PAKISTAN ENGINEERING COUNCIL
Syllabus for
Engineering Practice Examination (EPE) Food Engineering

Total Marks: 60

PART-II

This is an open book breadth and depth examination, comprising 60 Multiple Choice Questions (MCQs) of one mark each (total 60 marks) with a duration of three hours. There shall be two sections of Part-II for each major discipline of EPE. Qualifying Marks for this part shall be ***sixty per cent***.

SECTION-A / BREADTH

This section will generally confirm to latest (updated) B.E./equivalent qualification of Food Engineering. The examination of this section shall comprise 25 MCQs (total 25 marks).

1. MATHEMATICS AND STATISTICS FOR ENGINEERS 10%

i. **Analytical Geometry:** Review of vectors, scalars and vector products, Three-dimensional coordinate system and equation of straight line and plane.
ii. **Functions Limit and Continuity:** Review of functions and graphs, Limits & Continuity, Techniques of Finding Limits, Discontinuity, Limits of Sine and Cosine and Exponential Functions
iii. **Differentiation:** Introduction to Derivatives, Examples of Derivatives, Derivative as Rate of Change, Derivative's Rules, Implicit Differentiation, Higher order derivative, Leibnitz Theorem
iv. **Applications of Derivatives:** Applications of Derivatives, Monotonic functions, Optimization problems, Relative and Absolute extrema, First and second derivative tests, Point of inflection, Concavity, Curvature, Indeterminate Forms and L' Hospital rule, Differentials
v. **Integration:** Integrals and Properties of Integrals, Techniques of Integration, Integration by Parts, Definite Integrals, Integration of Trigonometric, Exponential and Inverse Functions, Integration by Partial Fractions, Reduction Rules
vi. **Applications of Integration:** Applications of Integration, Area under the curve, Area between curves, Solids of Revolution, Volume of Solids of revolution by disk, washer, Cylindrical shell & Cross Section Methods, Centre of Pressure and Depth of Centre of Pressure, Centre of mass, Arc length.
vii. **Improper Integrals:** Improper Integral, Integrals and Singularities, Convergence of improper integrals.
viii. **Infinite Sequence and Series:** Sequence and Infinite Series, Convergence and Divergence of sequences and series, Positive Term Series, Integral Test, Basic, Comparison Test, Limit Comparison Test, Ratio and Root tests, Alternating series, Absolute and Conditional Convergence.

ix. **Power and Taylor Series:** Power series, Maclaurin and Taylor Series and its Applications.

x. **System of Linear Equations and Applications:** Overview of linear system of equations, Cases of unique solution, No solution and infinite solutions, Echelon form, Gauss elimination method, Inversion of matrix in the context of solution of system of equations, LU factorization, Row space and column space, Relevant engineering case studies such as Network analysis, Traffic Flows, Balancing chemical reaction, Leontief Input-output model, Finding max stress in compound cylinder, Applications of linear systems in force balancing of structures, Markov process.

xi. **Vector Spaces and Transformations:** Vector Spaces: Real vector spaces, Subspaces, Basis and dimension, Rank, Nullity, Gram-Schmidt process for finding orthonormal basis, Linear Transformation, Kernel of Transformation, Range of Transformation, Matrix of Transformation, Applications: Cryptography, Coding and decoding, Breaking of codes, Robotic Applications of linear transformations.

xii. **Eigenvalues and Eigen Vectors:** Eigenvalues, Eigenvectors, Similar matrices, Diagonalization, Quadratic forms, Positive definite Matrices, Singular Value Decomposition, Inner product Spaces, Applications of linear Algebra: Constructing curves and surfaces, Computer graphics, Genetics.

xiii. **Application of Linear Algebra in Dynamical Systems:** Numerical System of linear ODEs, Eigenvalue problems, Homogeneous and nonhomogeneous system of ODE, Dynamical systems, Population dynamics, Prey-Predator models, Stability analysis.

xiv. **Basic Concepts and Modelling:** Linear Differential equations, Non-Linear, Differential equations, Solutions of differential equations, General solutions, Particular solutions, Initial and boundary value problems, Degree and order of ODEs, Formulation of first-order ODEs: Case studies related to finding age of fossils, Mixing problems and free fall motion, Finding temperature of a building, RL, RC circuits, Airplane take-off problem, Population dynamics and logistic equations etc.

