneja, B.N. Mathur, R.C. Chandan,and A.K. Banerjee, (Eds), Dairy India Year Book, 2009.

   Fundamentals of Indian Cooking. RakeshMangal, Subling Publication,2nd Edition, 2003

FE426: Recent Trends in Food Processing

L2 T1

P0 CR3 Course Outcome:

CO1: Ability to apply advance thermal techniques for the processing and preservation of food products.

CO2: Ability to explain the mechanism of advance thermal and non thermal processing for food product.

CO3: Ability to design membrane system for the recovery of bioactive components.

CO4: Ability to apply encapsulation /nanoecapsulation technique for food processing.

Course content:

Recent trends in thermal processing of foods: Heat Sterilization, UHT, Aseptic Packaging, Baking and Roasting, Frying; Microwave assisted Heating and its application.

Recent trends in drying technology: Superheated steam; FBD drying & coating; VFD; Refractance window; different mode of spray drying and hybrid drying.

High pressure processing of Foods: Principles and applications to food systems, effect on textural, nutritional and microbiological quality, High pressure freezing: principles and applications.

Electric field application in food: Principles of pulse electric processing and Ohmic heating. Main processing parameters, equipment, mechanism of microbial and enzyme inactivation, safety aspects. Applications in food systems.

Electromagnetic wave applications in food: Radio frequency heating, IR, Microwave.

Ultrasound: Principle of ultrasound – Fundamentals – Ultrasound as a processing and preservation aid.

Advanced food processing technology: Membrane processing for the recovery of bioactive compounds; Vacuum and pressure frying; Biosurfactants as Emerging Additives in Food Processing; Nanotechnology and its application; Cold plasma technology and electron accelerator technology.

Advances in food quality assurance: E-nose and E-tongue and other advanced biosensors

Text Books:

1. Da-wen Sun: Emerging Technologies for Food Processing, Elsevier Academic PressMarcel Dekker Inc. NY (1995)
2. Novel Food Processing Technologies (Food Science and Technology Series) by Gustavo V. BarbosaCanovas, Maria S. Tapia, M. Soledad Tapia, M. Pilar Cano, Publisher: CRC Press.

Suggested readings:

1. Leistner L. and Gould G. Hurdle Technologies – Combination treatments for food stability safety and quality, Kluwer Academics / Plenum Publishers, New York (2002)
2. Emerging Technology for food processing, Da-Wen Sun, Academic Press
   Innovation and Future Trends in Food Manufacturing and Supply Chain Technologies, edited by Craig Leadley

FE427: Process Modelling and Simulations

L3 T0

P0 CR3 Course outcomes:

CO1: Ability to prepare flowsheet of food processing operations.

CO2: Ability to identify the design, operating and performance parameters in food processing operations.

CO3: Ability to develop first principle based model equations for unit operations in food processing.

CO4: Ability to solve, validate and analyze for sensitivity of model equations.

CO5: Ability to design experiments and develop models for mapping process outputs to inputs and process parameters.

Course content:

Introduction: The Role of Models in Process Systems Engineering; A Systematic Approach to Model Building; Conservation Principles; Constitutive Relations; Basic mathematic tools for model solution.

Dynamic Models: Dynamic Models - Lumped Parameter Systems; Solution Strategies for Lumped Parameter Models; Dynamic Models - Distributed Parameter Systems Solution Strategies for Distributed Parameter Systems; Process Model Hierarchies

Model Analysis: Basic Tools for Process Model Analysis; Statistical Model Calibration and Validation; Analysis of Dynamic Process Models; Process Modeling for Control and Diagnostic Purposes; Modeling Discrete Event Systems;

Computer Aided Process Modeling: Modeling Hybrid Systems; Modeling Applications in Process Systems; Computer Aided Process Modeling; Empirical Model Building.

Food Process Modeling: Mathematical modeling of common food processes: heating, thermal processing, drying, evaporation, size reduction.

