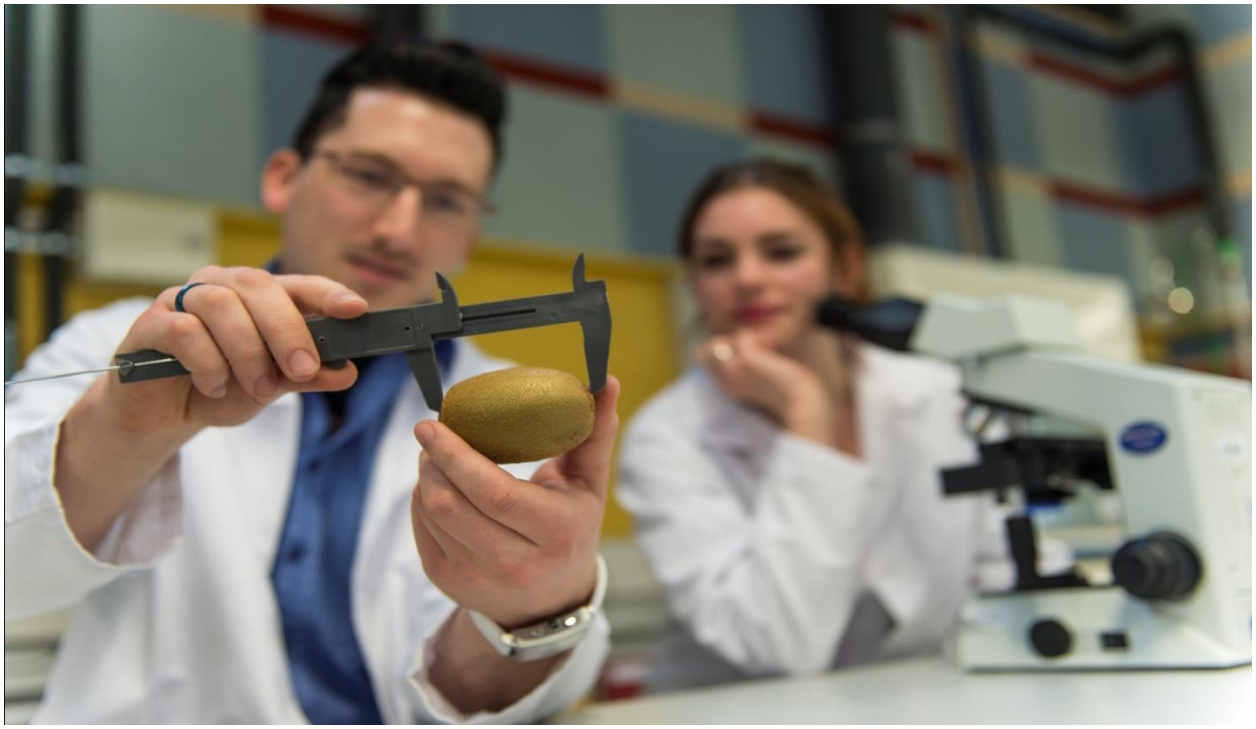
II. DEPARTMENT OF FOOD ENGINEERING



Sr. No.	Course No.	Course title	Credits	Semester
1	FE-111	Engineering Drawing and Graphics	3 (1+2)	I
2	FE-112	Fluid Mechanics	3 (2+1)	I
3	FE-113	Mathematics	2 (2+0)	I
4	FE-124	Heat and Mass Transfer	3 (2+1)	II
5	FE-125	Statistical Methods and Numerical Analysis	2 (1+1)	II
6	FE-236	Energy Generation and Conservation	3 (2+1)	III
7	FE-237	Unit Operations in Food Processing – I	3 (2+1)	III
8	FE-248	Unit Operations in Food Processing – II	3 (2+1)	IV
9	FE-249	Post Harvest and Storage Engineering	3 (2+1)	IV
10	FE-3510	Biochemical Engineering	3 (2+1)	V
11	FE-3511	Food Refrigeration and Cold Storage	3 (2+1)	V
12	FE-3612	Food Processing Equipment Design	2 (1+1)	VI
13	FE-3613	Food Plant Design and Layout	3 (2+1)	VI
14	FE-3614	Instrumentation and Process Control	3 (2+1)	VI
		Total Credits	**39 (25+14)**	

FE-111 ENGINEERING DRAWING AND GRAPHICS 3 (1+2)

Theory

First and third angle methods of projection; Preparation of working drawing from models and isometric views; Different methods of dimensioning; Types of rivet heads and riveted joints; Processes for producing leak proof joints; Symbols for different types of welded joints; Nomenclature, thread profiles, multi-start threads, left and right hand thread Square headed and hexagonal nuts and bolts Conventional representation of threads Different types of lock nuts, studs Machine screws, cap screws and wood screws Foundation bolts.