xv. **Analytical Methods of Solution for First-order ODEs:** Variable separable method, Reduction to variable separable form, Homogeneous equations, Differential equations reducible to homogeneous form, Solution of the related ODE models by these methods, Exact equations, Integrating factors, Linear equations and related examples, Bernoulli's equations, Orthogonal trajectories and solution of the related ODE models by these methods.

xvi. **Mathematical Models Based on Second-order ODEs:** Formulation of a single RLC circuit, Spring mass systems, Earthquake model of a single-story building, Bungee Jumper model, Bridge collapse problem etc.

xvii. **Analytical Methods of Solution for Second-order ODEs:** Homogeneous linear ODEs, Method of reduction order, Wronskian determinant to check independence of the solution, and related examples, Cauchy-Euler equations and related examples, non-homogeneous linear ODEs, Method of undetermined coefficients, Method of variation of parameters and related example, Analytical solution of the related ODE models by these methods.

xviii. **Laplace Transform:** Laplace Transform, Derivation of Basic formulae, Inverse Laplace Transform, first shift theorem, Laplace transform of integrals and derivative, Solution of second order ODEs by Laplace Transform, Unit step function and its Laplace transform, Second shift theorem, Convolution, Application of Laplace transform to a system of ODEs and related applications.

xix. **Partial Differential Equations:** Partial Differential Equations and their types, Applications of partial differential equations in Engineering, Method of Separation of

Variables Method (MSVM) and solution of wave equation by the MSVM, Method of Separation of Variables Method (MSVM) and solution of heat equation by the MSVM.

Suggested Books:

- Thomas' Calculus – George B. Thomas, Jr., Maurice D. Weir, & Joel R. Hass (Pearson, USA)
- Calculus: Early Transcendentals – James Stewart (Brooks/Cole, USA)
- Calculus – Swokowski, Onlinick, & Pence
- Calculus – Robert T. Smith & Roland B. Minton
- Elementary Linear Algebra – Howard Anton & Chris Rorrers (Latest Edition)
- Introductory Linear Algebra – Bernard Kolman & David R. Hill (Latest Edition)
- A First Course on Differential Equations with Modelling Applications – D. G. Zill (Brooks/Cole, Latest Edition)
- Differential Equation with Boundary Value Problems – D. G. Zill & M. R. Cullen (Brooks/Cole, Latest Edition)
- An Introduction to Mathematical Modelling – E.A. Bender (Wiley, New York, Latest Edition)
- Advanced Engineering Mathematics – Erwin Kreyzig (John Wiley & Sons Inc., Latest Edition)

2. COMPUTER APPLICATIONS FOR ENGINEERS 8%

i. **Computer Hardware:** type and features of computer, classification of computers, parts of computer, inputs and output from the computer, Central Processing Unit (CPU), processor, control unit, memory

ii. **Software:** types of software, Operating System (OS), computer network, types of computer networks, data communication

iii. **Data Processing:** data and information, data types, data processing, data representation, and flowchart

iv. **Windows Operating Systems:** elements of Windows Operating Systems, display properties, control panel, keyboard setting, and task bar

v. **Microsoft Office:** features of Microsoft Word, parts of word interface, managing documents, spreadsheet, Microsoft Excel, creating a workbook, rows and columns, formulas, formatting toolbar, Microsoft Power Point, Power Point screen, working with slides, adding content, working with text, color schemes, slides effects, master slides, saving and printing

vi. **Introduction to the Internet:** services of internet, internet concepts, World Wide Web (WWW), web services, electronic mail, search engines, HTML, building links to HTML files, HTML levels.

vii. **Computer Programming:** Basic concept of programming languages.

Suggested Books:

- Perry, G. and M.Johnsons. 1992. Turbo C++ by Examples. Prentice Hall

Computer Publishing, New York.

- Shelly and Cashman. 1996. Using Computer, a Gateway to Information. Boyd and Fraser Publishing Company, USA.