Text Books:

1. Hangos, K. M. and Cameron, I. T. Process Modelling and Model Analysis, (Academic Press, 2001)
2. Tijskens, L.M., Hertog, M.L., Nicolaï, B.M., (eds). Food process modelling. (Woodhead Publishing; 2001)

Suggested readings:

1. Ozilgen, M. Food process modeling and control: chemical engineering applications, (Gordon and Breach Science Publishers, 1998)
   Bakalis, S., Knoerzer, K., Fryer, P.J., (eds). Modeling food processing operations. (Elsevier, 2015)

FE 428: Refrigeration, Air Conditioning and Cold Storage

L2 T1 P0 CR3

Course outcomes:

CO1: Ability to describe the commonly used refrigerants and refrigeration systems
CO2: Calculate the thermal effectiveness of a vapor compression / vapor absorption refrigeration systems and storage space
CO3: Ability to estimate the size and capacities of components of refrigeration systems, cold storages, air food chilling systems and food freezing systems
CO4: Ability to calculate the rate of freezing, ventilation system requirement in storage space. CO5: Ability to explain the operational and maintenance requirements of food refrigeration and freezing related equipment and systems

Course content:

Introduction: Introduction to Refrigeration – Unit of Refrigeration and C.O.P.– Ideal Cycles- Refrigerants Desirable Properties – Classification – Nomenclature – ODP & GWP.

Vapour compression refrigeration system: Vapor Compression Cycle: P-H and T-S Diagrams – Deviations from Theoretical Cycle – Subcooling and Super Heating- Effects of Condenser and Evaporator Pressure on COP- Multipressure System – Low Temperature Refrigeration – Cascade Systems – Problems. Equipments: Type of Compressors, Condensers, Expansion Devices, Evaporators.

Other refrigeration systems: Working Principles of Vapour Absorption Systems and Adsorption Cooling Systems – Steam Jet Refrigeration- Ejector Refrigeration Systems- Thermoelectric Refrigeration- Air Refrigeration – Magnetic – Vortex and Pulse Tube Refrigeration Systems.

Air conditioning systems and load estimation: Air Conditioning Loads: Outside And Inside Design Conditions; Heat Transfer Through Structure, Solar Radiation, Electrical Appliances, Infiltration And Ventilation, Internal Heat Load; Apparatus Selection; Fresh Air Load, Human Comfort & IAQ Principles,
Effective Temperature & Chart, Calculation Of Summer & Winter Air Conditioning Load; Classifications, Layout Of Plants; Air Distribution System; Filters; Air Conditioning Systems With Controls: Temperature, Pressure And Humidity Sensors, Actuators & Safety Controls.

Cold Storage: Small and large commercial storages, Cold Room temperatures, Insulation, properties of insulating materials, air diffusion equipment, Doors and other openings. Cold load estimation; prefabricated systems, walk-in-coolers, and Refrigerated container trucks: Freezer Storages, Freezer room Temperatures, insulation of freezer rooms: Pre-cooling and pre freezing. Cold Storage practice, Stacking and handling of material in and around cold rooms, Optimum temperatures of storage for different food materials-meat and poultry products, marine products, fruits and vegetables, spices and food grains.

Text Books:

1. Arora, C.P., "Refrigeration and Air Conditioning", 3rd Edition, McGraw Hill, New Delhi, 2010.
2. Raymond, R. Gunther, Refrigeration, Air conditioning and Cold Storage Chilten Company, Philadelphia, USA, 1957.

Suggested readings:

1. Roy J. Dossat, "Principles of Refrigeration", 4th Edition, Pearson Education Asia, 2009.
2. Stoecker, W.F. And Jones J. W., "Refrigeration and Air Conditioning", McGraw Hill, New Delhi, 1986
3. ASHRAE Hand Book, Fundamentals, 2010 4. Jones W.P., "Air Conditioning Engineering", 5th Edition,Elsevier Butterworth-Heinemann, 2001

FE 430: Food Plant Hygiene and Sanitation

L3 T0

P0 CR3 Course outcome:

CO1: Ability to identify the role hygiene in food preparation, personal and food handling habits.

CO2: Ability to interpret the plant layout and design for safe food processing in term of sanitations.

CO3: Ability to identify and implement knowledge for effective insect and pest control programme in food industries.

CO4: Ability to predict and interpret the sanitary aspects of water supply, quality of water, purification and disinfection of water.

CO5: Ability to identify and design effective cleaning practices and waste disposal methods in food industries.

Course content:

General principle of food hygiene, Hygiene in rural and urban areas in relation to food preparation, personal hygiene and food handling habits. Place of sanitation in food plants. Sanitary aspects of building and equipment: Plant layout and design, Comparative studies on sanitary fabrication of different types of processing equipment.

Safe and effective insect and pest control: Extraneous materials in foods, Principles of Insects and pets control. Physical and chemical control. Effective control of micro-organisms: microorganisms important in food sanitation, micro-organisms as indicator of sanitary quality. Physical and chemical methods.

Sanitary aspects of water supply: Source of water, quality of water, water supply and its uses in food industries. Purification and disinfection of water preventing contamination of potable water supply.

