DETAIL SYLLABUS

(B. Tech. in Food Engineering and Technology)

First Year

Mathematics I	MS101
3 - 1 - 0 : 4 Credits : 4 Hours	

Rolle's theorem, Cauchy's mean value theorem (Taylor's and Maclaurin theorems with remainders, Indeterminate forms, Concavity and convexity of a curve, points of inflexion. Asymptotes and curvature.

Limit, continuity and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, differentials, derivatives of composite and implicit functions, derivatives of higher order and their commutativity, Euler's theorem on homogeneous functions, harmonic functions, Taylor's expansion of functions of several variables, maxima and minima of functions of several variables – Language's method of multipliers.

First order differential equations – exact, linear and Bernoulli's form, second order differential equations with constant coefficients, Euler's equations, system of differential equations.

Limit, continuity, differentiability and analyticity of functions Cauchy-Riemann equations, Elementary complex functions, Line integrals, Cauchy's integral theorem, Cauchy's integral formula, Power series, Taylor's series, Laurent's series, Zeros and singularities, Residue theorem.

Fundamental theorem of integral calculus, mean value theorems, evaluation of definite integrals – reduction formulae.

Textbook:

1. Higher Engineering Mathematics, B.S. Grewal, Khanna Publishers, 38th Edition, 2004.

References:

1. Differential and Integral Calculus, Vol-I & II, N. Piskunov, CBS Publishers, 1st Edition 1996 (reprint).

Physics I	PH101
2 - 1 - 1 : 4 Credits : 5 Hours	

Conservation Principles, rotational Dynamics, free, forced and damped oscillations, coupled oscillations, wave motion, reflection and refraction, interference, diffraction, polarization.

Vector calculus: Curvilinear co-ordinates, gradient of a scalar fields, divergence and curl of a vector field, Gauss's and Stoke's theorems.

Electrostatics, magnetostatics, motion of charges in electric and magnetic fields, electromagnetic induction, displacement current, Maxwell's equations, electromagnetic Waves.

Laboratory Experiments:

1. To determine the coefficient of viscosity of a liquid from its rate of flow through a capillary tube.
2. To determine the velocity of sound in a solid by Kundt's tube method.
3. To determine the acceleration due to gravity (g) by Kater's pendulum.
4. To determine the wavelength of a monochromatic light by Fresnel's biprism and Lloyd's mirror.
5. To determine the wavelength of light and radius of curvature of the convex surface of a lens by Newton's ring method.
6. To determine the wavelength of light by diffraction through a plane transmission grating.
7. To determine the value of Planck's constant using photocells.
8. To determine the melting point of a solid with a thermocouple.
9. To determine the value of e/m of an electron by using a cathode ray tube and a pair of bar magnets (Thompson's method).
10. To observe waveforms and to measure amplitude, frequency and phase with cathode ray oscilloscope.
11. To verify Thevenin's, Norton's and maximum power transfer theorems.
12. To study the performance of inverting and non-inverting amplifiers using an operational amplifiers.

Texts books:

1. Fundamentals of Physics, D. Halliday and R. Resnick, John Wiley Publication, 8th Edition, 2008.
2. Introduction to Electrodynamics, D. J. Griffiths, PHI, 3rd Edition, 1999.

References:

1. Electricity and Magnetism, A.S. Mahajan and A.A. Rangwala, Tata McGraw Hill Publishing Co. Ltd, 27th reprint, 2001.
2. Optics, A.K. Ghatak, Tata McGraw Hill Publishing Co. Ltd, 3rd Edition, 2005.
3. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press, 3rd Edition, 1993.

Chemistry   CH101

2 - 1 - 1 : 4 Credits : 5 Hours

Thermodynamics of Chemical Processes: Concept of entropy, chemical potential, equilibrium conditions for closed systems, phase and reaction equilibria, Maxwell relations, Real gas and real solution.

Electrochemical Systems: Electrochemical cells and EMF, Applications of EMF measurements: Thermodynamic data, activity coefficients, solubility product and pH, corrosion.

Kinetics of Chemical Reactions: Reversible, consecutive and parallel reactions, Steady state approximation, Chain reactions, Photochemical kinetics.

Bonding Models in Inorganic Chemistry : Molecular orbital theory, Valence-bond theory, Crystal field theory.

Fundamentals of Microwave, IR and UV-VIS Spectroscopy : Basic concepts of spectroscopy, Selection rule, Determination of molecular structure.

Coordination Chemistry : Coordination numbers, Chelate effect, Coordination complexes and application, Bio-inorganic chemistry : Metal ions in Biological systems., environmental aspects of Metals, NOx, CO, CO2.

Organic Reaction Mechanism : Mechanisms of selected organic, bio-organic, polymerization and catalytic reactions.

Stereochemistry of Carbon Compounds : Selected Organic Compounds : Natural products and Biomolecules (Amino acids/nucleic acids/proteins).

Laboratory Experiments :

(At least nine of the experiments listed below)
1. Surface tension and parachor
2. Measurement of the coefficient of viscosity.
3. Conductometric titration
4. pH-metric/potentiometric titration
5. Solubility product
6. Kinetics of ester hydrolysis
7. Estimation of Fe2+
8. EDTA titration
9. Estimation of base content and acid content of commercially available antacid and vitamin C respectively
10. Synthesis of Mohr's salt
11. Synthesis of aspirin
12. Demonstration of a few important physico-chemical processes. (e.g. Gel electrophoresis, Oscillatory reactions)
13. Determination of CMC of a surfactant

Text Books:
1. Physical Chemistry, P. C. Rakshit, Sarat Book House, 7th Edition, 2004.
2. Inorganic Chemistry, R. L. Dutta, New Book Stall, 1980.
3. Organic Chemistry, I. L. Finar, Dorling Kindersley (India) Pvt. Ltd, 5th Edition, 2008.

References:
1. Text Book of Physical Chemistry, S. Glasstone, McMillan, 2nd Edition, 1966.
2. Concise Inorganic Chemistry, J. D. Lee, Wiley, 5th Edition, 2008.

Communicative English   EN 101
3 - 0 - 0 : 3 Credits : 3 Hours

<u>Objectives</u>

1. To develop overall proficiency in English with a view to enabling the students to use English for communication and for study purposes;

2. To develop the student's interactive skills by developing their ability to listen to English for formal as in class lectures and informal as in face to face interactive situations) with a high degree of understanding, and helping them to speak English with a reasonable degree of fluency and with an acceptable pronunciation of the sounds of English;

3. To develop student's ability to read English texts-both of scientific and non-scientific nature silently with a high degree of comprehension;

4. To develop the student's skill of writing short paragraphs, formal and informal letters, curriculum vitae/resume, applications of various types, study notes, summery and appropriate words-both scientific and non-scientific.

Course content and activities

A. Oral Communicative Activities

Information transfer activities: Pair and group works involving transfer of information (reading a brochure and advertise/a notice a schedule or programme/drawing etc. and discussing these, finding a solution, arriving at a decision through speaking); extempore speech using clues, group discussion etc.
Pair work: describing pictures, interpreting diagrams, gleaning information from different types of written materials including articles etc and talking about them, formal seminar presentation, formal group discussion.

B. Reading

Reading and comprehension: global and local comprehension, drawing interferences Materials: Stories and essays (preferably a collection of comparatively short essays on scientific, interestingly written topics, biographical/autobiographical writtings, short stories-adventure and scientific fiction), Reading silently in class followed by short comprehension questions, brief writing exercises, summaries in brief, personal responses (not typical question-answer type)-both oral and written. Reading material from Internet and talking and writing about them; reading scientific reports, articles collected from newspapers and magazines, Internet etc. and writing notes etc. on them

C. Writing

Preparing reports, project proposals. Writing applications of various types and for various purposes, curriculum vitae/resume, letters to the editors, letters to various agencies. Writing short notes on article/reports read summary of articles/paragraphs read, notes on lectures (talks-radio/TV/audio, video cassettes), opinions on discussions/letters heard, notice both formal and informal/friendly, notes to inform others etc., interpreting pictures, advertisements, visuals (video, TV etc.) and writing briefly about them.

D. Vocabulary and grammar:

Using useful but unfamiliar words and phrases in conversation and in writing; Group verbs, idiomatic expressions; synonyms and antonyms.

Structure of simple sentences; use of adverbials, longer sentences, combining sentences, Tenses, Use of passive in scientific discourse, various types of questions, direct and indirect narration.

Textbooks:

1. English for Engineers and Technologists: a skill approach, Vol. 182, Anna University, Madras, Orient Longman, 2nd Edition, 1990.
2. Foundation English for Science Students, G. Graves, Delhi: Oxford University Press, 1975.
3. A Practical English Grammar, A.J. Thomson and A.V. Martinet, Oxford University Press, 4th Edition, 1986.

References:

1. Collins Co build English Grammar, Harper Collins India, 6th Edition, 1990.
2. Oxford Advanced Learner's Dictionary (with CD-ROM), Oxford University Press, 7th edition, 2005.
3. Understanding Technical English, R. Sudarsanam, New Delhi: Sterling Publishers Pvt. Ltd., 1st Edition, 1988.

Sociology   SO 101
3 - 0 - 0 : 3 Credits : 3 Hours

1. **Society:** Meaning and element of society – Distinction between society, Aggregation and Organisation – Relationship between Individual and Society.
   Social Group **:** Meaning and brief classification of social group- Primary group- meaning, characteristic and importance of primary ground – method of making decision in a primary group – Secondary group- meaning and characteristics – Organization of authority in a Secondary group.

2. **Social Change :** Concepts and direction of social Change- Deterioration – and Cycle theory-Causes of social change- Deterministic theories of social change- a brief explanation of biological, physical, cultural and technical factors influencing the rate and direction of social change.
   Social Disorganisation: Meaning, characteristics and causes- social problem- meaning classification and causes- methods for solving social problems.

3. **Personal Administration :** Concept, aims and objectives, functions and principles of personal administration. Interview- types of interview – training- importance and methods-induction.

4. **Human Relations & Behavioural Approach to Manpower :** Concept of Human relations-origin and growth- (a brief reference to the Hawthrone Experiments, Mechanical or Commodity concept and social or Human concept of Labour – Classification made by Doghlas Megxg theory – X and theory – Y – importance of Human Relations.

Werlmotivation – Meaning and kinds – Baslow's need Hierarchy- Motivational techniques- meaning and significance of group Dynamics- Employees Morale – meaning and importance of and steps to promote employee morale

5. Concept, characteristics and techniques of leadership- types of leader- functions and qualities of a leader.

Text Books:

1. Sociology: A Guide to Problems and Literature, T.B. Bottomore, Blackie and Son (India) Ltd. 1986.
2. Sociology. G. Anthony, Polity Press. 1997.
3. Introductory Sociology. N. Jayaram. McMillan India Ltd. 2006.

Engineering Graphics   ME101
1 – 0 – 2 : 3 Credits : 5 Hours

Introduction to IS code of drawing; Conics and Engineering Curves – ellipse, parabola, hyperbola, cycloid, trochoid, involute; Projection of lines – traces, true length; Projection of planes and solids; sold objects – cube, prism, pyramid, cylinder, cone and sphere; Projection on Auxiliary planes; Isometric projection, isometric scale; Section of solids – true shape of section; Introduction to CAD tools – basics; Introduction of Development and Intersection of surfaces.

Text Books:

1. Engineering Graphics, K. L. Narayana, and P. Kannaaiah, Tata McGrawHill, New Delhi, 2nd Edition, 2005.
2. Elementary Engineering Drawing, N. D. Bhatt, Charotar Book Distributor, Anand, 2nd Edition, 2006.

References :

1. Engineering Graphics, V. Lakshminarayanan, and R. S. Vais, Jain Brothers, New Delhi, 14th Edition, 2008.
2. Engineering Graphics, A. M. Chandra, S. Chandra, Alpha Science, 2nd Edition, 2003.
3. Engineering Drawing and Graphics + AutoCAD. K. Venugopal, New Age International, New Delhi, 4th Edition, 2003.

Basic Electrical Engineering   EL101
3 - 0 - 1 : 4 Credits : 5 Hours

Engineering Circuit Analysis : Current, Voltage, Power, Circuit elements, Ohm's law, Kirchoff's law, Nodal Analysis, Mesh Analysis, Source transformations, Linearity and Superposition, Thevenin's and Norton's Theorems, Maximum power transfer theorem, Star-Delta and Delta-Star Conversion, Simple RL and RC Circuits, Unit Step Forcing Function, source free RLC Circuits, Sinusoidal Forcing Function, Complex Forcing Function, Phasor Concept,

Impedance and Admittance, Phasor diagrams, Response as a Function of ω, Instantaneous Power, Average Power, RMS values of Current and Voltage, Apparent Power and Power Factor, Complex Power, Introduction to Three Phase Circuits.

AC Machines : Transformer **:** Working principle, Ideal Transformer, Equivalent Circuit, Transformer tests, Voltage regulation, Efficiency. Three Phase Induction Motor **:** Construction, Production of rotating field, Slip, Torque and Slip, Equivalent Circuit. Single Phase Induction Motor **:** Double field revolving theory, Equivalent circuit, Typical Applications, Stepper Motors.

DC Machines : Principle of DC Generator, Methods of excitation, Characteristics and Applications, Principle of DC Motor, Types, Speed – Torque Characteristic, Speed Control, Motor starting, Applications.