Practicals

Introduction of drawing scales; Principles of orthographic projections; References planes; True length and inclination of lines; Projections of solids: Change of position method, alteration of ground lines; Section of solids and interpenetration of solid-surfaces; Development of surfaces of geometrical solids; Isometric projection of geometrical solids;Preparation of manual drawings with dimensions from models and isometric drawings of objects and machine components; Preparation of sectional drawings of simple machine parts; Drawing of riveted joints and thread fasteners; Demonstration on computer graphics and computer aided drafting use of standard software; Sectional drawings of engineering machines; Computer graphics for food engineering applications; Interpretation of sectional views of food equipment and components; Practice in the use of basic and drawing commands on AutoCAD; Generating simple 2-D drawings with dimensioning using AutoCAD; Small Projects using CAD/CAM.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1.	First and third angle methods of projection	7
2-3	Preparation of working drawing from models and isometric views	13
4	Different methods of dimensioning	6
5	Types of rivet heads and riveted joints	6
6	Processes for producing leak proof joints	6
7	Symbols for different types of welded joints	6
8	Nomenclature, thread profiles	6
9-10	multi-start threads, left and right hand thread	13
11-12	Square headed and hexagonal nuts and bolts	13
13	Conventional representation of threads	6
14	Different types of lock nuts, studs	6
15	Machine screws, cap screws and wood screws	6
16	Foundation bolts	6
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Study of drawing scales	1
2.	Study of plane and diagonal scale	1
3.	Study of vernier, comparative and scale of chord	1
4.	Study of principle of orthographic projects, reference plane and different quadrant	1
5.	Drawing of orthographic projection by first angle project method	1
6.	Drawing of orthographic projection by third angle project method	1
7.	Drawing of projection of point	1
8.	Drawing of projection of line	1
9.	Drawing of projection of plane	1
10.	Drawing of projection of solid	1
11.	Drawing of projection of section of solid	1
12.	Study of interpretation of solid	1
13.	Study and drawing of development of surfaces of geometrical solids	1
14.	Study and drawing of isometric projection	1
15.	Preparation of manual drawing with dimension from different model	1
16.	Preparation of manual drawing with dimension from isometric object	1
17.	Preparation of manual drawing with dimension from machine component	1
18.	Drawing of section of machine parts	1
19.	Study and drawing of riveted joints	1
20.	Study and drawing of welded joints	1
21.	Drawing of thread and thread fasteners	1
22.	Study of computer graphics	1
23.	Study of computer aided drafting	1
24.	Study and application of computer graphics in food engineering	1
25.	Interpretation of sectional view of food equipment and components	1
26.	Study and use of AutoCAD	1
27.	Study of two dimensional drawing command in AutoCAD	1
28.	Study of three dimensional drawing command in AutoCAD	1
29.	Two dimensional drawing in AutoCAD	1
30.	Three dimensional drawing in AutoCAD	1
31.	Isometric drawing in AutoCAD	1
32.	Small project using cad / cam	1
	Total	**32**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Machine Drawing	N.D. Bhat and V.M. Panchal	Charotar Publishing House, Anand. 1995
2	Elementary Engineering Drawing	N. D. Bhat	Charotar Publishing House, Anand. 1995
3	Mastering CAD/CAM	Ibrahim Zaid	Mc-Graw Hill Books, USA, 2004

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Principles of CAD/CAM/CAE Systems.	Lee K.	Prentice-Hall, USA.
2	Engineering Drawing and Graphics	Venupogal K.	New Age International, New Delhi 2007
3	Drawing for Engineering	Smith Paul	Juta and Company Ltd., 1999
4	The Workman's Manual of Engineering Drawing	Maxton J.	Lockwood and Company, 1871

FE-112 FLUID MECHANICS 3 (2+1)