Effective detergency and cleaning practices: Importance of cleaning technology, physical and chemical factors in cleaning, classification and formulation of detergents and sanitizers, cleaning practices.

Sanitary aspects of waste disposal. Establishing and maintaining sanitary practices in food plants, role of sanitation, general sanitary consideration and sanitary evaluation of food plants.

Text Books:

1. Principles of Food Sanitation. N. G. Marriott, Springer, 5th Edition, 2006.

2. Hobbs Food Poisoning and Food Hygiene. Jim Mclauchlin and Christine Little (Eds), 7th Edition, 2007.

Suggested readings:

1. Practical Food Microbiology & Technology. Harry H. Weiser, Mountney, J. and Gourd, W.W. AVI Publishing House, 2nd Edition, 1971.

Sanitation in Food Processing. John Troller, Academic Press, 2nd Edition, 1993.

FE 431: Plant Design and Process Economics

L2 T1

P0 CR3 Course outcome:

CO1: Ability to identify the proper plant design and layout for the specific food industry.
CO2: Ability to select appropriate material haling and flow system or the food processing.
CO3: Ability to calculate the financial analysis of any food processing plant. CO4: Ability to design new food processing plant.

Course content:

Technical feasibility survey of food industry, process development, Food process flow sheets
Hygienic food process design – Equipment design and specifications. The Nature of process synthesis and Analysis; Developing a conceptual design and finding the best.
Plant Designs: process designs development and general designs considerations: marketability of the product, availability of raw materials, technology, equipment, human resources, land and utilities, site characteristics, waste disposal, government regulations and other legal restrictions, community factors and other factors affecting investment and production costs. Cash flows: Time value of money, investment, costs, sales, profits, taxes, depreciation.
Process Economics: Economics feasibility of project using order of magnitude cost estimates plant and equipment cost estimations, product cost estimations.
Profitability Analysis: Rate of return, payback period, discount rate of return, net present worth, integral rate of return, comparing investment alternatives.
Steam Production and Distribution: boiler types, accessories to boilers, pressure vessel design, heat transfer in boilers, design of fire tubes and water tube boilers, economizer, draught in boilers, performance of boilers, flue gas analysis, water treatments for boilers.
Principles of aeration and ventilation, design features, performance characteristics and application of blowers.

Text Books:

1. Plant Designs and Economics for Chemical Engineers. M.S. Peters and K.D Timmerhaus, McGraw Hill, 5th Edition, 2005.
2. Dairy Plant Engineering and Management. T Ahmad, KitabMahal, 8th Edition, 2009.

Suggested readings:

1. Systematic Methods of Chemical Engineering and Process Designs. L. Biegler, I.E. Grossmann and A.W. Westeberg, Prentice Hall,1st Edition, 1997.
2. Analysis, Synthesis and Design of Chemical Processes. R. Turton, R. C. Bailie, W. B. Whiting, Prentice Hall, 3rd Edition, 2008.
   Boardman, A. E., & Boardman, A. E. (2008). Cost-benefit analysis. Pearson.

FE: 432 Food Plant Utilities

L3 T0 P0 CR3

Course outcome:

CO1 : Ability to employ the selection and operation of boiler in food processing plant as a food process engineer.

CO2: Ability to demonstrate the pre-process and post-process handling of water for safe application.

CO3: Ability to define the benefits of processed/ purified air application in food processing.

CO4: Ability to identify the suitable power supply installations in processing plants.

Course content:

Steam generation and performance: Boiler types, boiler operation and design considerations, forced and induced draught. Flue gas composition and performance analysis.

Process water treatment:Water treatment for prevention against boil corrosion and scale formation on heat exchange equipment. Water treatment against microbial contamination. Process plant sanitation - chemistry and CIP cleaning systems.

Cleaning & corrosion: Detergent types, properties and corrosion inhibition.

Waste water treatment:BOD and its reduction, fundamentals of batch and continuous type effluent treatment system.

***Process air generation and applications*:**Process air requirement & supply system. Air Moving and vacuum equipment.

Power supply system:Power supply system for food process plants. Equipment and Plant earthing.