Electrical Measuring Instruments : Basic Characteristics of Measuring Devices, Error Analysis, Standards and Calibration, Moving Coil, Moving Iron and Electrodynamic Meters, AC/DC ammeters and voltmeters, Ohmmeters, Wattmeters, Watt-hour meter, AC bridges, Q.meter, Cathode Ray Oscilloscope.

Power System : Introduction to generations, Transmissions and Distribution Power Systems, Domestic Wiring, Safety measures.

Laboratory Experiments

Experiments on Circuits : Verification of Network Theorems, Design and Study on circuits using R, L and C, Power measurement in single phase A.C. Circuits.
Transformer: Open circuit and Short Circuit Tests.
D.C machines : Open Circuit Characteristic of Generator, Speed Control of D.C. motors.
Electrical Measuring Instruments : Calibration of meters, Power measurement in 3-phase circuits, AC bridges.
Power System : Design and Physical model of domestic wiring.

Textbooks:

1. Electrical Engineering Fundamentals, V. Del Toro, PHI, 2nd Edition, 1994.
2. Basic Electrical Engineering, D.P. Kothari, I.J. Nagrath, Mc Graw-Hill, 2nd Edition, 2002.
3. Engineering Circuit Analysis, W.H. Hayt and J.E. Kemmerly, Mc Graw-Hill, 7th Edition, 1993.

References:

1. Circuits, Devices and Systems, R.J. Smith and R-C-Dorf , John Wiley & Sons, 5th Edition, 1992.
2. Modern Electronic Instrumentation and Measuring Techniques, D. Helfrick and W. D. Copper, Prentice Hall of India, 3rd Edition, 1990.
3. Electrical Measurements and Measuring Instruments, E. W. Golding and F. C. Widdis, A.H. Wheeler & Company, Calcutta, 5th Edition, 1993.
4. Advanced Electrical Technology, H. Cotton, Issac Pitman, 7th MKS Edition 2008.

Workshop Practice   ME103
0 - 0 - 2 : 2 Credits : 4 Hours

Machining: Introducing to various machine tools and demonstration on various machining process. Making jobs as per drawings

Fitting Practices: Study of different vices, power hammer. Making jobs as per drawing.

Welding Practice: Introduction to different welding processes. Practice on Oxy-acetylene gas welding and manual metal arc welding.

Carpentry: Introduction to different hand tools and wood turning lathe. Making jobs.

Textbooks:
1. Workshop Technology Vol. I & II, W. A. J. Chapman, E. Arnold, CBS, 4th Edition, ,2001.
2. Workshop Technology Vol. I & II, B. S. Raghuwanshi, Dhanpat Rai & Sons, 5th Edition, 2001.

References:
1. Manufacturing Process, M. L. Begeman, B. H. Amstead, John Wiley & sons, 6th Edition, 1998.

Mathematics II   MA103
3 - 1 - 0 : 4 Credits : 4 Hours

Vector spaces – Linear dependence of vectors, basis, linear transformations, rank and inverse of a matrix, solution of algebraic equations – cponsistency conditions. Eigenvalues and eigenvectors, Hermitian and skew Hermitian matrices.

Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, Laplacian, line and surface integrals, theorems of Green. Gauss and Stokes, orthogonal curvilinear coordinates.

Polynomials – Orthogonal Polynomials – Lagrange's, Chebysev Polynomials; Trigonometric Polymomials- Fourier Series, Fourier transforms, Laplace transform, z-transform, Wavelet transforms.

Finite differences, Newton's forward and backward interpolation formulae, Central difference interpolation. Trapezoidal rule and Simpson's 1/3rd rule of integration. Solution of polynomial and transcendental equations – bisection method, Newton Raphson method and Regula falsi method.

Textbooks:

1. Advanced Engineering Mathematics, E. Kreyszig, John Wiley and sons, 8th Edition, 2003.
2. An Introduction to Linear Algebra, V. Krishnamurthy, V. P. Mainra, J. L. Arora, Affiliated East-west Press Pvt. Ltd, 1st Edition, 1976.

References:
1. Higher Engineering Mathematics', B.S. Grewal, Khanna Publishers, 38th Edition, 2004.

Physics II   PH102
3 - 0 - 1 : 4 Credits : 5 Hours

Elements of special theory of relativity: postulates, Galilean and Lorentz transformations, equivalence of mass and energy.

Introduction to quantum mechanics and applications: limitations and failure of classical physics, wave-particle duality, uncertainty Principle, atomic and molecular spectra, elements of lasers and holography.

Solid state physics: Bravais lattice, Reciprocal lattice, X-ray diffraction, Brillouin zones, Band theory of solids.
Statistical physics: Quantum statistics, Fermi energy of metals.

Nuclear physics: Nuclear force, properties and models of nuclei, nuclear excitations and decay, nuclear reactions, elementary particles.

Laboratory Experiments:

1. To verify Hooke's law and determination the Young's modulus of elasticity of the material of a bar the method of flexure.
2. To determine the thermal conductivity of a bad conductor in the form of a disc by the Lees and Chorlton method.
3. To determine the thermal conductivity of a good conductor by Searle's method.
4. To determine the Rydberg constant by studying the Hydrogen spectrum.
5. B-H curve and determination of Curie temperature of a ferromagnetic material.
6. To determine the value of Stefan's constant.
7. To determine the Lande's g-factor with Electron Spin Resonance spectrometer.
8. To study the current-voltage, power output versus load, aerial characteristics and spectral response of the photoelectric solar cell.
9. To determine the Hall co-efficient of a given semiconductor.
10. To determine the band gap by measuring the resistance of a thermistor at different temperatures.

11. To construct AND, OR and NOT gates from NOR and NAND gates using IC chips.
12. To determine the dielectric constant of a given dielectric material.

Textbooks:

1. Concepts of Modern Physics, Arthur Beiser, McGraw Hill, 6th Edition. 2009.
2. Introduction to Solid State Physics, C. Kittel, Wiley Eastern Ltd., 8th Edition, 2007.
3. Quantum Mechanics, L.S. Schiff, McGraw Hill, 3rd Edition, 1993.

References:

1. Introduction to Special Relativity, Robert Resnick, Wiley, 4th Edition, 2009.
2. Quantum Mechanics, A. Ghatak and S. Lokanathan, McMillan Publishers, 1st Edition, 2004.

Introductory Computing   CO101

3 - 1 - 0 : 4 Credits : 4 Hours

Computer Fundamentals:

- History, Generations, Classification of Computers;
- Organization of a Computer;
- Concept of Programming and Programing Languages.

Introduction to Programming:

- Concept of Algorithm, Flow Chart, Pseudocode, Illustrative Problem Solving Examples.
- Features of a Programming Language: Character Set, Identifiers, Keywords, Data Types, Variables, Declarations, Operators & Expressions; Statements: Assignment, Input/Output; Flow Control- Conditionals and Branching; Iteration; Functions, Function Types, Scope Rule; Recursion; Arrays, Pointers, Structures. (A programming language like C/C++ shall be used as a basis language. The same language is to be used for the laboratory).

Textbooks:

1. Programming in C, E. Balaguruswamy. Tata McGraw Hill, 4th Edition, 2007.
2. Let us C, Kanetkar Y., BPB, 8th Edition, 2006.
3. The C Programming Language, B. W. Kerningham & D. Ritchie., Prentice Hall India, 2nd Edition, 2007.

References:

1. Programming in C, Gotfreid, Tata McGraw Hill, Edition, 2008.
2. Fundamentals of Computers, V. Rajaraman, Prentice Hall India, 5th Edition, 2007.
3. The Elements of Programming Style, B. W. Kerningham, McGraw Hill, 2nd Edition, 1982.
4. Techniques of Program Structures and Design, E. Yourdon, Prentice Hall, Illustrated Edition, 1986.
5. Theory and Problems of Computers and Programming, F.S. Schied, McGraw Hill, 2nd Edition, 1982.

Computing Laboratory   CO102

0 - 0 - 2 : 2 Credits : 4 Hours

Laboratory exercises shall involve the following:

1. Familiarization of a computer and the environment and execution of sample programs
2. Expression evaluation
3. Conditionals and branching
4. Iteration
5. Functions
6. Recursion
7. Arrays
8. Structures
9. Linked lists
10. Data structures

It is suggested that some problems related to continuous domain problems in engineering and their numerical solutions are given as laboratory assignments. It may be noted that some of basic numerical methods are taught in the Mathematics course.

Textbooks:

1. The Elements of Programming Style, B. W. Kerningham, McGraw Hill, 2nd Edition, 1982.
2. The C Programming Language, B. W. Kerningham & D. Ritchie., Prentice Hall India, 2nd Edition, 2007.
3. Programming in C, E. Balaguruswamy. Tata McGraw Hill, 4th Edition, 2007.

References:

1. Let us C, Kanetkar Y., BPB, 8th Edition, 2006
2. Programming in C, Gotfreid, Tata McGraw Hill, Edition, 2008.

Basic Electronics   EL102

3 - 0 - 2 : 5 Credits : 7 Hours

Diodes and Transistors : Semiconductor Materials, Semiconductor Diode, Equivalent Circuits, Diode Testing, Zener Diodes, Load Line Analysis, Rectifier Circuits, Wave Shaping Circuits, Bipolar Junction Transistors, Field-Effect Transistors, Transistors Biasing, Transistors Small Signal Analysis, Transistor Amplifier Circuits.

Operational Amplifiers : Operational Amplifier Basics, Equivalent Circuit, Practical Op-amp Circuits, DC Offset, Constant Gain Multiplier, Voltage Summing, Voltage Buffer, Controlled Sources, Instrumentation Amplifiers, Comparator, Oscillator Circuits.

Thysistors : Silicon Controlled Rectifier, Silicon Controlled Switch, Shockley Diode, DIAC, TRIAC.

Digital Systems: Number Systems and Codes, r's Complements and (r-1)'s Complements, Binary Addition and Subtraction, Representation of Negative Number, Floating Point Representation. Logic Gates: Basic and Universal, Boolean Theorems, De' Morgan's theorems, Sum-of-Products form, Algebraic Simplification, Karnaugh Map, Basic Combinational Circuit Concept : Half Adder, Full Adder, Sequential circuit concept : Basic Flip-Flops (RS, D, JK Flip-Flop).

Experiments using diodes and bipolar junction transistor (BJT) : diode characteristics, designs and analysis of half-wave and full-wave rectifiers, Clipping circuits and Zener regulators, BJT characteristics and BJT amplifiers.

Experiments using Operational amplifiers : Summing amplifier, Comparator, Oscillators.

Experiments using logic gates : Digital IC testing, Realization of Boolean Equation, Realization of Adder, Subtrator.

Experiments using flip-flops : Realization of Basic Flip-Flops.

Textbooks:
1. Electronic Principles, A.P. Malvino, Mc Graw-Hill, 6th Edition, 1999.
2. Electronic Devices and Circuit Theory, R.L. Boylestad and L. Nashelsky , PHI, 6th Edition, 2001.
3. Digital Systems, R.J. Tocci , PHI, 6th Edition, 2001.

References:
1. Micro electronics, J. Millman & A. Grabel, Mc Graw-Hill, 2nd Edition, 1987.
2. Op Amps and Linear Integrated Circuits, R.A. Gayakward, New Delhi , Prentice Hall of India, 5th Edition, 2002.

Engineering Mechanics   ME102
3 - 1 - 0 : 4 Credits : 4 Hours

Force systems: Moment of a force about a point and about an axis; couple moment; reduction of a force system to a force and a couple.

Equilibrium: Free body diagram; equations of equilibrium; problems in two and three dimensions; plane frames and trusses.

Friction: Laws of Coulomb friction., problems involving large and small contact surfaces; square threaded screws; belt friction; rolling resistance.

Properties of areas: Moments of inertia and product of inertia of areas, polar moment of inertia, principal axes and principal moments of inertia.

Principle of Virtual Work

Kinematics and Kinetics of particles: Particle dynamics in rectangular coordinates cylindrical coordinates and in terms of path variables; central force motion.

Rigid Body Dynamics: Relative velocity, Translation, Pure rotation and plane motion of rigid bodies, D'Alembert's principle, linear momentum, principle of conservation of momentum, Impact of solid bodies, work, energy, power, principle of conservation of energy

Textbooks:
1. Engineering Mechanics. K.L. Kumar, Tata McGraw Hill, 2nd Edition, 2002.
2. Engineering Mechanics. S. Timoshenko and D.H. Young, McGraw Hill, 4th Edition, 1995.

References:
1. Engineering Mechanics. R.C. Hibbler, Prentice Hall, 12th Edition, 2009.
2. Mechanics for Engineering. F. P. Beer and F. R. Johnston, McGraw Hill, 4th Edition, 1995.
3. Engineering Mechanics. I. H. Shames, Prentice Hall India, 4th Edition, 1997.