3. ENGINEERING MECHANICS 7%

i. **Introduction:** General principles; units of measurement
ii. **Force Vectors:** Addition of vectors, Cartesian vectors, free vector, position vectors, Force directed along a line.
iii. **Equilibrium of a Particle:** Conditions for the equilibrium, Free body diagram; 3D force systems; force system resultants; moment of force, Virognon's theorem; cross product; moment of a couple; equivalent systems.
iv. **Equilibrium of a Rigid Body:** Equilibrium in 2D and 3D, constrains for a rigid body, Redundant and improper constraints
v. Friction: Types of friction, angle of repose, application of friction
vi. **Kinematics of a Particle:** Rectilinear motion, curvilinear motion, motion of projectile, Absolute dependent motion of two particles
vii. **Kinetics of a Particle:** Equation of motion for a system of particle, equation of motion in rectangular, cylindrical, normal and tangential coordinates, principles of work and energy for a system of particles, Linear momentum, conservation of momentum, impact, angular momentum; kinematics of a rigid body, translation, rotation

Suggested Books:

- Engineering Mechanics Statics; R. C. Hibbeler, 11th ed. 2007, Pearson Prentice Hall.
- Engineering Mechanics Dynamics; R. C. Hibbeler, 11th ed. 2007, Pearson Prentice Hall.

4. ENGINEERING THERMODYNAMICS 7%

i. **Thermodynamics:** Thermodynamics and energy, Dimensions and units, Systems and control volume; properties.
ii. **Energy and Energy Transfer:** Forms of energy, energy transfer by heat and work, mechanical work, First law of thermodynamics, Pure substances and phases of pure substance, property diagrams and tables, Ideal gas equations, compressibility factor, Mass and energy analysis for closed systems and control volumes; examples.
iii. **Second Law of Thermodynamics & Entropy:** Second law concepts, Reversible and irreversible process, Carnot cycle, entropy, isentropic processes, increase of entropy principle, Power and Refrigeration cycles, Essential equipment.
iv. **Thermodynamics Properties for Mixture:** Maxwell relations, Clapeyron equation, Joule Thomson Coefficient, Gibbs free energy and fugacity for pure substance, Criteria for phase equilibria in multi-component system, Vapor-liquid equilibrium, control.
v. **Chemical & Phase Equilibria:** Chemical equilibrium in single phase system, chemical reactions, Combined chemical and phase equilibrium, PH as criteria for ionization of biochemical.

Suggested Books:

- **Thermodynamics – An Engineering Approach**; Cengel & Boles, 5th ed. 2006, Tata McGraw.
- **Chemical, Biochemical and Engineering Thermodynamic**; Stanley L. Sandler, 4th ed. 2006, John Wiley & Sons, Inc.

5. ENGINEERING MATERIALS 8%

i. **Introduction to Materials Engineering:** Types of materials, Source of materials and their extraction, Crystalline and amorphous materials, Application and selection of materials (basic criteria for different environments).

ii. **Metallic Materials:** Pure metals and alloys, Nature and properties of metals and alloys, Major properties of metal and alloys, Single crystal and polycrystalline metals, Crystal defects and the mechanism of deformation and fracture, Plastic flow in polycrystalline materials, Structure property relationship, Macro and micro examination, Structural aspect of solidification and solid phase transformation in binary systems, Ferrous and non-ferrous metals, Steel making processes, Heat treatments, TTT diagram, Surface hardening coatings, Powder metallurgy, Non-destructive testing.

iii. **Ceramics, Glasses and Refractory Materials:** Compositions, Properties, Structures of various non-metallic materials, Application of ceramics, Glasses, refractory materials, Methods of manufacture.

iv. **Polymers and Rubbers:** Polymerization, Structural feature of polymers, Thermoplastic polymers, Thermosetting polymers, Additives, Major mechanical properties, Rubber (Elastomers), Synthesis of rubber.

v. **Composites:** Introduction to composite materials, Types of composite material, Method of fabrication of composite materials, Property averaging, Major mechanical properties.

vi. **Environmental Degradation:** Metal degradation by atmosphere, Aqueous and galvanic corrosion, Stress corrosion cracking, Methods of corrosion prevention, Behavior of metal at elevated temperature pyrometer, Oxidation, Scaling and creep, Chemical degradation of ceramic and polymers, Radiation damage of surface, Improvement against degradation.