Text Books:

1. Food Plant Design: Antonio, by López-Gómez Gustavo V. Barbosa-Cánovas, CRC Press
2. Food Plant Sanitation: design maintenance, and good manufacturing practices, by Michael M. Cramer, CRC Press

Suggested readings:

1. Handbook of Food Processing Equipment, by George D Saravacos, A. E. Kostaropoulos
   Food Engineering and Dairy Technology, by Dr.-Ing. H.G. Kessler, VERLAG. A. KESSLER Publishing, Germany

FE433: Food Safety & Quality Assurance

L3 T0 P0 CR3

Course outcomes:

CO1: Ability to establish quality control, quality assurance and total quality management required for food.
CO2: Ability to apply good hygienic practices, good manufacturing practices and risk analysis in food operations.
CO3: Ability to evaluate the risk and hazards associated with food and their prevention and control.
CO4: Ability to implement national and international standards laws and regulations in food industries.
CO5: Ability to identify the auditing process for the food processing operations as per requirement of different quality standards.

Course content:

Principles of food safety and quality, Food Safety System, Quality attributes, Food safety hazards, sources of hazard, classification, prevention and control. Quality control and Assurance: Definition, scope, importance and difference. Total Quality Management, tools of TQM.

Good Hygienic Practices, Good Manufacturing Practices, Risk Analysis, Risk Management, Risk Assessment, Risk Communication, Traceability and authentication. HACCP principles, Implementation of HACCP.

Management Systems, Auditing and Accreditation: An Overview, structure and clauses of 9001 (Quality Management System). An overview and Structure of 22000 (Food Safety Management System), Clause wise Interpretation of ISO 22000:2005, Case Studies. An Overview and Requirements of ISO 17025 (Laboratory Quality Management System).

International Food Standards: International Standardization Organization (ISO), Joint FAO/WHO Food Standards Program. Codex Alimentarius Commission (CAC). Retailer Standards: BRC Food and BRC IOP Standards, International Food Standard (IFS), The Safe Quality Food (SQF).

National Standards: Food Safety and standards – 2006, Food Safety and Standard Authority of India (FSSAI) regulations, FSSAI licensing and registration of food business. Agmark standards, Bureau of Indian Standards for food, Agricultural and Processed food Export Development Authority (APEDA), Marine Product Export Development Authority, Export Inspection council and Export Inspection Agency. The Consumer Protection Act, 2019.

Text Books:

1. Andres Vasconcellos J. 2005. Quality Assurance for the Food industry - A practical approach. CRC press.
2. Inteaz Alli. 2004. Food quality assurance - Principles & practices. CRC Press. New York.

Reference Books:

1. Sara Mortimore and Carol Wallace. 2013. HACCP - A practical approach. Third edition. Chapman and Hall, London.
2. Bizmanualz, 2008. ISO 22000 Standard Procedures for a Food Safety Management System. Bizmanualz, Inc. USA.

FE451: Operation Research

L3 T0 P0 CR3

Course outcomes:

CO1: Ability to identify and develop operational research models from the verbal description of the real system.

CO2: Ability to apply mathematical tools to solve optimization problems.

CO3: Ability to obtain computer-software based solutions to proposed models.

CO4: Ability to construct and solve transportation models and assignment models.

CO5: Ability to relate classical problems of operations research to food supply chain management.

Course content:

Introduction to operations research: Operations research techniques, simulation models. Linear programming formulation and graphic solution: Models of mathematical operations research, art of modeling, construction of the LP model, graphical LP solution.

The Simplex method: Standard LP form, basic solution, The Simplex method, the M-method, the twophase method, degeneracy, alternative optimal solution, unbounded solution, infeasible solution Sensitivity analysis and dual problem: Definition of the dual problem, the relationship between the optimal primal and dual solution, economic interpretation of duality, the dual Simplex method, primal-dual computations, sensitivity analysis.

Transportation, assignment, and transshipment models: Definition of the transportation model, determination of a starting solution, the transportation algorithm, definition of the assignment problem, the Hungarian method, the transshipment model.

Network models: Network definition, minimal spanning tree algorithm, shortest route problem, shortest route algorithm, maximal flow model, enumeration of cuts, maximal flow algorithm, CPM, PERT.

Queuing systems: Elements of a queuing model, role of exponential distribution, birth and death models, steady state measures of performance, single server models, multiple-server models, machine servicing model, Pollaczek-Khintchine formula, queuing decision models

Text Books:

1. Gupta, P. K. and Hira, D. S. *Operation Research*, (S. Chand publishing, 2008)
2. Sharma, S. C. *Operation Research: Inventory Control and Queuing Theory*, (Discovery Publishing House, 2006)

Suggested readings:

1. Hillier, F. S. and Lieberman, G. J. *Introduction to Operations Research*, (McGraw-Hill,2005)
   Winston, W. L. *Operations Research: Applications and Algorithms*, (Duxbury Press, 2003)

FE453: Optimization Techniques

L2 T1 P0 CR3

Course outcomes:

CO1: Ability to apply the knowledge of optimization to formulate and solve engineering problems. CO2: Ability to experiment various multivariable optimization problems of food process engineering.