Environmental Science   ES 101
3 - 0 - 0 : 3 Credits : 3 Hours

General:

Basic ideas of environment, basic concepts related to environmental perspective, man, society and environment, their inter relationship.   1L

Mathematics of population growth and associated problems, definition of resource, types of resource, renewable, nonrenewable, potentially renewable, effect of excessive use vis-a-vis population growth, definition of pollutant and contaminant. Environmental impact assessment. 2L

Environmental degradation: Acid rain, toxic element, particulates, noise pollution, air pollution and its effect on man.   1L

Overall methods for pollution prevention, environmental problems and sustainable development , components of environment.   1L

Ecology:

Elements of Ecology: System, open system, closed system, definition of ecology, species, population, community, definition of ecosystem, biotic and abiotic components. Ecological balance and consequence of change: Effect of abiotic factor on population, flow chart of different cycles with only elementary reaction [oxygen, nitrogen, phosphate, sulphur], food chain [definition and one example of each food chain]   3L

Air Pollution and Control :

Atmospheric Composition: Troposphere, stratosphere, mesosphere, thermosphere, tropopause, stratopause and mesopause.   1L

Energy Balance: Conductive and convective heat transfer, radiation heat transfer, simple global temperature modal (Earth as a black body, earth albedo), problems.   3L

Green-house effects: Definition, impact of greenhouse gases on the global climate and consequently on sea water level, agriculture and marine food.   1L

Climate, weather: Difference between climate and weather, Global warming and its consequence: Adiabatic lapse rate, atmospheric stability, temperature inversion, radiation inversion, Atmospheric dispersion: Maximum mixing depth, ventilation coefficient, smokestack plumes and atmospheric lapse rate.   3L
The point-source Gaussian plume model excluded.

Source and effect of pollutants: Toxic chemicals in the environment, toxic chemicals in air, suspended particulate matter, carbon dioxide, sulphur dioxide, nitric oxide, lead, carbon monoxide.   2L

Primary and secondary pollutants: Emission standard, criteria pollutant, oxides of carbon, oxide of nitrogen, oxide of sulphur, particulate, PAN.   1L
Depletion Ozone layer: CFC, destruction of ozone lair by CFC, impact of other greenhouse gases, effect of ozone modification.   1L

Standards and control measures: Industrial, commercial and residential air quality air quality standard, Control measure (ESP, Cyclone separator, bag house, catalytic converter, scrubber (ventury). Statement with brief reference)   1L

Water Pollution and Control :

Hydrosphere: Hydrological cycle.   1L
Natural water, Pollutants : their origin and effects: Oxygen demanding wastes, pathogens, nutrients, salts, thermal application, heavy metals, pesticides, volatile organic compounds.   1L

River / lake / ground water pollution :
River : DO, 5day BOD test, BOD reaction rate constants, temperature dependents of BOD, effect of oxygen demanding wastes on river [Deoxygenation, reaeration], COD, Oil, Grease, pH.   2L

Lake : Eutrophication [Definition, source and effect]   1L

Ground Water: Aquifers, hydraulic gradient, ground water flow. (Definition only)   1L

Standard and control: Waste water standard [BOD,COD,Oil, Grease], Water treatment system [coagulation and flocculation, sedimentation and f1ltration, disinfection, hardness and alkalinity, softening], wastewater treatment, primary treatment, secondary treatmens [Trickling f1lters, rotating biological contractor, activated sludge, sludge treatment, oxidation ponds], tertiary treatment definition.   3L

Arsenic pollution: Biochemical effect, contamination, speciation   2L

Land Pollution:
Lithosphere Composition, Pollutants: Municipal, industrial, commercial, agricultural, hazardous solid wastes.   1L
Recovery and conversion method Waste and waste management Land filling, incineration, composting.   2L

Noise Pollution, Sources, effects: Definition of noise, effect of noise pollution, noise classification, transport noise, occupational noise, neighbourhood noise, definition of noise intensity, noise threshold limit value.   2L

Textbooks:

1. Introduction to Environmental Engineering and Science, G.M. Masters, Prentice Hall of India Pvt. Ltd., 2nd Edition, 1997.
2. Environmental science: the way the world works By B. J. Nebel, Prentice Hall Inc., 7th Edition, 1999.

References:
1. Ecology: The Link between the natural and social sciences, Odum, E.P., IBH Publishing Co. Delhi, 2nd Edition, 1975.

Second Year

Mathematics III   MS 201
2 - 1 - 0 : 3 Credits : 3 Hours

Discrete probability :
- Randomness, finite probability space, probability measure, events
- Conditional probability, independence, Bayes' theorem
- Discrete random variables
- Binomial, Poisson, geometric distributions
- Mean and variance: concepts, significance, computations, applications
- Integer random variables.

Continuous probability :
- Continuous random variables, the nature of these, illustrations of use
- Exponential and normal distribution: probability density functions, calculation of mean and variance
- The central limit theorem and the implications for the normal distribution
- Joint distribution.

Expectation :
- Moments, transform methods, mean time to failure
- Conditional expectation, examples
- Imperfect fault coverage and reliability.

Stochastic processes :
- Introduction: Bernoulli and Poisson processes, renewal process, renewal model of program behavior
- Discrete parameter Markov chains: transition probabilities, limiting distributions
- Queuing: M/M1 and M/G/1, birth and death process
- Finite Markov chains, program execution times

Sampling distributions :
- Purpose and the nature of sampling, its uses and applications
- Random approaches to sampling: basic method, stratified sampling and variants thereof, cluster sampling
- Non-random approaches: purposive methods, sequential sampling
- Data analysis; tools; graphical and numerical summaries
- Multivariate distributions, independent random variables

Estimation :
- Nature of estimates: point estimates, interval estimates
- Criteria to be applied to single point estimators: unbiased estimators, consistent estimators, efficiency and sufficiency of estimators
- Maximum likelihood principle approach, least squares approach; applicability conditions for these
- Confidence intervals
- Estimates for one or two samples.

Hypothesis tests :
- Development of models and associated hypotheses, the nature of these
- Hypothesis formulation: null and alternate hypotheses
- Testing hypothesis based on a single parameter, choice of test statistic; choice of samples and distributions
- Criteria for acceptance of hypothesis
- t-test, chi-squared test; applicability criteria for these.

Correlation and regression :
- The nature of correlation and regression, definitions
- Definition and calculation of correlation coefficients
- Approaches to correlation: the linear model approach, the least squares fitting approach, strengths and weaknesses of these and conditions for applicability.

Textbooks:
1. Scaum's Outline Series on Theory and Problems of Probability and Statistics. M. R. Spiegel, Tata McGrawHill, 2nd Edition, 2005.
2. Statistics: Concepts and Applications, H. Frank, S. C. Altheon, Cambridge Low Priced Edition, 2002.

References :

1. Statistical Methods for Engineering and Scientists, R. M. Bethea, B. S. Duran, and T. L. Boullion, CRC Press, 3rd Edition, 1995.
2. Probability, Random Variables, Stochastic Processes, A. Papoulis, McGrawHill, 5th Edition, 2008.

Food Chemistry   FT 201
3 - 0 - 1 : 4 Credits : 5 Hours

Water: Physical properties, types of water, water activity and shelf life of food Distribution of water in various foods and moisture determination.

Carbohydrates: Nomenclature and classification, structure and chemical properties of carbohydrates- monosaccharide, disaccharides and polysaccharides (cellulose, starch, fructans, galactans, hemi-cellulose, pectic substances, carageenan); changes in carbohydrates during processing. Carbohydrates determination methods. Enzymic and non-enzymic browning

Proteins: Classification, structure and properties of proteins, Proteins from plant and animal sources. Changes in protein during processing, protein determination methods.

Lipids: Classification, structure, physical and chemical properties of fatty acids and fats. Lipids- simple and derived. Different types of fats, uses in food processing, food emulsions, fat replacers. Changes during food processing. Protein lipid interaction, Lipid Carbohydrate interaction, Lipid-Lipid interaction.

Minerals: Classification, minerals in meat, milk, plants and their interaction with other components, losses of minerals during processing, metal uptake in canned foods

Vitamins : Role of vitamins in food industry, effect of various processing treatments and fortification of foods. Food sources, effects of deficiency

Plant pigments: Their roles in food industry, Bitter substance and tannins.

Practicals:
1. Preparation of standard solutions for the chemical analysis i.e. HCl, H_2SO_4, $KmnO_4$, Sodium Thiosulphate and Iodine.
2. Determination of moisture content.
3. Reducing and non reducing sugar
4. Determination of fiber content of different food material.
5. Detection of amino acid, containing aromatic ring, by Xanthoproteic test.
6. Determination of protein by Kjeldal method.
7. Determination of Ash content.
8. Detection of presence of starch by Iodine test.
9. Determination of water activity of different food materials.
10. To distinguish between mono-saccharides and di-saccharides of barfoed test.
11. Determination of minerals: calcium, phosphorous and iron;
12. Estimation of vitamins: ascorbic acid, carotene and thiamine.
13. Estimation of fats & Oils i.e. Free fatty acid, Peroxide value, Saponification value, RM Number, TBA test, Iodine value,

Text Book:

1. Principles of Food Chemistry, John M, Deman, Chapman and Hall, 3rd Edition, 1999.
2. Food Chemistry, Fennema Owen R., Food Science & Technology series, CRC press, New York, 4th edition, 2007.

References:
1. Food chemistry, Lillian Hoagland Meyer, CBS publication, New Delhi, 2nd Edition, 2006.
2. Food Science Chemistry & Experimental Foods, Dr. M. Swaminathan, Bappco Ltd 2nd Edition, 2001.
3. Food chemistry, S. Yadav, Anmol Publications 1st Edition, 1997.

Basic and Food Microbiology   FT 202
2 - 0 - 1 : 3 Credits : 4 Hours

Introduction: Classification, morphology, physiology, growth, nutrition and reproduction, pure culture techniques and maintenance of cultures, control of microorganisms by physical, chemical, antibiotic and other chemotherapeutic agents

Incidence of microorganisms in foods, sources of contamination. Principles underlying spoilage and preservation of foods. Contamination, spoilage and preservation of cereal products, sugar products, fruit and vegetables, meat products, fish and sea foods, egg and poultry products, milk and milk products and other foods, microbiological standards of foods.

Food borne infections, food plant sanitation, inspection and control, personnel hygiene.

Advanced technologies in food microbiology: rapid method for the detection of food borne pathogens.

Beneficial microorganisms and their utilization in food fermentation of bread, malt beverages, wines, vinegar, fermented vegetables, fermented dairy products. Probiotics and prebiotics.

Practical:
1. Culture media preparation, sterilization and activities of microorganism;
2. Determination of microbial growth curves based on absorbance.
3. Isolation, plating and characterization of microbes, population, colony count.
4. Gram staining.
5. Antibiotic sensitivity and determination of minimum inhibitory concentration.
6. Isolation and characterization from normal and decayed food items.
7. Effect of environmental factor on growth and development of microbes.
8. Study on food fermentation processes.
9. Isolation and identification of coli forms and vibrio species.

Text Book

1. Microbiology, J. Willey, L. M. Sherwood, C. Woolverton, McGraw Hill International, 8th Edition, 2010.
2. Food Microbiology, W. C. Frazier & D.C. Westhoffs, TMH, 4th Edition, 1993.
3. Essentials of food Microbiology, J. Garbutt, Arnold Publication, 2nd Edition, 1997.

References:
1. Microbiology, M. J. Pelczar Jr., E.C.S. Chan and N.R. Krieg, TMH Book Company, 5th Edition, 1993.
2. Modern Food Microbiology, James M. Jay, CBS Publishers Delhi, 4th Edition, 1993.

Fluid Mechanics   FT 203
3 - 1 - 1 : 5 Credits : 6 Hours

Definition and properties of fluids: Units of measurements; fluid statics, pressure at a point and its measurement; fuids 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's equation 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 flows-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 instruments, Positive displacement and centrifugal pumps.

Practicals:

1. To verify Bernoulli's equation experimentally.
2. To determine the flow rate and coefficient of discharge using Venturimeter.
3. To measure discharge through Rotameter.
4. To determine the Reynolds number and types of flow (Laminar or Turbulent), the flow rate and coefficient of discharge using Orifice meter.
5. To determine Pressure drop through a packed bed.
6. To determine losses due to pipe fitting, sudden enlargement and contraction.
7. To verify Darcy's law and to find out the coefficient of permeability of the given medium.
8. Measurement of viscosity and surface tension of liquids.
9. Demonstration of momentum theorem using impulse and reaction turbines
10. To determine the characteristics of centrifugal pump and to find out total head, pump efficiency and overall efficiency of pump.
11. To determine power consumption in agitated vessel.

Text Books:
1. Introduction to Fluid Mechanics. F. Kreith, CRC Press, London, 1st Edition, 2000.
2. Introduction to Fluid Mechanics. R. W. Fox, A. T. McDonald, and P. J. Pritchard, John Wiley and Sons, 6th Edition, 2003.
3. Hydraulics and Fluid Mechanics, Jagdish Lal, Metropolitan Book Co., 9th Edition, 2005.

References:
1. Hydraulics and Fluid mechanics, E. H. Lewitt, Issac Pitman and Sons, London, 10th Edition, 2001.
2. Chemical Engineering (Vol. I& II), J. M. Coulson & J. F. Richardson, Butterworth Heinemann, 4th Edition, 2002.

Computations in Food Processing   FT 204
2 - 1 - 1 : 4 Credits : 5 Hours

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 multi-component 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: Introduction to application of MS Excel, MATLAB and statistical software for solving process engineering calculations.

Practicals:
1. Simple calculations using spread sheet.
2. MS Excel programming.
3. MS Excel Graphics.
4. Statistics in MS Excel.
5. Introduction to MATLAB programming.
6. Simple MATLAB programs.
7. MATLAB Graphics.
8. Use of word processing software for creating report.
9. Familiarization with software related to food industry.
10. Visit to industry and knowledge of computer application in same.

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.

References:

1. Solving Problems in Food Engineering. S. Yanniotis, Springer, 1st Edition, 2003.
2. MATLAB manual, Mathworks.
3. Stoichiometry. B. Bhatt and S. Vora, Tata McGraw Hill, New Delhi, 3rd Edition, 1998.
4. Food Process Engineering, D.R. Heldman, and R.P. Singh. Academic Press, 4th Edition, 2004.
5. Food Engineering in Computer Climate, Institution of Chemical Engineers, Great Britain, 1st Edition, 2008.