Suggested Books:

- Materials Science and Engineering: An Introduction, William D Callister, 8th edition, 2010.

6. FLUID MECHANICS 8%

i. **Fluid Properties:** Definition of fluid, Classification of fluids, Concept of continuum, Viscosity, Vapor pressure, Surface tension, Variation of fluid properties with temperature.

ii. **Fluid Statics:** Concept of pressure and basic equation for compressible and incompressible, Pressure measurements and devices, Hydrostatic forces on plane and curved surfaces, Buoyancy and stability, Pressure variation in fluid with rigid body motion.

iii. **Fluid Kinematics:** Flow characterization, Description of velocity and acceleration field

(Streamlines, streak-lines and path-lines), Control volume and control mass, Deriving Reynold Transport Theorem (RTT).

iv. **Fluid Dynamics:** Application of Newton's 2nd law in fluids, Total, stagnation and dynamic pressures, Deriving Bernoulli equation and its applications.

v. **Integral Analysis of Fluid Flow:** Deriving continuity, Linear momentum and momentum equations using RTT, Solving problems related to continuity, linear and angular momentum.

vi. **Flow in Pipes:** Characteristics of pipe flow laminar and turbulent, Calculating friction factors and wall shear stresses, Solving pipe flow network problems.

vii. **Differential Analysis of Fluid Flow:** Deriving continuity equation by applying principle of conservation of mass, Calculating velocity and acceleration field using material derivative, Deriving Navier, Stokes equation, Solving Navier Stokes equation for simple geometries.

viii. **Potential Flow Theory:** Concept of Vorticity, Circulation, Inviscid and Irrotational flow fields, Basic velocity potential, functions, and their superposition, Prediction of Lift and Drag using potential flow theory.

ix. **Flow Over Immersed Bodies:** Boundary layer theory and its thicknesses, Concept of local and average drag coefficient, Calculating drag and lift forces due to pressure and velocity field.

x. **Turbo machinery:** Classification of fluid Machines, Fans, Pumps, turbines and other flow devices, Deriving Euler's equation of Turbo machine, Solving turbo-machine problems using velocity triangle, Turbo machine performance characteristic curves, Series and Parallel combination of pumps, affinity laws.

xi. **Introduction to Compressible Flows:** Mach number and speed of sound, Isentropic flow of an ideal gas, Convergent and divergent nozzle.

xii. **Introduction to Open Channel Flow:** Steady, 1-dimensional open channel flow analysis, Froude Number, Uniform flow channels and critical depth.

xiii. **Introduction to Computational Fluid Dynamics:** Finite difference formulations, Concept of discretization, Solving simple fluid flow problems using available CFD code.

Suggested Books:

- Fundamentals of Fluid Mechanics; Bruce R Munson, 7th edition, 2012, John Wiley & Sons.
- Durst, F., & Arnold, I. (2008). Fluid mechanics: an introduction to the theory of fluid flows (Vol. 1). Berlin: Springer.
- Finnemore, E. J., & Franzini, J. B. (2002). Fluid mechanics with engineering applications. McGraw-Hill Education
- Jog, C. S. (2015). Fluid Mechanics (Vol. 2). Cambridge University Press.

7. HEAT & MASS TRANSFER 10%

i. **Basic Concepts of heat transfer:** Difference between thermodynamics and heat transfer, Basic laws governing heat transfer.

ii. **Modes of heat transfer:** Heat transfer by conduction, Fourier's law of heat conduction, Thermal conductivity of materials and thermal resistance, Heat transfer by convection, Heat transfer by radiation, Conduction-Steady state one dimension: heat conduction through plane wall, heat conduction through composite wall, overall heat transfer coefficient.

iii. **Blocks Heat Conduction through hollow and composite cylinders:** Introduction to hydrodynamics, Ideal and real fluids viscosity, Continuity equation in Cartesian coordinates, Equation of continuity in polar coordinates, Velocity potential and stream function, laminar and turbulent

iv. **Forced convection:** laminar flow, laminar flow over plate, energy equation of thermal boundary layer over a flat plat, integral energy equation

v. **Turbulent flow:** Turbulent boundary layer, Turbulent flow over a flat plat, in tube, over cylinder and over spheres, Liquid metal heat transfer.