CO3: Ability to illustrate the different methods of optimization and be able to suggest a technique for a specific problem.

CO4: Ability to analyze, how optimization can be used to solve technical problems, relevance to the food processing industries.

Course content:

Modelling: Significance, Fundamentals, and Methods, Significance of Mathematical Modelling and Simulation for Optimization, Analytical Solutions in Conduction Heat Transfer Problems; Numerical Solutions.

Optimization: Optimization: An Introduction, Statistical Optimization: Response Surface Methodology; Random-Centroid Optimization; Multi-Objective Optimization in Food Engineering; Applications of the Minimum Principle of Pontryagin for Solving Optimal Control Problems; Neural Networks and Genetic Algorithms; Computational Fluid Dynamics for Optimization in Food Processing; Dynamic Optimization; Eigenvalue Optimization Techniques for Nonlinear Dynamic Analysis and Design; Complex Method Optimization; Mixed Integer Linear Programming Scheduling in the Food Industry.

Optimization Studies for Different Food Processes: Analytical Solutions in Conduction Heat Transfer Problems; Temperature Measurement and Optimization; Optimization of Freeze-Drying Process Applied to Food and Biological Products; Optimization of Spray Drying; Pulsed Microwave Heating of Foods; Structural Optimization Techniques for Developing Beverage Containers; Optimization of Extraction process; Optimization of Canned Food Processing; Optimal Design of Continuous Thermal Processing with Plate Heat Exchangers; Process Optimization Strategies to Reduce Variability in Thermal Processing of Packaged Foods.

Text Books:

1. E. K. P. Chong and S. Zak, An introduction to optimization, 2nd Edition, 2004, John Wiley and Sons (Asia) Pvt. Ltd., Singapore
2. R. Fletcher, Practical methods of optimization, 2nd Edition, Wiley, 2000, New York

Suggested readings:

1. D. Bertsekas Nonlinear programming, 2nd Edition, Athena Scientific, 1999, Nashua.
2. V. Chvatal Linear programming, W. H. Freeman, 1983, New York.
3. D. Luenberger, Linear and nonlinear programming, 2nd Edition, 1984, Kluwer Academic Publisher, New York

FE454: Numerical Methods

L2 T1 P0 CR3

Course outcomes:

CO1: Ability to demonstrate understanding of common numerical methods in food processing systems

CO2: Ability to apply numerical methods to obtain approximate solutions of mathematical problems.

CO3: Ability to derive numerical methods for various mathematical operations, such as interpolation, differentiation, integration and solution of differential equations

CO4: Ability to apply computational fluid dynamics for the analysis of food processing systems

Course content:

Introduction to finite differences, difference formulae, fundamental theorem of difference calculus, the difference table, to express value of the function in terms of leading term and the leading differences of a difference table, the operator E, properties to two operators E&D, relation between operator E of finite differences and differential coefficient D of differential calculus, one or more missing terms, factorial notation, to show that x (-n) = 1/ [(x+n)n], generalized factorial notations, methods of representing any given polynomial in factorial notation.

Introduction to interpolation, interpolation with equal intervals, different interpolation methods (NewtonGregory forward and backward difference formulae), interpolation with unequal intervals, divided differences and table, Newton's divided difference formula, relation between divided differences and ordinary differences, Lagrange's interpolation formula for unequal intervals, Hermite's interpolation formulae, central difference interpolation formulae (Gauss, Stirling, Bessel formulae), piecewise and spline interpolation, (cubic splines) least squares approximations.

Numerical differentiation based on interpolation, numerical integration, a general quadrature formula for

equidistant ordinates, the trapezoidal rule, Simpson's 1/3rd and 3/8th Rules, Weddles Rule, Method of undetermined coefficients, extrapolation method) Romberg integration.

Numerical solution of ordinary differential equations of first order by Euler's and Runge-Kutta's method.

Solution to Algebraic and transcendental equations by Regula-Falsi method, iteration method, NewtonRaphson method, simultaneous linear Algebraic equations by Gauss-Jordan method, Crout's method, factorization method, Gauss-Seidel iterative method, determination of Eigen values.

Text Books:

1. Numerical Methods for Scientific and Engineering Computation. M.K. Jain, S.R.K. Iyengar& R.K. Jain, New Age International, New Delhi, 5th Edition, 2007.
2. Introductory Methods of Numerical Analysis. S.S. Sastry, Prentice Hall of India, New Delhi, 4th Edition, 2007.