Thermodynamics   ME205
3 - 1 - 0 : 4 Credits : 4 Hours

Definitions and concepts: SI Units, Thermodynamic systems, states, properties, processes, heat, work and energy

Thermodynamic Equilibrium: Zeroth Law, Temperature Scale; First Law of Thermodynamics; Properties of pure substances and steam, Mollier Chart.

Second Law of Thermodynamics; Carnot Cycle, Entropy; Corollaries of Second Law; Applications of First and Second Law to closed and open systems, non-flow and flow processes; steady state, steady flow and transient flow processes; Heat Engine and Heat Pumps/ Refrigeration.

Irreversibility and availability, exergy analysis; thermodynamic relations; Properties of mixtures and ideal gases

Thermodynamic Cycles: Otto, Diesel, Dual and Joule Cycle. Third Law of Thermodynamics.

Introduction to IC Engines.

Introduction to Power Cycle – Carnot, Rankine and Modified Rankine Cycle.

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.

References:

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.

Food Biochemistry and Nutrition   FT 205
3 - 0 - 1 : 4 Credits : 5 Hours

Biochemistry:

Introduction to biochemistry; usefulness of cells and organisms in biochemical studies; Water: its effect on dissolved bio-molecules; Enzymes: properties, classification, coenzymes and cofactors, enzyme kinetics, regulatory enzymes, iso-enzymes, enzyme inhibition and kinetics of enzyme inhibition, enzyme purification; elements of bioenergetics; Metabolism of carbohydrates, glycolysis, TCA cycle, oxidative phosphorylation, biosynthesis of starch; Lipid metabolism, fatty acid oxidation, biosynthesis of fatty acids, phospholipids, cholesterol; Amino acid oxidation, protein biosynthesis; clinical problems associated with excess and deficiency of proteins. Nucleic acids; Hormones; Elements of immunology.

Biochemistry of Foods: Biochemistry of Post harvest changes in plant products, post mortem changes in animal products, etc.

Nutrition:

Introduction to the study of nutrition, characteristics, functions, digestion and assimilation of food, metabolism, food sources of different nutrients, eg, proteins and amino acids, carbohydrates, lipids, minerals, fat-soluble vitamins, water-soluble vitamins-ascorbic acid and vitamin B complex; energy metabolism, special nutrition needs during pregnancy, lactation, infancy, for children, adolescents and aged; nutrition and public health; introduction to therapeutic nutrition, diet in disease conditions: jaundice, coronary heart disease, obesity, anaemia, renal problems, GI tract problems; inborn errors of metabolism, diabetes: neutraceuticals.

Practical:

1. Assay of enzymes;
2. Kinetics of any one enzyme and determination of Michaelis –Menten constant;
3. Polyacrylamide gel electrophoresis;
4. Determination of amino acid and protein by spectrophotometric method, biuret and Lowry method;
5. Amino acid analysis by amino acid analyzer;
6. Determination of vitamins A, C, and beta carotene;
7. Chromatographic experiments;
8. Analysis of blood for haemoglobin, protein, sugar and cholesterol;
9. Analysis of urine for urea, creatinine;
10. Body mass index;
11. Determination of protein efficiency ratio.

Text Books:

1. Lehninger Principles of Biochemistry, D. L. Nelson and M. M. Cox, W. H. Freeman Co. NY., 4th Edition, 2005.
2. Food and Nutrition I & II, M. Swaminathan, Edition, 1997.

References:

1. Biochemistry, J. M. Berg, J. T. Tymoczko and L. Stryer, Freeman Publisher,5th Edition, 2005.
2. Fundamentals of Biochemistry, D. Voet, J. G. Voet, C. W. Pratt, John Wiley & Sons, 2nd Edition, 2002.
3. Text Book of Biochemistry, T. M. Devlin, John Wiley & Sons, 5th Edition,2002.
4. Principles of Biochemistry, G. L. Zubey, W. W. Parson, D. E. Vance, C. Wu, Brown Publishers, 1st Edition,1999.

Principles of Food Processing and Preservation   FT 206
3 - 0 - 0 : 3 Credits : 3 Hours

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

Preservation of by low temperatures: Chillin**:** 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, Actual freezing, frozen storage and thawing of foods.

Preservation of foods by high temperature: Basic concepts in thermal destruction of micro-organisms-D, Z, F, values Heat resistance and thermophilisms in micro-organisms. Cooking, blanching, pasteurization and sterilization of foods. Extrusion, baking, roasting, frying, dielectric heating, ohmic, microwave and infrared heating. Assessing adequacy of thermal processing of foods, general process of canning of foods, spoilages in canned foods.

Preservation by water removal: Sun 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 behavior, 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.

Radiations: Sources of 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.

Effects of various food processing operations on the nutritive value of foods.

Text Books:

1. Food Science, Norman N. Potter and J.H. Hotchkiss, Chapman and Hall, 5th Edition., 1998.
2. Food processing technology: principles and practice, P. J. Fellows, Taylor and Francis, 3rd Edition 2009.

References:

1. Principles of Food Science-Part-II: Physical Method of Food Preservation, M. Karel, O.R. Fennema and D.B. Lund, Marcel Dekkar Inc., 2nd Edition, 2001.
2. Principles of Food Preservation, V. Kyzlink, Elsevier Press, 2nd Edition, 2003.
3. Modern Food Microbiology, J. M. Jay, D. Van Nostrand, 7th Edition, 2005.

Transfer Processes in Food Engineering   FT 207
3 - 0 - 1 : 4 Credits : 5 Hours

Overview of the processing operations carried out for converting agricultural produce to food; Classification into momentum, heat and mass transfer operations; Necessity of estimating their transfer rates as function of driving force.

Momentum Transfer: Pressure drop-flow rate, relationship for flow through pipe, rectangular conduit and extruder, in laminar flow; Turbulent flow and fanning's friction factor; Compressible flow: flow through nozzle and porous media; Apparent viscosity, generalized viscosity coefficient and generalized Reynolds number for non-Newtonian fluids; Non-Newtonian liquid flow in pipes and slits

Heat Transfer: Steady state heat transfer in conduction, convection and radiation; Overall heat transfer coefficient; Forced, natural convection, condensation and boiling heat transfer; Tubular and plate and fin type heat exchangers and estimation of their effectiveness; NTU-Effectiveness relationship; Unsteady state heat transfer in plate, cylinder and spherical bodies; Numerical methods in heat transfer.

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 and mass transfer coefficient; Mass transfer coefficients; Unsteady state mass transfer in plate, cylinder and spherical bodies; Analogy between momentum, heat and mass transfer

Practicals:
1. Determination of viscosity of liquid foods.
2. Determination of flow behaviour index of non Newtonian fluids.
3. Heat transfer through composite walls.
4. Heating rate in jacketed vessels.
5. Heat Exchangers and effectiveness.
6. Estimation of heat trsnsfer coefficients.
7. Estimation of diffusivity of gases/liquids.
8. Diffusivity values during drying of foods.
9. Pressure drop in flow through porous media .
10. Pressure drop in flow through extruders.
11. Temperature distribution in a drying oven.

Text Books:
1. Transport Phenomena in Food Processing Engineering, A.K. Datta, Himalaya Publishing House, 1st Edition, 2001.
2. Heat Transfer (in SI Units). Holman, J. P., Tata McGraw Hill, 9th Edition (Special Indian Edition), 2008.
3. Fundamentals of Heat and Mass Transfer. F. P. Incropera, and P. W.David, Wiley, 3rd Edition, 1990.

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

Mechanical Operations in Food Processing   FT 208
3 - 0 - 1 : 4 Credits : 5 Hours

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

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

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

Centrifugation: Principle of settling and centrifugation, devices for centrifugal separation.

Membrane separation processes: Reverse osmosis, nano filtration, ultrafiltration, microfiltration, dialysis and pervaporation.

Practicals:
1. Determination of physical properties such as bulk density, porosity, sphericity, angle of repose etc
2. Particle size distribution using sieve shaker.
3. Size reduction using Ball Mill and calculation of critical speed of mill.
4. Size reduction using Jaw crusher and calculation of equivalent diameter of solid particle.
5. Study of mechanical expression of edible oil.
6. Mixing experimentation and determination of uniformity coefficient.
7. Determination of power consumption in mixing/agitation.
8. Filters and filter resistance.
9. Determine the terminal velocity of Cyclone separator.
10. Studies on membranes separation processes.

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.

References:
1. Fundamental of Food Process Engineering, R.T. Toledo, CBS publishers, 3rd Edition, 1980..
2. Chemical Engineering (Vol. I& II), J. M. Coulson & J. F. Richardson, Butterworth Heinemann, 4th Edition, 2002.
3. Food Engineering Operation, J. G. Brennan, J. R. Butters, N. D. Cowell and A. E. V. Lilly, Elsevier Pub. 1st Edition, 1985.

Fruits and Vegetables Process Technology   FT 209
2 - 0 - 1 : 3 Credits : 4 Hours

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

Post harvest handling of Fresh Fruits and Vegetables: Role of plants growth regulators in relation to storage; physical and chemical treatment to increase the shelf-life, conditions for transportation and storage, disease and injuries during marketing, biosynthesis of flavours, biosynthesis of flavors, flavor characteristics;

Minimally processed Fruits and Vegetables : Factors affecting shelf life and the quality of minimally processed fruits and vegetables, physiology and biochemistry of fresh cut.

Storage of Fresh Fruits and Vegetables : Containers: Tin, glass and other packaging materials used in fruits and vegetables preservations. Canning and bottling, effect of canning and bottling on nutritive value, spoilage of canned foods, detection and control.

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

Preservation by freezing: general methods for freezing of fruits and vegetables; problem relating to storage of frozen products; standards for frozen food products.

Dehydration of Fruits and Vegetables: Methods; packaging, storage, quality control

Pickles and chutneys: 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: Use in fruit and vegetable preservation.

Practical:

1. Estimation of benzoic acid, So_2 estimation
2. Pectin determination in fruits and vegetable products.
3. Preparation fruit juices e.g. carambola, orange, pineapple, mango etc., syrups, squashes,
4. Canning of fruits and vegetables,
5. Preparation of jams and jellies, marmalade, preserves and candies
6. Preparation of pickles, chutneys
7. Preparation of tomato products
8. Drying of fruit and vegetables
9. Visit to fruits and vegetable processing industries; processing of mushrooms.

Text Book

1. Processing Fruits: Science and Technology, Vol. I, Biology Principles and Applications, L. Somogyi, Woodhead Publishing, 1st Edition, 1996.
2. Processing Vegetables: Science and Technology, D. S. Smith, J. N. Cash and W K. Nip, Y.H. Hui, , CRC, 1st Edition, 1996.

References:

1. Hand Book of Analysis and Quality Control for Fruits and Vegetable Products, S. Ranganna, Tata McGraw Hill, 3rd Edition, 2002.
2. Hand Book of Canning and Accepting Packaging, S. Ranganna, Tata McGraw Hill, **1st** Edition**, 2000.
3. Processing Fruits: Science and Technology, Vol II: Major Processed Products. L. Somogyi, D. M. Barette and Y.H. Hui, Woodhead Publishing, 1st Edition, 1996.
4. Handbook of Vegetable Preservation and Processing, Y. H. Hui, S.Ghazala, D.M. Graham, K.D. Murrell and W.K. Nip, Marcel Dekker, 1st Edition,2003.
5. Processing Fruits: Science and Technology, D.M. Barrett, L. Somogyi and H.S. Ramaswamy, Woodhead Publishing, 2nd Edition, 2004.

Instrumentation and Process Control   EL321
3 - 0 - 1 : 4 Credits : 5 Hours

Unit-I : Concept of instrumentation systems, Functional elements , performance characteristics of instrumentation systems- static and dynamic characteristics, first and second order systems and their responses, transducer classifications

Unit II: Manometer, McLeod and Pirani Gauge, pitot tubes, Elastic sensors-Bourdon tubes, bellows, diaphragms, springs, rings, fluidic and pneumatic transducers, resistive, inductive and capacitive sensors, displacement and motion measurements, strain gauges, resistive thermometers, thermocouples, flow meters, pH measurements and E-Nose sensors

Unit-III: Models of physical systems, differential equations, transfer functions in Laplace transform and z-transform, block diagrams of open and closed loop systems, stability criterions and stability analysis of systems

Unit-IV: Controller- ON/OFF and PID controllers-electronic circuits, digital controller and PLC, final control elements, control valves and actuators

Practicals:
1. Study of RTD
2. Study of thermocouples
3. Study of IC thermal sensors
4. Study of load cell
5. Study of E-Nose
6. Study of RPM sensor
7. Closed-loop DC and AC servo systems
8. Frequency response of first and second order systems

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.

3. Automatic Control Systems. B C Kuo, Prentice Hall, 7th Edition, 2002.

References:
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.

Third Year

Instrumental Methods of Food Analysis   FT 301
1 - 0 - 1 : 2 Credits : 3 Hours

Principle of measurement by using analytical instruments such as: Chromatographic techniques: General principles. Partition and adsorption chromatography, Paper, thin layer, gas liquid, ion exchange and affinity chromatography. Gel filtration, High Pressure Liquid Chromatography. Electrophoretic Techniques: General principles, Paper and gel electrophoresis. Polyacrylamide gel electrophoresis. Spectroscopy**:** Beers and Lambert's Law. Extinction coefficient. General principles of colorimeters and spectrophotometers, AAS, Emmission spectroscopy, IR spectroscopy. Flourimetry**,** Spectroflourometers. Use of radioisotopes**.**

Acceptance sampling: operational characteristics, risks, attribute sampling plans, administration of attribute, sampling error; Physical, chemical and rheological properties of food.