vi. **Free convection:** Parameters in free convection, momentum, and energy equation for laminar flow, Integral equation for momentum and energy on a flat plate, Transition and turbulence in free convection, Empirical correlation for free convection, Simplified free convection relations for air, combined free and forced convection.

vii. **Heat exchangers:** Types of heat exchangers and heat exchanger analysis, logarithmic Mean Temperature Difference (LMTD), heat exchanger effectiveness number of transfer units (NTU) evaporators, Design of heat exchanger.

viii. **Heat transfer by radiation:** Surface emission properties, absorptivity, reflectivity and transmissivity.

ix. **Heat transfer by radiation (continued):** Concept of black body, the Stefan-Boltzmann law, Kirchhoff's law, Planck's law, Wien Displacement law, intensity of radiation and Lambert's Cosine law.

x. **Mass Transfer:** Modes of mass transfer, concentration, velocities and fluxes, Fick's law, General Mass Diffusion Equation in Stationary Media, Steady state diffusion in common geometries, Steady state diffusion in liquids, Mass transfer coefficient, correlations for connective mass transfer, Reynolds and Colburn Analogies for mass transfer-combined heat and mass transfer.

Suggested Books

- Fundamentals of heat and mass transfer. 2011. Bergman, T.L., Incropera, F.P., DeWitt, D.P. and Lavine, A.S. John Wiley & Sons.
- Heat and mass transfer: fundamentals and applications 2014. Cengel, Y. McGraw-Hill Higher Education.
- Fundamentals of heat and mass transfer. 2011. Bergman, T.L., Incropera, F.P., DeWitt, D.P. and Lavine, A.S.. John Wiley & Sons.

8. INTRODUCTION TO FOOD ENGINEERING 10%

i. **Historical Background of Food Engineering:** Food engineering and its scope; Importance of chemistry and biological science in food engineering.

ii. **Food Processing:** Baked and snack foods, Honey, syrups, Confectionery, Beverages, Milk and fish.

iii. **Thermal Techniques in Food Processing:** Heat processing of food, Freezing and cold storage, Microwave heating.

iv. **Food process and plant design:** Personal cleanliness, Buildings and facilities, Plant layout, Food process design.

v. **Preservation Techniques in Food Processing:** Food processing from harvest to preservation, packaging and distribution.

Suggested Books:

- Introduction to Food Engineering; R. Paul Singh & Dennis R Heldman; Fourth Edition, AP & Elsevier
- Case-studies in Food Processing; J. Peter Clark, Ed 2009, Springer.

9. FOOD PROCESSING & PRESERVATION 7%

i. **Introduction**: Food processing and preservation.
ii. **Food safety and security**: Food sources and global food situation.
iii. **Food constituents and their functions**: Water, carbohydrates, lipids, proteins, vitamins and minerals.
iv. **Food classification based on perishability and pH**: Spoilage agents in food: Enzymes, microorganisms, insects, rodents, birds and physical factors.
v. **Principles of food preservation**: Preparatory operations in food processing**.**
vi. **Preparatory operations in food processing**: Cleaning, sorting and grading, peeling, removal of inedible constituents, size reduction, mixing, filtration and prevention of enzymatic browning-applications.
vii. **Heat exchangers**: types of heat exchangers, heat exchanger analysis, logarithmic Mean Temperature Difference (LMTD), heat exchanger effectiveness number of transfer units (NTU), evaporators. Design of heat exchanger.
viii. **Preservation by high temperature**: Canning - unit operations and their significance.
ix. **Preservation by low temperature**: Distinction between refrigeration and freezing. Cold storage: Factors affecting. Freezing and frozen storage: unit operations, effect on food and microorganisms.
x. **Preservation by removal of moisture**: Sun drying, dehydration - equipment, procedures, precautions. Defects in dried foods, Types of dehydrators, Still air and forced draft.
xi. **Food additives:** Chemical additives, contaminants and adulterants - differentiation. Uses of food additives: Non preservative, preservative.
xii. **Fermentation techniques**: alcoholic, acetic and lactic fermentations – applications, procedures.
xiii. **Irradiation technology**: Applications in food preservation. Merits and demerits.
xiv. **Food Packaging:** Packaging materials, protective packaging in tropical environment, Aseptic packaging.