Suggested readings:

1. Elementary Numerical Analysis, Kendal Atkinson. Wiley India, 3rd Edition, 2006.
2. Numerical Methods in Engineering and Science.B.S. Grewal, Khanna Publishers, New Delhi, 6th Edition, 005.
3. Numerical Methods for Scientists and Engineers. K S Rao, Prentice Hall of India, New Delhi, 3rd Edition, 2007.

FT512: Transport Phenomena in Food Processing

L 3 T0 P1 CR4

Course outcomes:

CO1: Ability to identify the transport processes in food processing and their mechanism. CO2: Ability to calculate heat transfer, mass transfer, momentum analysis for food processing unit operations. CO3: Ability to formulate and solve the problems related to transport processes and apply in food engineering.

Course content:

Transport processes and flux equations: Overall mass balance, energy balance, special mass balance, momentum balance, diffusive and convective transport, equations for fluxes, equation of continuity and equation of motion.

Momentum Transport: Viscosity and the mechanisms of momentum transport, shell momentum balances and velocity distributions in laminar flow for Newtonian and non Newtonian fluids, velocity distributions with more than one independent variable. Fluid flow through porous beds, permeability and Darcy's law, Kozeny- Karman equation, fluidization.

Diffusive heat transfer and mass transfer: Diffusive heat/mass transfer in steady/unsteady and one/multiple dimensions, mass transfer with chemical reaction, moving boundary problems, simultaneous heat and mass transfer, analytical solutions to problems of diffusive transport viz. heating, drying, freezing.

Convective heat transfer and mass transfer: Flow inside ducts, dispersion, laminar boundary layers, mass transfer with chemical reactions, simultaneous momentum, heat and mass Transfer, natural convection.

Multicomponent transport: Binary systems, multi-component flux equations, mass transport in food processing operations such as osmotic dehydration, dimensional analysis.

Analytical and Approximate Methods in Transport Phenomena: Governing equations and boundary conditions in Transport processes, application of methods of (i) separation of variable (ii) variation of parameters and (iii) Laplace transform to solve transport problems in food processing.

Textbooks:

- Geankoplis, C. J. *Transport processes and separation process principles*, Prentice Hall of India, New Delhi, 2003.
- Datta, A. K. *Transport Phenomena in Food Processing Engineering*, Himalaya Publishing House, 2001.

Suggested readings:

- Rao, M. A., Rizvi, S. S. H. and Datta A.K. *Engineering Properties of Foods*, CRC Press, 2005.

FT 513: Engineering Properties of Biological materials

L 2 T0 P1 CR3

Course outcomes:

CO1: Ability to describe the basic properties of food materials.
CO2: Ability to correlate the engineering properties of food and biological material to process design and quality control during processing.
CO3: Ability to identify and predict the physical changes in food during processing and storage.
CO4: Ability to apply the knowledge of food engineering properties on process design, food processing machine design on the pilot and industrial scale.

Course content:

Physical characteristics of different seeds and grain and other food products-shape and size-description of shape and size - volume and density, porosity, surface area. Particle Size Distribution.

Rheological Properties of Foods: Introduction to Rheology; Flow of Material; Newton's Law of Viscosity; Viscous; Newtonian Fluids; Non- Newtonian Fluids; ideal and non-ideal Plastic Fluids;ideal and non- ideal viscous Fluids; ideal and non-ideal solids. Measurement of rheological properties: different Viscosity Measurement & viscometers; Vibrational (Oscillation) Viscometer; Bostwick Consistometer. Deformation of Materia, Viscoelastic Behavior; Extensional Flow. Mechanical Models. Texture of Foods Dough Testing Instruments

Contact stresses between bodies: Hertz problems-firmness and hardness-mechanical damageimpact damage and dead load damage-vibration damage-friction-effect to load, sliding velocity, temperature, water film and surface roughness-friction in agricultural materialsrolling resistance-angle of internal friction, angle of repose

Flow of bulk granular materials - aero dynamics of agricultural materials and food products - drag coefficients - terminal velocity.

Thermal properties: specific heat-thermal conductivity thermal diffusivity-methods of determination-steady state and transient heat flow. Electromagnetic Properties: Color & Color Order Systems; Dielectric Properties of Foods; method of determination - energy absorption from high-frequency electric field. Water Activity and Sorption Properties of Foods. Surface Properties of foods.