Practicals:
1. Sample preparation; determination of specific gravity of oils
2. Qalitative estimation of amino acids by Thin layer/Paper chromatography
3. Estimation of pesticides by using Gas chromatograph
4. Estimation of Vitamin C by using HPLC
5. Demonstration of Electrophoresis
6. Heavy metal analysis by AAS
7. Sodium, Potassium estimation by Flame photometer
8. Vitamin A estimation by Spectroflourometer

Text books:
1. A First Course in Food Analysis, V. Sathe, New Age International Pvt. Ltd., 1st Edition, 1999.
2. Food Analysis, S. S. Nielsen, Kluwer Academic Publishers, 3rd Edition, 2003.
3. Food Analysis Laboratory Manual, S. S. Nielsen, Springer, 2nd Edition, 2010.

References:
a. Analytical Methods for Food Additives, R. Wood, L. Foster, A. Damant and P. Key, Woodhead Publishing, 1st Edition, 2004.
b. Food Analysis: Theory and Practice, Y. Pomeranz and C.E. Meloan, Chapman & Hall, 3rd Edition, 1994.
c. Official Methods of Analysis, AOAC International, 13th Edition, 2005.
d. Handbook of Food Analytical Chemistry, R.E. Wrolstad, T.E. Acree, E.A. Decker, M.H. Penner and D.S. Reid, John Wiley & Sons, Annotated Edition, 2004.

Thermal Operations in Food Processing   FT 302
3 - 0 - 1 : 4 Credits : 5 Hours

Thermal properties of food constituents and foods. Overview of thermal operations carried out in dairy and food processing.

Pasteurization and Sterilization: microbial destruction in batch and continuous sterilization; kinetics of loss of nutrients in sterilization; batch and continuous pasteurization, Indirect and direct methods of UHT processing; aseptic packaging; Steam generation and culinary steam production.

Refrigeration and freezing: Refrigeration systems- vapour compression and absorption refrigeration systems, system components, refrigeration loads, sizing of refrigeration systems and components, cold storages. Food freezing: 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 concentration of liquid food.

Drying: Principle of drying and dehydration, equilibrium moisture content, rate of drying and drying equipments. Drying methods: hot air drying in thin layers and in static beds, vacuum drying, freeze drying, spray drying, fluidized bed drying; drying equipments, prediction of drying time from drying data.

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.

Practicals:
1. Measurements and estimation of thermal properties of foods
2. Study of pasteurizers
3. Lethality calculation for batch processes of sterilization
4. Study of boilers
5. Study of refrigeration systems/test rigs
6. Working of domestic refrigerators
7. Visit to cold storages
8. Drying characteristics of foods in thin layers
9. Drying foods in static bed and fluidized bed dryers.
10. Drum drying and spray drying of food slurries.
11. Studies on Single effect/ multiple effect evaporators.
12. Studies on steam economy and usage of economizers.

Text Books:
1. Heat Transfer (in SI Units). Holman, J. P., Tata McGraw Hill, 9th Edition (Special Indian Edition), 2008.
2. Fundamentals of Heat and Mass Transfer. F. P. Incropera, and P. W.David, Wiley, 3rd Edition, 1990.

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

Mass Transfer Operations in Food Processing   FT 303
3 - 0 - 1 : 4 Credits : 5 Hours

Physical Chemistry of Mass Transfer Operations in Food Processing: fugacity, activity, water Relation to foods: roles of water and activity in foods; control of water activity by addition of solute and moisture removal; measurement of water activity; different models of sorption isotherms, their limitations and applicability, prediction and moderation of water activity of foods.

Mass Transfer Laws: Review of Fick's 1st law for molecular diffusion, molecular diffusion in biological solutions and gels, molecular diffusion in solids, diffusion coefficients in gas, liquid and solid, numerical solution of steady state diffusion, Fick's 2nd law and unsteady state operation, mass transfer coefficients, interphase mass transfer, diffusion of gases in porous solids and capillaries.

Humidification: Psychometry and psychometric chart, fundamental concept of humidification and dehumidification, humectants and dehumidifiers, heat pump drying, cooling tower.

Liquid-liquid extraction: Ternary liquid–liquid equilibrium and tie line data, choice of solvents, extraction equipments. Leaching principle and equipments.

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

Gas Absorption: Equilibrium solubility of gases in liquids, ideal and non ideal solutions. Equipments: 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.

Adsorption and Ion Exchange: Types of Adsorption, nature of adsorbents, adsorption equilibrium, adsorption of a single component from a gas mixture/liquid solution. Multistage cross current and counter current adsorption, continuous contact adsorption. Principle of ion-exchange, equilibria and rate of ion-exchange.

Practicals:
1. Determination of water activities of foods.
2. Concentration dependency of water activity.
3. Sorption isotherms and storage stability of foods.
4. Studies on Humidification/ Dehumidification columns.
5. Studies on commercial dehudifiers.
6. Psychrometric chart and psychrometers.
7. Practicak examples of Psychrometric processes.
8. Solvent extraction method for edible oil extraction/Kjeldahl method of fat determination.
9. Studies on Absorption columns
10. Boiling point elevation and solute concentration
11. Study of enthalpy concentration diagram.
12. Studies on Bubble cap/ tray/ fractional column
13. Studies on extraction column.

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.

References:

1. Mass Transfer Operation, R. E. Treybal, Mc Graw Hill, 3rd Edition, 1981.
2. Chemical Engineering (Vol. I& II), J. M. Coulson & J. F. Richardson, Butterworth Heinemann, 4th Edition, 2002.

Cereals, Pulses and Oilseeds Processing Technology	FT 304
3 - 0 - 1 : 4 Credits : 5 Hours	

Importance of cereals pulses and oilseeds, 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, National and International quality and grading standards.
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 equipments 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. Criteria in and assessment of milling, cooking, nutritional and storage qualities of raw & parboiled rice. Processed rice products (flaked, expanded and puffed rice). By-product (husk and rice bran) utilization.
Other Cereals: 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 other cereal grains and millets. 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 equipments, 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.

Practical:
1. Determination of physical properties of different grains.
2. Determination of Gluten content, sedimentation value, alcoholic acidity, water absortption capacity and polenske value of wheat flour.
3. Determination of adulterant ($NaHCO_3$) in wheat flour/ Maida.
4. Determination of alkali score and gelatinization temperature of rice.
5. Traditional and improved pretreatments and its effect on dehusking of some legumes.
6. Pearling of some millets.

7. Visit to a working modern roller flour mill and FCI godowns.
8. Visit to working rice mill.
9. Preparation and analysis of Bread, Biscuits, Cake and Cookies.
10. Determination of yeast activity.
11. Determination of different quality parameters of oils.
12. Determination of efficiency of oil extraction techniques (mechanical expelling and solvent extraction).

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 Edtion, 2001.
3. Legumes: Chemistry, Technology and Human Nutrition, R.H. Mathews, Marcel Dekker, 1st Edition, 1989.
4. Bailey's Industrial Oil & Fat Products, D. Swer, John Wiley & Sons, 5th Edition, 2005.

References:

1. Cereals and Cereal products: Chemistry and Technology, Vol. 4, D.A.V. Dendy and B.J.Dobraszczyk, Springer, 1st Edition, 2001.
2. Rice: Chemistry and Technology, B.O.Juliano, AACC, 2nd Edition, 1985.
3. Wheat: Chemistry and Technology, Y.Pomeranz, AACC, 3rd Edition, 1988.
4. Malts and Malting, D. E. Briggs, Kluwer Academic Publication, 1st Edition, 1997.
5. Oils and Fats manual, A. Karleskind, Lavoisier Publisher, Paris, 1st Edition, 1996.

Biochemical Engineering   FT 305
3 - 0 - 0 : 3 Credits : 3 Hours

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: Basic design and construction of fermenter and ancillaries, main parameters to be monitored and controlled in fermentation processes. Overview of aerobic and anaerobic fermentation processes and their application in biotech industry, Solid substrate and submerged fermentation and its application. Fermenter types; Modeling of batch, fed batch and continuous Fermenters.

Down stream processing operations; Cell disruption, Solid- Liquid and Liquid- Liquid Separation processes, Extraction, Micro Filtration 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 pectic Enzymes- sub merged fermentation and semisolid fermentation Techniques: Industrial production of Glucose transforming enzymes; Organisms involved, production, purification and immobilization of (a) Glucose isomerase and (b) Glucose Oxidase. Industrial scale production of Bakers' yeast and Brewer's yeast; Microbial oil production and Bio pesticides.

Text Books:
1. Biochemical Engineering Fundamentals, J. E. Bailey, F. Oilis, Tata Mc Graw Hill, 2nd Edition, 2010.
2. Bioprocess Engineering- Basic Concepts, M. L. Shuller, F. Kargi, PHI, 2nd Edition, 2002.
3. Principles of Fermentation Technology, P.F. Stanbary, A. Whitaker, Hall, 2nd Edition, Aditya Books Pvt. Ltd., 2008.

References:
1. Industrial microbiology, S.C. Prescott and C.G. Dunn, Agrobios (India), 1st Edition, 2007.
2. Industrial Microbiology, A. H. Patel, McMillan India Ltd., 2nd Edition, 2009.
3. Biosensors for Food Analysis, A. Scott, Royal Society of Chemistry, UK, 1st Edition, 1998.
4. Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists, Shigeo Katoh and Fumitake Yoshida, Wiley VCH, 1st Edition, 2009.

Recent Advances in Food Research   FT 306
0 - 0 - 1 : 1 Credits : 2 Hours

Status of Food and Nutrition in the world. Production levels of different food items: pulses, tubers, cereals, meat, oils. Population growth and food demand. Structural changes and the demand for food in Africa and Asia . Regionalism. Food security and strategic grain reserves. Agriculture, Technological change and the Environment Linkages between Agriculture and Nutrition implications for policy and research. Case studies for consideration.
(Practicing experts and students will make presentations and interact).

References: Journals, reviews etc.

Fundamentals of Management   BM 321
3 - 0 - 0 : 3 Credits : 3 Hours

Part I
Meaning, Objectives and Scope of Management;
Functions of Management- Planning, Organizing, Staffing, Directing and Controlling;
Styles of Management.

Part II
Basics of Financial Magnagement; Marketing Management; Human Resource Management; and Production Management

Textbooks:
1. Principles and Practice of Management, L. M. Prasad, Sultan Chand and Sons, New Delhi, 2nd Edition, 1982.
2. Marketing Management, V. S. Ramaswamy and S. Namakumari, Macmillan India Pvt. Ltd, New Delhi, 3rd Edition, 2007.

References:
1. Human Resource Management, S. S. Khanka, S. Chand & Company Pvt. Ltd., New Delhi, 1st Edition, 2008.
2. Production and Operations Management, P. Rama Murty, New Age International Publishers, New Delhi, 2nd Edition, 2007.

Food Quality and Safety   FT 307
2 - 0 - 1 : 3 Credits : 4 Hours

Quality and Assurance: Definition, scope, importance and difference, Total quality control and (TQC) Total quality management (TQM), Statistical quality control. Definition, importance, scope and difference between food quality and food safety**.**

Sensory Evaluation: Selection of panel of judges, Prerequisite for sensory analysis, application of consumer tests; control of factors affecting of sensory verdict, Instrumental measurements of sensory attribute of foods sensory characteristics of foods, types of tests, Texture profile analysis. Correlation between instrumental and Sensory analysis of food quality attributes**.**

Raw materials & Finished product quality: Quality parameters and evaluation procedures: appearance, color, texture, viscosity, consistency, flavour etc.

Food standards and laws: International – Concept of Codex Alimentarius, HACCP, GMP, GHP, USFDA, ISO 9000, ISO 22000, ISO 14000. Export Quality Control and Inspection act (1963), Environment Protection Act (1986), WTO & GATT, etc. GMP, GHP. National – Compulsory and voluntary trade and Company standards. Consumer Protection Act (1986), BIS/IS, Food Safety and standards – 2006, FPO, MPO, MMPO, Agmark. GMP, GHP.

Quality Certification & Accrediation: Introduction and procedure

Prevention of food adulteration Act: Food Adulteration: definition, common adulterants in different foods, contamination, method of detection, Food additives and legislation; PFA specification for food products, Nutritional labeling

Risk and Hazard associated with Food : Food hazards, sources of hazard, classification, Food safety; prevention and control, Statistical quality control. HACCP,Quality costs.

Practicals:

1. Sensitivity tests (Threshold/Dilution) to measure individual's ability for sensory analysis.
2. Types of sensory evaluation : Paired comparison test, Duo-trio test, Hedonic test, Triangle test, Ranking test, Composite scoring test

3. Interpretation of sensory evaluation response.
4. Conducting HACCP study; techniques for quality assessment of foods, vegetables, cereals, milk, dairy products, meat, poultry;
5. Qualitative and quantitative measurement of adulterants in milk, vegetable oils, spices etc.;
6. Quantitative measurement of additives in foods.
7. Quantitative measurement of chemical residues in foods.
8. Food sampling for qualitative analysis.