Suggested Books:

- Awan, J.A. 2018. Food Processing and Preservation. Unitech Communications, Faisalabad, Pakistan.
- Awan, J.A. 2018. Food Science and Technology. Unitech Communications, Faisalabad, Pakistan.
- Khetarpaul, N. 2005. Food Processing and Preservation. Daya Publishing House, New Delhi, India.
- Rehman, M.S. 2007. Handbook of Food Preservation. CRC Press Taylor & Francis

Group, Boca Raton, FL, USA.
- Zahoor, T., M. S. Butt. 2017. Handbook of Food Science and Technology. ISBN 978-969-8237- 97-4: © University of Agriculture, Faisalabad, Pakistan.
- Awan, J.A. 2005. Food science and technology. Unitech Communications, Faisalabad, Pakistan.
- Awan, J.A. 2005. Food processing and preservation. Unitech Communications, Faisalabad.
- Potter, N.N. and J.H. Hotchkiss. 1995. Food science (5th Ed). The AVI Pub Co Inc, Westport, Connecticut, USA

10. MATERIAL & ENERGY BALANCE 13%

i. **Fundamentals:** Basic concepts regarding energy balance, units and conversions, stoichiometric calculations.
ii. **Mass Balance:** Mass balances for items of plant; choice of basis/datum for balances, overall and component balances, balances for systems with recycle, purge and by-pass streams, mass balances for reactive processes, mass balances for unit operations, tie components, balances for batch & continuous plant.
iii. **Mass Balance on various applications:** Ideal and real gas relationships, Vapor pressure, Saturation, Partial saturation, Humidity, Balances for condensing systems, Humidification, Dynamic balances.
iv. **Energy Balance:** Energy balance; concepts and units, forms of energy, the first law of thermodynamics, calculation of enthalpy changes, applications of the general energy balance without reactions occurring. Balances with reaction; mass and energy balances for reacting systems and balances for combustion processes.
v. **Case Studies on Energy Balance:** Case studies on balances for a selection of important industrial processes, Efficiency and Conversion, Simultaneous mass, and energy balances; temperature and pressure dependence.

Suggested Books:

- Richard, F.M, Ronald, R.W., and Lisa G.B., Elementary Principles of Chemical Processes. 4th ed. New Jersey: John Wiley & Sons, 2015.
- Nayef, G., and Redhouane, H., Principles of Chemical Engineering Processes: Material and Energy Balances, 2nd ed. CRC Press, 2014.
- Himmelblau, D.M., Basic Principles and Calculations in Chemical Engineering. 8th ed. Prentice Hall PTR, 2013.
- Chopy and Hicks, Handbook of Chemical Engineering Calculations, 4th ed. New York N.Y: McGraw-Hill Professional Publishing, 2012.
- Reklaitis, G.V. and Schneider, D.R., Introduction to Material and Energy Balances. New Jersey: John Wiley & Sons, 2002.

11. UNIT OPERATIONS IN FOOD ENGINEERING-I 12%

i. **Preliminary preparative operation:** Cleaning, Sorting, Grading methods.
ii. **Size reduction:** Particle size distribution, Classification, Screening and sieving, Mechanism of size reduction, Machinery for crushing and grinding, Disintegration of fibrous materials, Energy requirements for comminution of solids.
iii. **Pneumatic and Hydraulic Conveying Systems:** Types of conveyers, types of

elevator.

iv. **Fluidization, mixing and agitation:** Flow pattern and baffles, rate of mixing and power consumption, Centrifugation theory and applications.

v. **Agglomeration Phenomena and its application:** Granulation, palletization, Tableting process and storage.

vi. **Filtration:** Mechanism of filtration, filter media, flow through filter cake or cloth, Cake resistance and relation between thickness of cake and volume of filtrate.