Textbooks:

- M.A. Rao, Syed S.H. Rizvi, Ashim K. Datta, Jasim Ahmed , *Engineering Properties* th Ed 2014 *of Foods*, CRC Press 4
- Sahin S. and Sumnu, S. G., *Physical Properties of Foods by Springer*, NewYork, 2010

Suggested readings:

- Ignacio Arana, *Physical Properties of Foods: Novel Measurement Techniques and Applications*, CRC Press, 2012
- M J Lewis Woodhead, *Physical Properties of Foods and Food Processing Systems*, Publishing Limited, 2010
- Ludger Figura, Arthur A. Teixeira, *Food Physics: Physical Properties - Measurement and Applications*, Springer2007

FT 517: Food Equipment and Plant Design

L 3 T0 P0 CR3

Course Outcomes:

CO1: Ability to determine prerequisites for site selection, plant layout, and design consideration for food processing plant.

CO2: Ability to recognize the unit operations and selection of equipment's required for food processing operations.

CO3: Ability to demonstrate skills for determining equipment design and fabrication methods and testing procedures.

Course content:

Design and selection of food processing equipment, heat transfer equipment, food evaporation equipment, refrigeration and freezing equipment, thermal process equipment, mass transfer equipment, equipment for novel processing.

Introduction to plant design-special features of food processing industry-plant location– location factors-site selection-location theory and models-layout-objectives-classical and practical layout–preparation of layout- fruit juice processing plant, reduction unit, evaporation plant, drying plant, bake ovens and frying plant, thermal processing plant, refrigeration and air conditioning plant, packaging plant–ancillary equipment's - building materials–water supply and drainage-illumination–ventilation-estimation of services-peak and critical load –electrical installations –installation, operation and maintenance for food processing industry.

Textbooks:

- Ahmad, T. *Dairy Plant Engineering and Management*, Kitab Mahal, 2009.
- George D. Saravacos, Athanasios E. Kostaropoulos. *Handbook of Food Processing Equipment*, Springer.

Suggested readings:

- Biegler,L., Grossmann,I.E. and Westeberg, A.W. *Systematic Methods of Chemical Engineering and Process Designs*, Prentice Hall of India, 1997.
- Turton, R., Bailie, R.C. and Whiting, W.B. Analysis, *Synthesis and Design of Chemical Processes*, Prentice Hall of India, 2008.

FT518: Recent Trends in Food Product Development and Packaging

L 2 T0 P1 CR3

Course Outcomes:

CO1: Ability to generate new ideas and develop innovative food product.
CO2: Ability to evaluate the acceptability of develop product through consumer feedback.
CO3: Ability to apply effective active and intelligent packaging system for quality improvement of food products.
CO4: Ability to implement novel modified atmosphere packaging system for fresh-prepared produce.

Course content:

Innovation product development: Concept, generation of ideas. Desk Research. Screening/appraisal of initial ideas. Detailed study of product, process and market, Planning and developmental activities and evaluating them. Development of prototype product and its testing for acceptance. Development of process and planning for production trials. Planning the test market. Evaluation of test results. Launching of the product. Advertising and marketing plans. Introduction to Consumer Survey, market Survey. Detailed feasibility analysis.

Novel Food Packaging: Active and intelligent packaging: An introduction; Oxygen, ethylene and other scavengers; Antimicrobial food packaging; Non-migratory bioactive polymers (NMBP) in food packaging; Time-temperature indicators (TTIs); The use of freshness indicators in packaging; Packaging-flavour interactions; Moisture regulation.

Developments in modified atmosphere packaging (MAP): Novel MAP applications for freshprepared produce; MAP, product safety and nutritional quality; Reducing pathogen risks in MAP-prepared produce; Detecting leaks in modified atmosphere packaging.

Optimizing packaging; Legislative issues relating to active and intelligent packaging; Recycling packaging materials; Green plastics for food packaging; Integrating intelligent packaging, storage and distribution; Testing consumer responses to new packaging concepts.

Textbooks:

- Ahvenainen, R. *Novel food packaging techniques*, Elsevier, 2003.
- Hu,R. *Food Product Design A Computer-Aided Statistical Approach*, Technomic Publishers, 2005.

Suggested readings:

- Moskowitz, H.R., Saguy,S. and Straus,T. *An Integrated Approach to New Food Product Development*, CRC Press, 2006.