Text Books:
1. Food Quality Assurance: Principles and Practices, I. Ali, CRC Press, 2nd Edition, 2004.
2. Quality Assurance in Food Industry: a Practical Approach, J. A. Vasconcellos, CRC Press, 1st Edition, 2003.
3. Statistical Quality Control for the Food Industry, M. R. Hubbard, Kluwer Academic/ Plenum Publishers, 3rd Edition, 2003.

References:
1. HACCP in Meat, Poultry and Fish Processing, A. M. Pearson and T.R. Dutson, Kluwer Academic Publishers, 2nd Edition, 1999.
2. Food Safety Contaminants and Toxins, J. P. F. D'Mello, Oxford University Press, 1st Edition, 2003.
3. Quality of Fresh and Processed Foods, F.Shasidi, A.M.Spanier, Chi-Tang Ho and T.Braggins, Kluwer Academics/ Plenum Publishing,3rd Edition, 2004.
4. Rapid and On-line Instrumentation for Food Quality Assurance, Jotbill, Woodhead Publishing,2nd Edition, 2003.

Food Plant Utilities   FT 308

2 – 0 - 1 : 3 Credits : 4 Hours

Steam Properties.

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.

Refrigeration Methods: Principles of refrigeration by vapour compression and absorption refrigeration systems, refrigerants and their characteristics, working and design features of refrigeration systems and their components.

Refrigeration Loads: Calculation of heat loads, principles of aeration and ventilation, design features, performance characteristics and application of blowers.

Text Books:
1. Thermal Engineering in SI Units, P.L. Ballaney, 23rd Edition, Khanna Publishers, Delhi., 2003.
2. Refrigeration and Air conditioning, C.P. Arora, Tata McGraw Hill Publishing Co. Ltd. 3rd Edition, New Delhi. 2008.

References:
1. Refrigeration and Air Conditioning, W.F. Stocker and J.W. Jones, 3rd edition, McGraw Hill Book Co., New York, 2002.
2. Refrigeration and Air Conditioning, M. Prasad, Revised (2nd) Edition, New Age International, New Delhi. 2003.
3. Physical Principles of Food Preservation, M. Karel, and D.B. Lund, 2nd Edition (Revised and Expanded), Marcel Dekkar Inc. 2003.

Dairy Products Technology   FT 309
2 - 0 - 1 : 3 Credits : 4 Hours

Introduction: Milk and Types of Milk, Factors affecting composition, quality and yield of milk.

Dairy Chemistry & Microbiology: Roles of lipids, proteins, carbohydrates, minerals, vitamins and enzymes, importance of psychrophilic, mesophilic and thermophilic spoilage organisms in storage, pasteurization and sterilization.

Cream Separation and Homogenization: Principles of cream separation, equipment, effectiveness, cut-off diameter and energy requirement. Cream, and its types, pasteurization. Homogenizers: principle of operation, design calculation for laminar and turbulent regimes, technology of homogenized milk production.

Pasteurization and Sterilization: Process and equipment for milk pasteurization, 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.

Concentration, Evaporation and drying: Process and equipment for evaporation and concentration of liquid milk, spray drying of liquid milk, energy consumption in spray drying, instantization methods, cyclone separation principle. Technology and standards of dried and condensed milk products. Cleaning and santitization of dairy equipments and plant

Dairy Products Manufacturing: Process Technology and standards of manufacturing of butter, cheese, Ice-cream, malted milk drinks, infant foods, fermented milk and other milk products (casein, whey proteins, lactose etc.). Indigenous dairy products manufacturing.

Practical:
1. Platform tests and milk grading
2. Chemical analysis of milk and assessment of raw milk for various quality parameters.
3. Cream separation and standardization.
4. Study of the effectiveness milk pasteurization, sterilization.
5. Study of different equipments used in processing of milk.
6. Preparation of the fermented milk products,
7. Preparation of cream, butter, cheese, paneer and traditional milk products.
8. Preparation of the fermented milk products.
9. Cleaning of dairy equipments.
10. Packaging of milk products.
11. Visit to dairy plants.

Text Books:

1. Applied Dairy Microbiology, E. H. Marth and J. L. Eteele, Marcel Dekker, 2nd Edition, 2001.
2. Dairy Science Technology, P. Walstra, J.T.M.Wouters and T.J. Geurts, CRC press, 2nd Edition, 2006.
3. 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.

References:

1. Milk and Dairy Product Technology, E. Spreer, Marcel Dekker, 2nd Edition, 1998.
2. Modern Dairy Technology, Vol. 1: Advances in Milk Processing, R.K.Robinson, Aspen Publishers, 2nd Edition, 1999.
3. Modern Dairy Technology, Vol. 2: Advances in Milk Products, R. K. Robinson, Aspen Publishers, 2nd Edition, 1996.
4. Outlines of Dairy Technology, Sukumar De, Oxford University Press, 3rd Edition, 2006.
5. Milk and Milk Products, C. Eckles, W. Combs, and H. Macy, Tata McGraw Hill, 3rd Edition, 2003.

Food Process Equipment Design   FT 310
3 - 0 - 0 : 3 Credits : 3 Hours

Revision on Solid Mechanics: Stress and Strain: stress at point, Cauchy stress tensor, equilibrium equation, Analysis of deformation and strain components. Principal stresses and strain, stress and strain invariants. Mohr's circle representation

Revision on Material and energy balance calculations for preliminary estimation of plant capacuty and equipment sizes. Preparation of flow sheets for material movement and utility consumption in food plant.

Materials of construction and Food-Metal Interactions, welding and machining of stainless steel.

Design of storage vessels for liquid food and grains. Pressure vessels design and design of vessel for drum drying. Performance characteristics and selection of fans, blowers, ejector compressors and vacuum pumps.

Design of fluid conveyance system; pipe, sanitary pipe fitting and valves. Performance characteristics and selection of centrifugal and positive displacement sanitary pumps.

Design of CIP system. Design of heat echange equipment-plate, scraped surface and extended surface for heating and cooling of gas and liquid.

Design of evaporator calandria, vapour separator and condenser.

Design considerations for location of food plant. Equipment layout and ventilation in food process plants.

Text Books:

1. Process Equipment Design, M V Joshi, V. V. Mahajan, Macmillan India Ltd., 3rd Edition, 2000.
2. Chemical Process Equipment, selection and Design, S.M. Walas, Butterworth-Heinemann series in Chemical Engineering, 3rd Edition, 2009.

References
1. Process Equipment Design - Vessel Design, L. E. Brownell and E.H. Young, Wiley Eastern Edn. NewYork, 2nd Edition, 1968.
2. Dairy Plant Engineering and Management. T Ahmad, Kitab Mahal, 8th Edition, 2009.

Social Responsibility and Ethics in Engineering   BM 322
3 - 0 - 0 : 3 Credits : 3 Hours

Engineering and Society: What is Engineering ? The Engineering View, The Engineering Image; The Engineer's Challenge: Cost, Deadlines, and Safety

Moral Dilemmas in Engineering: Engineering & Business;

Frameworks for Engineering Ethics: Moral Thinking and Moral Theories, Codes of Engineering Ethics, Support for Ethical Engineers

Engineering Ethics and Public Policy: Risk Assessment and Communication, Product Liability, Engineering and Sustainable Development.

Intellectual property: Foundations of intellectual property, Copyrights, patents, and trade secrets, Software piracy, Software patents, Transnational issues concerning intellectual property.

Entrepreneurship: prospects and pitfalls, Monopolies and their economic implications, Effect of skilled labor supply and demand on the quality of computing products, Pricing strategies.

Case Studies in Engineering Ethics: Challenger Disaster, Hyatt Regency Walkway Collapse, The Pfizer Heart Valve Case, The Therac-25 Case etc.

Textbooks:
1. Computers, Ethics and Social Values, D. G. Johnson & H. F. Nissenbaum, Prentice Hall, 1st Edition, 1995.
2. Cyber Ethics: Morality and Law in Cyber Space, R. A. Spinello, Jones & Bartlett Publishers, 3rd Edition, 2006.

Reference:
1. Social Issues in Computing: Putting Computing in Place, C. Huff & T. Finholt, McGraw Hill, 1st Edition,1994.
2. A Gift of Fire: Social, Legal, and Ethical Issues in Computing, Sara Baase, Prentice Hall, 1st Edition,2007.

Fourth Year

Food Packaging, Transportation and Storage   FT 401
2 - 0 - 1 : 3 Credits : 4 Hours

Introduction: Importance and Functions of Food Packaging, Packaging requirements for cereals, meat, poultry, fish, milk, vegetables, fruits, plantation crop based products and carbonated beverages Types of Packaging Materials: Polymer Films - Physical, chemical and permeability properties, manufacturing methods, testing and identification, permeability modeling, migration of chemicals. Metal Containers: Strength requirement, seaming and coating properties, contamination from lacquers. Glass containers and closures.

Food Packages: Rigid and Flexible packages: paperboard, lamination and sealing techniques, machinery for forming packages. Special packing: gas, vacuum and aseptic packaging, Advances in Food Packaging: Smart packaging, Intelligent Packaging, Active Packaging and Antimicrobial packaging, Retortable pouches, biodegradable and edibles packaging materials and films.

Testing of Packaging Material: Destructive & Non destructive test, Testing of rigid, semi rigid and flexible packaging material, Shelf life study etc. Corrosion and toxicity of packaging material.

Material Handling: Solids and granular materials handling - elevators, conveyors; Pumps - centrifugal and positive displacement; Liquid filling machines - open vent, closed vent and piston fillers.

Food Transportation: Modes, transportation damages, and their minimization.

Storage Principle and Practice: Storage losses and their estimation: Modified and control atmosphere storage: Bin and silo storage for cereals and pulses; Loss in cereal quality – insect and pest control.

Practical:
- Identification of different types of packaging and packaging materials
- Determination of tensile strength of given material;
- Destructive and nondestructive test on glass container, drop test
- Determination of wax weights, tensile strength of papers, bursting strength
- WVTR of packaging materials;
- Measurement of thickness of packaging materials;
- Testing of chemical resistance of packaging materials;
- Determination of shelf life of packaged foods; determination of ERH of foods.
- Introduction of students with the latest trends in packaging from websites and magazines.

Textbooks:
1. Food Packaging Principles and Practices. G. L. Robertson, Marcell Decker, 2nd Edition, 2006.
2. Innovation in Food Packaging. J.H. Han (Ed), Elsivier Publications, 1st Edition, 2005.
3. Food Packaging: Principles and Practices. G. L. Robertson, CRC Press, 2nd Edition, 2005.

References:
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. Food Packaging Science and Technology. K. L. Yam, D.S. Lee and L. Piergiovanni, CRC Press, 1st Edition,2008.

Plant Design and Process Economics   FT 401
2 - 0 - 1 : 3 Credits : 4 Hours

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, equipments, 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 equipments 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.

Practical: In practical of plant design and project engineering a plant design problem should be assigned to a group of (3-4) students. The students should carry out the conceptual design, flow sheeting, material and energy balance calculations, and cost and profitability analysis of any Food Plant.

Textbooks:
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, Kitab Mahal, 8th Edition, 2009.
3. Integrated Design and Simulation of Chemical Processes. Alexandre C. Dimian, and A. C. Dimian, Elsevier Science & Technology, 1st Edition, 2003.

References:
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.

Industrial Summer Training   **FT 471**
0 - 0 - 2 : 2 Credits : 0 Hours

Training will be of 8 weeks duration carried out during the summer break after the 6th semester. The students will submit their reports, and make a presentation in the 7th semester.

Project I   **FT 481**
0 - 0 - 6 : 6 Credits : 12 Hours

The students will carry out project works in groups of 2 or 3 students each under the guidance of a faculty member. The project shall consist of research/ design/ development/ implementation work. Evaluation will be based on the submitted report, quality of work and a two presentations.

Project II   **FT 482**
0 - 0 - 12 : 12 Credits : 24 Hours

The students will carry out project works in groups of 2 or 3 students each under the guidance of a faculty member. The project shall consist of research/ design/ development/ implementation work. It may also be a continuation of the work of.Project I, but to be evaluated separately based on similar criteria.

FT Electives

Bakery and Confectionary Technology   FT 421
2 – 0 - 1 : 3 Credits : 4 Hours

Current status, growth rate, and economic importance of Bakery and Confectionary Industry in India. Product types, nutritional and safety of products, pertinent standards & regulations.

Bakery Products: Ingredients & processes for breads, biscuits, cookies & crackers, cakes & pastries; doughnuts; rusks; other baked products. Equipments used, product quality characteristics, faults and corrective measures for above bakery products. Defining and assessing quality of ingredients & products.

Confectionary Products: Hard-boiled candies, toffees, fruit drops, chocolates and other confections:- ingredients, equipments & processes, product quality parameters, faults and corrective measures. Production & quality of chewing and bubble gums, cocoa products, breakfast cereals, macaroni products, sprouted grains.

Textbooks
1. Bakery Technology and Engineering. S. A. Matz, CBS Publications, 3rd Edition, 2003.
2. Cereals as Food and Feed. S. A. Matz, CBS Publications, 2nd Edition, 2001.
3. Baking Science and Technology. E. J. Pyler, Sosland Publishing Company, 3rd Edition, 2009.

References:
1. Industrial Chocolate Manufacture. T. Beckette, Wiley-Blackwell, 4th Illustrated Edition, 2005.
2. Dough rheology and baked product texture. F. Faubion, CBS Publications, 1st Edition (Indian reprint), 1997.
3. Chocolate, Cocoa and Confectionery. B.W. Minifie, CBS Publications, 3rd Edition, 1997.