Theory

Units and dimensions Properties of fluids; Static pressure of liquids: Hydraulic pressure, absolute and gauge pressure, pressure head of a liquid; Pressure on vertical rectangular surfaces Compressible and non-compressible fluids; Surface tension, capillarity; Pressure measuring devices: Simple, differential, micro-, inclined manometer mechanical gauges, piezometer, Floating bodies: Archimedis principle, stability of floating bodies; Equilibrium of floating bodies, metacentric height, Fluid flow: Classification, steady, uniform and non-uniform, laminar and turbulent, continuity equation; Bernoulli's theorem and its applications; Flow through pipes: Loss of head Flow through orifices, mouthpieces, notches and weirs Vena contracta, hydraulic coefficients, discharge losses; Time for emptying a tank; Loss of head due to contraction, enlargement at entrance and exit of pipe types of notches, rectangular and triangular notches, rectangular weirs; Venturimeters, pitot tube, rotameter Turbines and pumps: classification, centrifugal pumps, reciprocating pumps, positive displacement pump; Centrifugal pumps: operating characteristics of centrifugal pumps Reciprocating pumps: Working of reciprocating pump.

Practicals

Study of different tools and fittings;Study on flow rate versus pressure drop with U-tube manometerVerification of Bernoulli's theorem; Determination of discharge co-efficient for venturi, orifice, V-notchVerification of emptying time formula for a tank; Determination of critical Reynold's number by Reynold apparatus; Study of reciprocating, centrifugal pumps; Study of different types of valves; Study of pumps for viscous fluid; Floating bodies, liquid flow, venturimeter, orifice, weir, flow through pipes

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1	Units and dimensions	3
2-3	Properties of fluids; Static pressure of liquids: Hydraulic pressure, absolute and gauge pressure	7
4-5	Pressure head of a liquid; Pressure on vertical rectangular surfaces	6
6	Compressible and non-compressible fluids; Surface tension, capillarity	3
7-8	Pressure measuring devices: Simple, differential, micro-, inclined manometer	7
9-10	Mechanical gauges, piezometer	6
11-12	Floating bodies: Archimedis principle, stability of floating bodies	6
13-14	Equilibrium of floating bodies, metacentric height	9
15-17	Fluid flow: Classification, steady, uniform and non-uniform, laminar and turbulent, continuity equation	6
18-19	Bernoulli's theorem and its applications	6
20-21	Flow through pipes: Loss of head	6
22-23	Flow through orifices, mouthpieces, notches and weirs	6
24-26	Vena contracta, hydraulic coefficients, discharge losses; Time for emptying a tank; Loss of head due to contraction, enlargement at entrance and exit of pipe	9
27-28	types of notches, rectangular and triangular notches, rectangular weirs; Venturimeters, pitot tube, rotameter	7
29-30	Turbines and pumps: classification, centrifugal pumps, reciprocating pumps, positive displacement pump; Centrifugal pumps: operating characteristics of centrifugal pumps	7
31-32	Reciprocating pumps: Working of reciprocating pump	6
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Study of different tools and fittings	1
2.	Study of different types of manometers (simple and micromanometer)	1
3.	Study of different types of manometers (differential manometer)	1
4.	Study of different mechanical gauges for pressure measurement	1
5.	Numericals for pressure measurement by U tube manometer	1
6.	Verification of Bernoulli's theorem	1
7.	Determination of discharge co-efficient for venturimeter	1
8.	Determination of discharge co-efficient for orifice meter	1
9.	Determination of discharge co-efficient for rectangular and V notch	1
10.	Verification of emptying time formula for a tank and their numerical	1
11.	Study of principle and working of centrifugal pumps	1
12.	Study of principle and working of reciprocating/ positive displacement pump	1
13.	Determination of metacentric height by metacentric height apparatus	1
14.	Study of Reynold's number apparatus to predict type of flow	1
15.	Study of different types of valves	1
16.	Numericals on C.D. for venturimeter and orifice meter	1
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	A Textbook of Hydraulics	Khurmi RS	S. Chand Publication, 1983
2	A Textbook of Fluid Mechanics and Hydraulics	Bansal RK	Firewell Media, 2005
3	Hydraulics	Jagdish Lal	Metropolitan Publisher, Delhi 1963
4	Fluid Mechanics	Fox, Mcdonanld and Pritchard	8th Edition, Wiley Publishers, 2013

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Fluid Mechanics	Frank M. White.	7th Ed. McGraw-Hill Book Co., Inc., Boston, USA. 2010.
2	Fluid Mechanics: Fundamentals and Applications.	Yunus A. Çengel and John M. Cimbala.	McGraw-Hill, Inc., New York, USA. 2006.
3	Fundamentals of Fluid Mechanics	Bruce R. M., Donald F. Y. and Theodore H. O.	4th Ed. John Wiley & Sons, Inc., New York, USA. 2002
4	Fluid Mechanics with Engineering Applications	E. John Finnemore and Joseph B. Franzini.	10th Ed. McGraw-Hill, Inc., New York, USA. 2002