Suggested Books:

- Singh, R.P. and Heldman, D.R., 2008. Introduction to food engineering. Gulf Professional Publishing.
- Barbosa-Canovas, G.V. and Ibarz, A., 2014. Unit operations in food engineering. Crc Press.
- Irudayaraj, J.M. and Jun, S., 2015. Food processing operations modeling: design and analysis. CRC press

PART-II

SECTION-B / DEPTH

This section shall be based on practical concepts framed to judge the practical experience and field based knowledge of Registered Engineers (REs). The examination of this section shall comprise 35 MCQs. Each candidate may attempt the only opted area of practice, among the followings.

1. ENGINEERING PROPERTIES OF FOODS

i. **Introduction to fundamental properties**: Physical attributes, Size and size distribution, Shape, volume, density, porosity.

ii. **Rheological properties**: Flow of materials, Newton's law of viscosity, Viscous fluids, Plastic fluids, Measurement of viscosity.

iii. **Deformation of materials**: Viscoelastic behavior, Stress relaxation test, Creep test, Dynamic oscillatory test.

iv. **Textural properties**: Texture profile analysis, Compression, snapping bending, Cutting shear, puncture, penetration.

v. **Water activity and sorption properties**: Prediction and measurement of water activity Effect of temperature and pressure on water, Activity, preparation of sorption isotherms.

Suggested Books:

- Rao, M.A., Rizvi, S.S., Datta, A.K. and Ahmed, J., 2014. Engineering properties of foods. CRC press. USA
- Barbosa-Canovas, G.V., Juliano, P. and Peleg, M., 2009. Engineering properties of foods. In Food engineering: Encyclopedia of life support systems (pp. 39-70). EOLSS Oxford. UK

2. UNIT OPERATIONS IN FOOD ENGINEERING-II

i. **Process of drying:** Working principle, Equipment, Types.

ii. **Heat exchangers:** Principles, Types and applications, parameters of heat exchangers, **Thermal processing:** Pasteurization, Sterilization, Thermization, UHT.

iii. **Filtration processing:** Mechanism of filtration, Filter media, Flow through filter cake or cloth, Cake resistance and relation between thickness of cake and volume of filtrate, UHT.

iv. **Extrusion:** Introduction and importance, Working Principle, Single screw extruders, Twin screw extruders Applications, Advantages and disadvantages, Textured vegetables proteins, breakfast cereals etc.

v. **Distillation:** Rectifying and stripping sections, material balances. Constant molal overflow. Adsorption Technique, The nature of adsorbents, adsorption equilibria, Adsorption equipment and regeneration of spent adsorbents.

vi. **Liquid-Liquid Extraction:** Introduction, Extraction Processes, Extraction equipment Absorption, Extension of design techniques and Wetted wall columns method, determination of transfer coefficients, Equipment for gas absorption.

Suggested Books:

- Singh, R.P. and Heldman, D.R., 2008. Introduction to food engineering. Gulf Professional Publishing.
- Barbosa-Canovas, G.V. and Ibarz, A., 2014. Unit operations in food engineering. Crc Press.
- Irudayaraj, J.M. and Jun, S., 2015. Food processing operations modeling: design and analysis. CRC press.

3. FOOD PLANT LAYOUT & DESIGN

i. **Plant design and layout**: Objectives and functions, financial requirements, Plant location, site selection, space requirement, building design and construction, floors, drains, walls, doors, windows, ceiling, ventilation, lighting, auxiliary facilities. Food plant equipment, layout of equipment, requirements, design, construction, choice of material.

ii. **Selection of products from Food Industry**: Selection of novel products from food industry through market survey, food product development. Selection of the local preparation of the plant layout. Material and energy balances. Design of the major units and sizing, auxiliary equipment including services, health and safety considerations, plant and product cost estimation.

iii. **Use of computer for layout Design:** Use of computer for layout, environmental impact, material handling and equipment process flowchart.