Plantation Products and Spices Technology   FT 422
3 - 0 - 0 : 3 Credits : 3 Hours

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.

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.

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.

Composition, Structure and characteristics of cashew nut and other dry fruits.

Spices: Types, production, 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 and utilization.

Textbooks

1. Tea Production and Processing. B. Banerjee, Oxford & IBH Pub. Co., 1st Edition, 1993.
2. Coffee Technology. M. Sivetz, AVI publishing Co., 1st Edition, 1979.
3. Minor Spices and Condiments: Crop Management and Post Harvest Technology. J.S.Purthi, ICAR publication, 1st Edition, 2001.
4. Major Spices of India: Crop Management and Post Harvest Technology. J.S.Purthi, ICAR publication, 1st Edition, 2003.
5. Tree Nuts: Production, Processing, Products. J. G. Woodroof, AVI Pub. Co., 1st Edition, 1979.

References:

1. Handbook of Fruit Science and Technology: Production, Composition, Storage, and Processing. D. K. Salunkhe, S. S. Kadam, CRC Press, 1st Edition, 1995.
2. Global Advances in Tea Science. N.K.Jain, Aravali Books International, 1st Edition, 1999.
3. Coffee: Botany, Biochemistry and Production of Beans and Beverage. M.N. Clifford and K.C.Willson, AVI publishing Co., 1st Edition, 1985.

Oils and Fats Technology   FT 423
2 – 0 - 1 : 3 Credits : 4 Hours

Sources; chemical composition; physical and chemical characteristics; functional and nutritional importance of dietary oils and fats. Post-harvest handling storage and processing of oilseeds for directs use and consumption.

Extraction of oil by mechanical expelling and solvent extraction and obtaining deoiled cakes suitable for edible purposes. Processing of other plant sources of edible oils and fats like coconut, cottonseed, rice bran, maize germ, etc.

Refining: Clarification, degumming, neutralization (alkali refining), bleaching, deodorization techniques / processes. Blending of 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, especially by biotechnology.

Textbooks
1. Edible oil Processing. W. Hamm and R.J. Hamilton (Eds), CRC Press, 1st Edition, 2000.
2. Food oils and fats: technology, utilization, and nutrition. H. Lawson, Chapman & Hall, 1st Edition,1994.
3. Fats in Food Technology. K.K. Rajah, Sheffield Academic Press, 1st Edition, 2002.

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

Processing Technology of Meat, Poultry and Fish   FT 424
3 – 0 - 0 : 3 Credits : 3 Hours

World production of fish, meat and poultry, consumption pattern and nutritive value; introduction to meat, fish and poultry industry; characteristics and structure of fish, meat and poultry muscle.

Meat: Animal production, feeds and raising of animals; 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: 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: 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. Poultry Science. C. G. Scanes, G. Brant and M. E. Esminger, Prentice Hall, 4th Edition, 2004.
3. Fish Inspection, Quality Control and HACCP. R. Martin, R. Collete and J. Slavin (Eds), Technomic Publishing Co., 1st Edition, 1997.
4. Meat Science and Applications. Y. H. Hui, W K. Nip and R. W. Rogers, O. A, Young, Marcel Dekker, 1st Edition, 2001.
5. Meat Products: Technology, Chemistry and Microbiology. A.H. Varnam and J.P. Sutherland, Food Products Series: Vol III, Chapman Hall,1st Edition,1995.

References:

1. Advanced Technologies of Meat Processing, L.M.L. Nollet and F. Tolbra, CRC Press, 1st Edition,2006.
2. Muscle Foods: Meat, Poultry and Seafood Technology. D.M. Kinsman, A.W. Kotula and B.C. Breidenstein, Chapman & Hall, 1st Edition, 1994.
3. Advances in Fish Processing Technology, D. P. Sen, Allied Publishers Pvt. Ltd.,1st Edition, 2005.

Fermented and Non-Fermented Beverages   FT 425
3 – 0 - 0 : 3 Credits : 3 Hours

Introduction and ingredients: Scope and status of beverages in North East region and in India. Definition of beverage, study of ingredient like sweeteners, emulsifier, colouring agent, flavoring agent, stabilizer.

Technology for non-alcoholic beverages: Raw materials quality and handling. Equipment and machinery for carbonated beverages, water treatment, syrup preparation, containers and closures, handling of empty containers and cleaning, carbonation, filling, inspection and quality control.

Technology for non-carbonated beverages: Raw materials quality and handling. Technology, specification, equipment and machinery for instant tea and coffee, fruit juice based beverages, milk and whey based beverages.

Technology for alcoholic beverages: Raw materials quality and handling. Technology, equipment and machinery for Wine, Beer, Whiskey, Brandy, and Rum. Cereal Fermentation.

Packaging and storage of different beverages. Sanitation in beverage industry. Waste utilization of beverage industries.

Texts Books:
1. Industrial Mcrobiology. S.C Prescott and C.G. Dunn, Agrobios (India), 1st Edition, 2007..
2. Brewing, Yeast and Fermentation. C. Boulton, and D. Quain, Blackwell Science Ltd, 1st Edition, 2001.

References
1. Principles of Brewing Science. G.J. Fix, Brewers Publications, 2nd Edition, 1999.
2. Principles of Fermentation Technology, B. Whitaker, 2nd Edition, 2006.

Food Product Development   FT 426
2 - 0 - 1 : 3 Credits : 4 Hours

Innovation and 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. Actual production trials and test marketing. Evaluation of test results.

Launching of the product. Advertising and marketing plans. Suggestions for improving success.

Introduction to Consumer Survey, market Survey, Development of New Product by Using Statistical Software Like Design Matrix, Full Factorial Design, RSM, SPSS, One way ANOVA and Two way ANOVA etc

Textbooks
1. Food Product Design A Computer-Aided Statistical Approach. R. Hu, Technomic Publishers, 1st Edition, 2005.
2. An Integrated Approach to New Food Product Development. H. R. Moskowitz, S. Saguy, and T. Straus (eds), CRC Press, 1st Edition, 2006.

References ::
1. Concept Research In Food Product Design And Development. H. R. Moskowitz, S. Porretta, and M. Silcher (eds), Blackwell Publishing Ltd, 1st Edition, 2006.

Flavour Technology   FT 427
3 – 0 - 0 : 3 Credits : 3 Hours

Food flavor and its importance to consumers and food processors. Flavor and nutrition.

Sources, extraction, delivery systems, and analyses (chemical, instrumental, and sensory) of flavours and flavorings in foods. Sensory perception of flavor: Senses of taste and smell, tasting versus sniffing, astringency, pungency, interaction of senses in flavor perception; taste, odour,and acceptance of flavor stimuli.

Chemistry of substances responsible for taste and flavor-taste sensations, flavour enhancers, flavour potentiators or modifiers. Methodology of sensory evaluation and determination of threshold levels as specified by BIS.

Flavoring constituents of various foods like meat, fish, milk, vegetables, fruits, fats & oils, spices & herbs, cereals and pulses. Flavor changes during processing, preservation, packaging, and storage of foods. Roles as sulfur compounds, fatty acids, amino acids, terpenoids, lactic acid-ethanol in food flavours. Process and reaction flavours/volatiles in foods.

Spices and herbs as food flavorings: Processing of basil, mint, saffron, cloves, tamarind, ginger, cardamom, chilies, pepper etc. for essential oils, extracts and/or oleoresins..

Determination of hygroscopic nature and shelf life/acceptance of foods. Natural, Nature

identical and Synthetic flavors: Definitions, chemical composition/constituents, extraction and preparation of flavors, Stability and utility of flavor preparations. Methods used in flavor evaluation. BIS Specifications/PFA restrictions for use of certain constituents in flavoring materials.

Textbooks:
1. Flavor Chemistry and Technology. G. Reineccius, Taylor & Francis Publishers, 2nd Edition, 2006.
2. Food Chemistry. O.R. Fennema, Food Science & Technology series, CRC press, New York, 4th Edition, 2007.

References:

1. Spices and Flavor Technology. J.S. Pruthi, ICAR Publications, 2nd Edition, 1998.

Specialty Foods: Nutraceuticals and Functional Foods — FT 428

3 – 0 - 0 : 3 Credits : 3 Hours

Scope, importance and renewed emphasis on specicality foods, health foods, functional foods. Nutraceuticals, infant and baby foods, adolescent/ teen age foods, foods for pregnant ladies 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, Mc Graw Hill, 3rd Edition, 2002.
2. Nutrition and Dietetics. S. A. Joshi, Tata Mc Graw Hill Co. Ltd., 2nd Edition, 2003.

References :
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.
3. Basic Nutrition in Health and Disease. P. S. Howe, W. B. Saunders Company, London, 2nd Edition, 2003.

Traditional Indian Foods — FT 429

3 – 0 - 0 : 3 Credits : 3 Hours

TRADITIONAL INDIAN FOODS

Processing & Preservation methods of Sweets & Desserts: Kulfi, Falooda, Kheer, khurchan, khoa/mawa, Rabri, jalebi, imarti, Gulabjamun, Peda, petha, rewdi, gajak, milk cake, balushahi, bal mithai, singoni, Ras-malayi, Gulqand, ghevar, rasgolla, chamcham, son halwa, son papri, several varieties of halwa, laddu, barfi & rasgolla.

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

Processing & Preservation methods of Fermented Foods: Idli, dosa, Vada, khamman dhokla, Dahi (Curd), Srikhand.

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

Processing & Preservation methods of Preserves & Beverages: Murabba, sharbat, pana, aam papad, sharbat, coconut water, tea, milk (khas, rose), Alcoholic Beverages (palm wine, fenny, bhang & Indian beer)

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.

References:

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 YearBook, 2009.
3. Fundamentals of Indian Cooking. Rakesh Mangal, Subling Publication,2nd Edition, 2003.

Industrial Microbiology and Enzyme Technology   FT 430
3 – 0 - 0 : 3 Credits : 3 Hours

Introduction, Classification of Microbial products. Microbial Processes for Production of organic acids, solvents, antibiotics, enzymes, polysaccharides, lipids, pigments and aroma.

Equipments and Accessories for industrial processes.

Stability of Enzymes. Enzymes stabilization by selection and genetic Engineering, protein engineering.

Reaction Environment rebuilding, Chemical modification, intra-molecular cross linking, immobilization.

Application of enzymes in industry, analytical purpose and medical therapy
Text Books:
1. Industrial microbiology. S.C Prescott and C.G. Dunn, Agrobios (India), 1st Edition, 2007.
2. Industrial microbiology. Casida, L.E.J.R. Reprinted, New Age International, 1st Edition, 2010.

References:

1. Enzymes: Biochemistry. Biotechnology and Clinical Chemistry, Trevor Palmer, and Philip L. Bonner, Horwood Publishing Limited, 2nd Edition, 2007.
2. Journals and Reviews.

Food Process Design and Analysis   FT 431
3 - 0 - 0 : 3 Credits : 3 Hours

Principles of Process Design: Food science concepts such as: principles of conventional processes, minimal processing, non-thermal processing, chemical kinetics, food microbiology and

food safety. Food engineering concepts such as identification of unit operations, flow sheet preparation, material and energy balances, mechanical processes, and safety and hygiene. Principles of spreadsheet aided process design.

Identification: Identification of design, operating and performance parameters in mechanical, thermal and mass transfer operations carried out in food processing

Mathematical Modeling: Developing mathematical relationship between the independent and dependent variables affecting the food processing operations by using physical and chemical principles governing the processes for, particulate size reduction, homogenization, centrifugation, packaging, mixing, conveying, extrusion, storage, heating, cooling, freezing, puffing, frying, distillation, extraction, concentration and drying.

Empirical Modeling: Factorial, fractional-factorial and rotatable central composite experimental design; Developing empirical equations using experimental data. Examples of usage of soft computing tools such as ANN, GA, fuzzy logic etc., in developing predictive models, optimization of processing parameters, and modeling of sensory evaluation.

Textbooks
1. Simulation Modeling And Analysis. Averill M. Law, McGraw Hill, 4th edition, 2007.
2. Food Processing Operations Analysis. H. Das, Asian Books publication, New Delhi, 1st Edition, 2005.
3. Process Modelling, Simulation and Control for Chemical Engineers. W.L. Luyben, McGraw Hill Book Co, 2nd Edition, 1990.

References
1. Food Process Design. Z B. Maroulis and G D. Saravacos, Marcel Dekker, 1st Edition, 2003.
2. Food Process Modelling. L. M. M. Tijskens, M. L. A. T. M. Hertog, B. M. Nicolaï, CRC Press, 1st Edition, 2001.

Food Process Automation FT 432
3 - 0 - 0 : 3 Credits : 3 Hours

Introduction: Food quality, automated evaluation of food quality, food quality quantization and process control, typical problems in food quality evaluation eg., beef quality evaluation; food odor measurement, continuous snack food frying quality

Data acquisition: Sampling elaboration with examples, concepts and systems for data acquisition such as: ultrasonic signal acquisition for beef grading, electronic nose data acquisition for food odor measurement, snack food frying data acquisition for quality process control, Image acquisition: elaboration with examples.

Data analysis: Data preprocessing, Static data analysis, Dynamic data analysis, Image processing: Image segmentation, Image feature extraction etc.

Modeling : Modeling strategies: Theoretical and empirical modeling, Static and dynamic modeling, Linear statistical modeling, ANN modeling etc.