FT519: Food Process Modelling and Simulation

L 2 T0 P1 CR3

Course outcomes:

- CO1: Ability to identify the design, operating and performance parameters in food processing operations.
- CO2: Ability to develop mechanistic process models for unit operations in food processing.
- CO3: Ability to use up-to-date approach of computation for solving model equation. ➢ CO4: Ability to solve and validate the model equations and analyze for sensitivity.
- CO5: Ability to develop and validate phenomenological models for food processing operations.

Course content:

Introduction to Process Modeling: Balance equations and rate equations, mathematical models, empirical models and linear regression, systematic modelling approach, general property balance models in food processing, analytical solutions to ordinary differential equations, Laplace transformations and numerical methods in mathematical modeling.

Transport Phenomena Models: Equation of continuity, equation of energy, equation of motion, ODE models in food processing, transport phenomena models involving PDE, chart solutions to unsteady state transport problem, interfacial mass transfer, and rheological modeling.

Kinetic Modeling : Kinetics and food processing, the rate expression, temperature effects on the reaction rates, enzyme catalyzed reaction kinetics, metabolic process engineering, microbial kinetics, kinetics of microbial death, model of ideal reactors, modeling batch and continuous thermal processing operations of foods.

Mathematical Modeling in Food Engineering Operations: Moving boundary and other transport phenomena models for processes involving phase change, unit operation models: drying, baking, frying, evaporation, distillation, extraction, crystallization.

Model Solution and Simulation tools: MATLAB/SCILAB/SIMULINK as tools for solving mathematical models and for simulation. Solution strategies for lumped parameter models and distributed parameter models. Simulation of food manufacturing processes.

Text Books:

- Hangos, K. M. and Cameron, I. T. *Process Modelling and Model Analysis*, Academic Press, 2001.
- Ozilgen, M. *Food process modelling and control: chemical engineering applications*, Gordon and Breach Science Publishers, 1998.

Suggested readings:

- Ozilgen, M. *Hand book of food process modelling and statistical quality control: with extensive MATLAB applications*, CRC Press, 2011.
- Das, H. *Food processing operations analysis*. Asian books private limited, 2005.
- Tijskens, L.M., Hertog, M.L., Nicolaï, B.M., *Food process modelling*, Woodhead Publishing, 2001.

FT 555: Food Supply Chain Management Case Study

L 3 T0 P0 CR3

CO1: Ability to identify the effective food supply chain management requirements. CO2: Ability to analyze the effect of food production, manufacturing, retailing and logistics on food supply chain. CO3: Ability to apply effective sourcing and purchasing models to improve supply chain operations. CO4: Ability to estimate the risk in supply chain and apply effective traceability system. CO5: Ability to apply the skills for developing supply chain system for food industries.

Course content:

Introduction: Introduction to supply chains in India, Types of food Chain, Factors Influencing Food Supply Chains, Case studies in food supply chain.

Food Production: Entities in agriculture supply chain, Agriculture and poverty alleviation, barriers in development of agri-industry, future steps for agriculture industry. Case studies on farmer empowerment by Industry.

Food Manufacturing: Importance of food processing, market conditions, food processing and packaging, Inventory management, food safety, procurement, Case studies

Food retailing: The retail environment, Online retailing of food, Future challenges in food retailing

Food Logistics: movement of Food, Trends in food logistics, packaging in logistics, temperature controlled in supply chains, Case studies.

Challenges in International food supply chains: International food supply chains, Factor affecting international food supply, International politics and food, Case studies

Course Outcomes:

Food Sourcing and Procurement: sourcing, sourcing models, purchasing models, supplier segmentation, supplier development, strategic sourcing, sustainable procurement, case example

Risk Management: Risk management and uncertainty, Risks in the supply chain, Risks in the food supply chain, managing supply chain risks, managing risks in food supply chains, Case examples

Trends in Food Supply Chains: Traceability and use of technology, food production, food processing in a technological context, food packaging in a technological context, food logistics

Food regulation, safety and quality: Attributes to consider when designing food supply chains, food regulation and its effect on safety, food laws and regulation, reference standards, compatibility standards, private food standards, other initiatives within the food supply chains, case examples.

Sustainability challenges in food supply chain: Introduction to sustainability, sustainable supply chains, sustainable food supply chains, measuring sustainability, developing sustainability within food supply chains, case studies.

Textbooks:

- Samir Dani, Kogan Page. *Food Supply Chain Management and Logistics From Farm to fork.*
- Michael A. Bourlakis, Paul W. H. Weightman, *Food Supply Chain Management*. Wiley-Blackwell.

Suggested readings:

- Preston W. Blevins, *Food Safety Regulatory Compliance: Catalyst for a Lean and Sustainable Food Supply Chain*