Suggested Books:

- James, M.More., Plant Layout and Design, MacMillian Publishing Co., New York, 1976.
- Antonio López Gómez, Gustavo V. Barbosa-Cánovas. Food plant design. Taylor & Francis inc., 2007.
- Max S. Peters, Klaus D. Timmerhaus, Plant Design And Economics For Chemical Engineers, 5TH Edition 2003, McGrawhil

4. FOOD PACKAGING

i. **Fundamentals of Food Packaging:** Introduction to conventional and modern food packaging, importance and functions of packaging, elements of successful packaging

ii. **Packaging materials and their processing:** Introduction to packaging materials: polymers (plastics), paper, glass and metals. Selection criteria of packaging materials for different food products, processing of packaging materials for food applications, Industrially preferred manufacturing processes of food packaging products such as injection moulding, extrusion, blow moulding, sheet and film extrusion, paper and paperboard calendaring, lamination, steel drawn cans

processes. Fresh and frozen food packaging systems (meat, poultry, sea food, fruits and vegetables, dairy products).

iii. **Recent trends in Food Packaging:** Active, Controlled atmosphere (CA), Modified atmosphere (MA), Anti-microbial, Edible, Aseptic and biodegradable packaging.

iv. **Packaging equipment and machinery:** Vacuum, Seal and shrink packaging machine, Form & fill sealing machine, Aseptic packaging systems, Retort pouches, Bottling machines, Carton making machines, Package printing machines.

Suggested Books:

- Rui M. S. da Cruz. Food Packaging, Innovations and Shelf Life. CRC Press, 1st Edition 2019.
- Alexandru Grumezescu. Food Packaging. Elsevier, Academic Press, 1st Edition, 2016.
- Sina Ebnesajjad. Plastic Films in Food Packaging: Materials, Technology and Applications (Plastics Design Library) 1st Edition, 2018.
- Ruben Hernandez, Susan E. Selke, John Culter, John D. Culter, Plastics Packaging: Properties, Processing, Applications, and Regulations, 2000.

5. FOOD QUALITY CONTROL

i. **Definition of Quality:** Quality assurance, total quality concepts; evolution of quality activities in the history.

ii. **Principles of total Quality Management:** Quality Management System and ISO-9000 standards; functions of Quality Assurance Department and its relations with other departments.

iii. **Description of Critical Control Points:** HACCP, GMP systems; classification of food quality attributes; definition and objective evaluation of sensory food attributes, sensory test techniques.

iv. **Nutritional Quality Control:** Approximate analysis of foods; statistical quality control tools.

Suggested Books:

- Pomeranz, Y and Melcoan C.E. **Food Analysis: Theory and Practices.** 2002. 3rd Ed., Kluwer.
- Mark Clute, **Food Industry Quality Control System**, 2009 CRC Press Taylor & Francis Group
- J. Andres Vasconcellos, **Quality Assurance for The Food Industry**, 2004, CRC Press Taylor & Francis Group.
- Imtiaz Ali, **Food Quality Assurance Principles and Practices**, 2003 CRC Press Taylor & Francis Group.

6. FOOD PRODUCT DEVELOPMENT

i. **Introduction:** Keys to new product success and failure, Idea generation, screening, feasibility, test marketing, product life cycles. Key requirements for successful product development: Developing an innovation strategy, Sensory evaluation in food product development, Food additives, Formulation and the product process development. The knowledge base for product development, The consumer in product development. Managing and improving product development: Managing the product development process.

ii. **Case studies:** Product development in the food system, Improving the product development process.

iii. **Packaging and Labeling:** Levels of packaging, Packaging materials. Innovative packaging of new products. Parts of a food label. Shelf life: water activity, preservatives, ingredient effects and new processing technologies.

iv. **Health and Safety Concerns:** Physical and microbial contamination, HACCP Principles & Application. Regulatory Considerations: International and local perspectives.

v. **Economic Feasibility:** Economic analysis based upon market competitiveness. Essentials of Marketing Food Products: Organizing marketing functions, Consumption, Participants in the marketing process, Test marketing.

Suggested Books:

- Fuller, G.W., New Food Product Development: From Concept to Marketplace, 3rd ed, CRC Press, 2016.
- Fadi Aramouni, Kathryn Deschenes. "Methods for Developing New Food Products: An Instructional Guide", 2014. DEStech Publications.
- Mary Earle, Richard Earle. "Case Studies in Food Product Development", 2008. Woodhead Publishing Limited.
- Mobley, R.K. An Introduction to Predictive Maintenance. 2nd ed. Butterworth-Heinemann, 2002.
- Mary Earle, Richard Earle, Allan Anderson. "Food Product Development: Maximizing Success", 2001. Woodhead Publishing Limited and CRC Press LLC.