Prediction: Prediction and classification, Sample classification for beef grading, examples such as, based on linear statistical and ANN models, Electronic nose data classification for food odor

pattern recognition, Snack food classification for eating quality evaluation based on linear statistical and ANN models, One-step-ahead prediction

Control: Process control, Internal model control, Predictive control, Neuro-fuzzy PDC for snack food frying process, Systems integration: Food quality quantization systems integration, Food quality process control systems integration, Food quality quantization and process control systems development

Textbooks
1. Measurement Systems: Applications and Design. E O Doeblin and D N Manik, Tata McGraw Hill, 5th Edition, 2003.
2. Automatic Control Systems. B C Kuo, Prentice Hall, 7th Edition, 2002.

References
1. Automation for food engineering: food quality quantization and process control. Y. Huang, D. Whittaker, and R. E. Lacey., CRC Press, 1st Edition, 2001.
2. Measurement and control in food processing. M. Bhuyan. CRC Press, 1st Edition, 2006.
3. Optical Monitoring of Fresh and Processed Agricultural Crops, M. Zude (ed),CRC Press, 1st Edition, 2009.

Numerical Methods in Food Processing   FT 433
3 – 0 - 0 : 3 Credits : 3 Hours

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 (Newton-Gregory 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, Newton-Raphson method, simultaneous linear Algebraic equations by Gauss-Jordan method, Crout's method, factorization method, Gauss-Seidel iterative method, determination of eigen values.

Textbooks:
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.

References:
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, 2005.
3. Numerical Methods for Scientists and Engineers. K S Rao, Prentice Hall of India, New Delhi, 3rd Edition, 2007.

Energy Conservation in Food Processing   FT 434
3 – 0 - 0 : 3 Credits : 3 Hours

Fundamentals of Engineering Analysis and Management: Fundamentals of Heat Transfer, Fluid Mechanics, and Thermodynamics in Food Processing, Fundamentals of Energy Auditing, Sustainability in the Food Industry

Energy Conservation Technologies Applied to Food Processing Facilities: Energy Conservation in Steam Generation and Consumption System, in Compressed Air System, in Power and Electrical Systems, in Heat Exchangers, Waste-Heat Recovery and Thermal Energy Storage in Food Processing Facilities, novel Thermodynamic Cycles Applied to the Food Industry for Improved Energy Efficiency

Energy Saving Opportunities in Existing Food Processing Facilities: Energy Consumption pattern, Energy Conservation in Grains and Oilseeds Milling Facilities, in Sugar and Confectionary Processing Facilities, in Fruit and Vegetable Processing Facilities, in Dairy Processing Facilities,in Meat Processing Facilities, in Bakery Processing Facilities

Energy Conservation in Emerging Food Processing Systems: Membrane Processing of Foods, Energy Efficiency and Conservation in Food Irradiation,in Pulsed Electric Fields Treatment, in High-Pressure Food Processing, in Microwave Heating, in Supercritical Fluid Processing

Conversion of Food Processing Wastes into Energy: Food Processing Wastes and Utilizations, Anaerobic Digestion of Food Processing Wastes, Fermentation of Food Processing Wastes into Transportation Alcohols, Bio-diesel Production from Waste Oils and Fats, Thermo-chemical Conversion of Food Processing Wastes for Energy Utilization

Textbooks
1. Energy Efficiency and Management in Food Processing Facilities. Lijun Wang, CRC Press, 1st Edition, 2009.
2. Energy in Food Processing. R.P. Singh, Elsevier Publishing Co. Amsterdam, 1st Edition, 1986.

References
1. Environmentally Friendly Food Processing. Berit Mattsson and Ulf Sonesson, CRC Press, 1st Edition, 2003.

Food Plant Hygiene and Sanitation   FT 435
3 – 0 - 0 : 3 Credits : 3 Hours

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 equipments.

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.

Textbooks
1. Food Hygiene and Sanitation. S. Roday, Tata McGraw Hill, 1St Edition, 1998.
2. Principles of Food Sanitation. N. G. Marriott, Springer, 5th Edition, 2006.
3. Hobbs Food Poisoning and Food Hygiene. Jim Mclauchlin and Christine Little (Eds), 7th Edition, 2007.

References:
1. Practical Food Microbiology & Technology. Harry H. Weiser, Mountney, J. and Gourd, W.W. AVI Publishing House, 2nd Edition, 1971.
2. Sanitation in Food Processing. John Troller, Academic Press, 2nd Edition, 1993.

Food Industry Waste Management   FT 436
3 – 0 - 0 : 3 Credits : 3 Hours

Basic considerations: Standards for emission or discharge of environmental pollutants from food processing Industries as per the updated provision of Environment (Protection) Act, 1986. Elements of importance in the efficient management of food processing wastes.

Characterization and utilization of by-products from Cereal Pulses, Oilseeds, Fruits and vegetables, Plantation products, Fermented foods, Milk, Fish, Meat, Egg and poultry processing industries.

Characterization of food Industry effluents, Physical an chemical parameters, Oxygen demands and their interrelationships, Residues (solids), Fats, Oils and grease, Forms of Nitrogen, Sulphur and Phosphorus, Anions and cations, Surfactants, Colour, Odour, Taste, Toxicity. Unit concept of

treatment of food industry effluent, Screening, Sedimentation Floatation as pre - and primary reactants.

Biological oxidations: Objects, Organisms, Reactions, Oxygen requirements, Aeration devices Systems: Lagoons, Activated sludge process, Oxidation ditches, Rotating biological contracters and their Variations and advanced modifications.

Advanced wastewater treatment systems. Physical separations, Micro-strainers, Filters, Ultra filtration and reverse osmosis. Physico-chemical separations: activated carbon adsorption, Ion-exchange electro-dialysis and magnetic separation. Chemical oxidations and treatment Coagulation and flocculation. Disinfection. Handling disposal of sludge.

Textbooks:
1. Waste Management For The Food Industries. Ioannis S. Arvanitoyannis, Academic Press, 1st Edition, 2008.
2. Managing food industry waste: common sense methods for food processors. R. R. Zall, BlackWell Publishing Asia, 1st Edition, 2004.
3. Bioprocess Engineering- Basic Concepts. K. Shuller, Prentice Hall (India), 2nd Edition, 2002.

References:
1. Handbook of Waste Management and Co-product Recovery in Food Processing: Vol. 1. K. Waldron (ed), Woodhead Publishing, 1st Edition, 2007.
2. Environmentally Friendly Food Processing. Berit Mattsson and Ulf Sonesson, CRC Press, 1st Edition, 2003.
3. Environment (Protection) Act 1986, Govt of India.

Industrial Safety and Hazards   FT 437
3 – 0 - 0 : 3 Credits : 3 Hours

Industrial safety, Industrial hygiene and safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiation etc. Explosions including dust , vapor, cloud and mist explosion.

Elements of safety, safety aspects related to site, plant layout, process development and design stages, identification of hazards and its estimation, risk, risk analysis and assessment methods; fault free method, event free method, scope of risk assessment, controlling toxic chemicals and flammable materials. Toxic substances and degree of toxicity, its estimation, their entry routes into human system, their doses and responses, control techniques for toxic substances exposure, use of respirators, ventilation systems.

Prevention of losses, pressure relief, provision for fire fighting, release of hazardous materials from tanks, pipes through holes and cracks , relief systems : types and location of relief's.

Handling, transportation and storage of flammable liquids, gases, and toxic materials and wastes, regulation and legislation, government role, risk management routines, emergency preparedness, disster planning and management.

Textbooks:
1. Chemical Process Safety Fundamentals with Applications. D.A. Crawl and J.A Louver, Prentice Hall, 2nd Edition, 2002.

2. Safety Management: A Guide for Facility Managers. J. F. Gustin, Fairmont Press, 2nd Edition, 2007.

References:
1. Guidelines For Hazard Evaluation Procedures. Center for Chemical Process Safety (CCPS), Wiley Inter Science, 1st Edition, 2008.
2. Guidelines for Risk Based Process Safety. Center for Chemical Process Safety (CCPS), Wiley Inter Science, 1st Edition, 2007.
3. Other CCPS Guidelines.

Optimization Techniques   FT 438
3 – 0 - 0 : 3 Credits : 3 Hours

Introduction:- Introduction, engineering applications of optimization, statement and classification of optimization problem, single variable and multi variable optimization with and with constraints

Linear Programming:-Formulation of linear programming problem, graphical approach, general linear programming problem, simplex method, duality in linear programming and transportation problems.

Project scheduling: Project scheduling by PERT and CPM, network analysis

Sequencing theory: General sequencing problem jobs through 2 machine and 3 machines and 2 job through n machines.

Dynamic programming: Introduction, principle of Optimality. Formulation and solution of Dynamic Programming problems. Traveling salesman's problems. Application to transportation problem and linear programming problems.

Textbooks:
1. Operations Research-An Introduction. H.A. Taha, Prentice Hall, 8th Edition, 2007.
2. Numerical Optimization with Applications. S. Chandra, Jayadeva, and A. Mehra, Narosa Publishing House, 1st Edition, 2009.
3. Operations Research- Principles and Practice. A. Ravindran, D. T. Phillips and J. J. Solberg, Wiley India, 2nd Edition, 2007.

References:
1. Introduction to Mathematical Programming: Applications and Algorithms. W.L. Winston and M. Venkataramanan, Duxbury Press, 4th Edition, 2002.
2. Introduction to Operations Research - Concepts and Cases. F.S. Hillier, and G.J. Lieberman, Tata McGraw Hill, 9th Edition, 2009.

Advanced Food Processing Methods   FT 439
3 – 0 - 0 : 3 Credits : 3 Hours

High Pressure Processing: Principles of high pressure processing, use of high pressure to improve food safety and stability. Effects of high pressure on food quality: Pressure effects on microorganisms, enzyme, texture and nutrients of food. Modelling HP processes. Other applications of high pressure processing.

Pulsed electric fields processing: Historical background, PEF treatment systems, main processing parameters. Mechanisms of action: mechanisms of microbial and enzyme inactivation. PEF for processing of liquid foods and beverages, PEF Processing for solid foods. Food safety aspects of pulsed electric fields. Pulsed electric field and high pressure processing.

Osmotic dehydration: mechanism of osmotic dehydration, effect of process parameters on mass transfer, determination of moisture and solid diffusion coefficient, application of osmotic dehydration.

Athermal membrane concentration of liquid foods and colours: osmotic membrane distillation, direct osmosis, membrane modules, Applications of membrane concentration.

Processing by radio frequency electrice fields: radio frequency electric fields equipments, RFEF non-thermal inactivation of yeasts, bacteria and spores, electrical costs.

Ultrasound processing: fundamentals of ultrasound, ultrasound as a food preservation and processing aid, effects of ultrasound on food properties.

Alternate thermal processing: Microwave heating: dielectric properties of foods, heat and mass transfer in microwave processing, application of microwave processing for foods;

Radiofrequency processing: dielectric heating, material properties, radio-frequency heating and drying applications; Ohmic heating: Fundamentals of ohmic heating, electrical conductivity, modeling, treatment of products.

Hybrid drying technologies: combined microwave vacuum drying, combining microwave vacuum drying with other processes, equipment for microwave vacuum drying, product quality degradation during dehydration.

Textbooks:
1. Emerging Technologies for Food Processing. Da-Wen Sun (Ed), Academic Press, 1st Edition, 2005.
2. Novel Food Processing Technologies. M. P. Cano, M. S. Tapia, and G. V. Barbosa-Canovas, CRC Press, 1st Edition, 2004.

References
1. Minimal Processing technologies in the food industry. N. Bengtsson, T Ohlsson, and O Ohlsson, Woodhead Publishing Limited, 1st Edition, 2002.
2. Advances in Food Dehydration. C Ratti (Ed), CRC Press, 1st edition, 2009.

Engineering Properties of Biological Materials   FT 440
3 – 0 - 0 : 3 Credits : 3 Hours

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.

Rheology - ASTM standard, terms - physical states of materials - classical ideal material - rheological models and equations - visco elasticity - creep stress relaxation - Non Newtonian fluid and viscometry - rheological properties - force - deformation, stress - strain, elastic - plastic behaviour.

Contact stresses between bodies - Hertz problems - firmness and hardness - mechanical damage - impact damage and dead load damage - vibration damage - friction - effect of

load, sliding velocity, temperature, water film and surface roughness - friction in agricultural materials - rolling resistance - angle of internal friction, angle of repose - flow of bulk granular materials - aero dynamics of agricultural 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.

Electrical properties - dielectric loss factor, loss tangent, A.C. Conductivity and dielectric constant - method of determination - energy absorption from high-frequency electric field. Electro-magnetic field effects.

Textbooks
1. Engineering Properties of Foods. M.A. Rao, S.S.H. Rizvi, and A.K. Datta (eds), CRC Press, 3rd Edition, 2005.
2. Physical Properties of Foods. S. Sahin and S. G. Sumnu, CRC Press, 1st Edition, 2006.
3. Thermal Properties of Foods and Agricultural Materials, N.N. Mohesenin, Gordon and Breach Science Publishers. 1st Edition, 1980.
4. Physical Properties of Plant and Animal Materials. N.N. Mohesenin, Gordon and Breach Science Publishers, 1st Edition, 1980.

References:

1. Physical Properties of Foods. M. Peleg and E.B. Bagelay (eds), AVI publishing Co. 1st Edition, 1983.
2. Physical Properties of Foods. Ronal Jowitt, Felix Escher, Bengt Hallstrom, Hans F. Th. Meffert, Walter E.C. Spices. Gilbert Vox (eds), Applied Science Publishers, 1st Edition, 1983.