FE-113 MATHEMATICS 2 (2+0)

Theory

Differential calculus: Taylor's and Maclaurin's expansions, indeterminate form;Function of two or more independent variables, partial differentiation;Homogeneous functions and Euler's theorem, composite functions; Total derivatives, derivative of an implicit function, change of variables, maxima and minima; Ordinary differential equations: Exact and Bernoulli's differential equations, equations reducible to exact form by integrating factors; Equations of first order and higher degree, Clairaut's equation, differential equations of higher orders; Linear differential equations with constant coefficients; Methods of finding complementary functions and particular integrals; Partial differential equations: Formation of partial differential equations, Lagrange's linear equation, higher order linear partial differential equations with constant coefficients; Solution of non-linear partial differential equations, Charpit's method, application of partial differential equations (one-dimensional wave and heat flow equations, two-dimensional steady state heat flow equation (Laplace equation);Matrices: Elementary transformations, rank of a matrix, reduction to normal form, Gauss-Jordon method to find inverse of a matrix; Consistency and solution of linear equations, Eigen values and Eigen vectors, Cayley-Hamilton theorem; Linear transformation, orthogonal transformations, diagonalisation of matrices, bilinear and quadratic forms

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-2	Differential calculus: Taylor's and Maclaurin's expansions, indeterminate form	7
3-4	Function of two or more independent variables, partial differentiation	6
5-6	Homogeneous functions and Euler's theorem, composite functions	6
7-10	Total derivatives, derivative of an implicit function, change of variables, maxima and minima	12
11-13	Ordinary differential equations: Exact and Bernoulli's differential equations, equations reducible to exact form by integrating factors	9
14-15	Equations of first order and higher degree, Clairaut's equation, differential equations of higher orders	7
16	Linear differential equations with constant coefficients	3
17-18	Methods of finding complementary functions and particular integrals	7
19-22	Partial differential equations: Formation of partial differential equations, Lagrange's linear equation, higher order linear partial differential equations with constant coefficients	12
23-25	Solution of non-linear partial differential equations, Charpit's method, application of partial differential equations (one-dimensional wave and heat flow equations, two-dimensional steady state heat flow equation (Laplace equation)	9
26-27	Matrices: Elementary transformations, rank of a matrix, reduction to normal form, Gauss-Jordon method to find inverse of a matrix	7
28-30	Consistency and solution of linear equations, Eigen values and Eigen vectors, Cayley-Hamilton theorem	9
31-32	Linear transformation, orthogonal transformations, diagonalisation of matrices, bilinear and quadratic forms	6
	Total	**100**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Higher Engineering Mathematics	B.S. Grewal.	Khanna Publishers Delhi. 2004
2	Differential Calculus	Shanti Narayan	S. Chand and Co. Ltd., New Delhi. 2004
3	Integral Calculus	Shanti Narayan	S. Chand and Co. Ltd., New Delhi. 2004
4	A Textbook of Vector Calculus	Shanti Narayan	S. Chand and Co. Ltd., New Delhi. 2004

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Engineering Mathematics	B.V. Ramana	Tata McGraw-Hill Book Co., Delhi. 2008
2	A Textbook of Matrices	Shanti Narayan	S. Chand and Co. Ltd., New Delhi. 2004
3	Engineering Mathematics	Pal and Bhunia	Oxford University Press, UK 2015

FE-124 HEAT AND MASS TRANSFER 3 (2+1)

Theory

Basic heat transfer processes Heat transfer coefficients, properties related to heat transfer; One-dimensional steady state conduction; Theory of heat conduction, Fourier's law and its derivation; Heat transfer through composite walls; One-dimensional steady state heat conduction with heat generation; Heat flow through slab, hollow sphere and cylinder with linear heat transfer; Convection: Forced and free convection; Use of dimensional analysis for correlating variables affecting convection heat transfer; Concept of Nusselt number, Prandtl number, Reynolds number, Grashoff number, some important empirical relations used for determination of heat transfer coefficient; Radiation: Heat radiation, emissivity, absorptivity, transmissivity, radiation through black and grey surfaces; Heat Exchangers: General discussion, fouling factors, jacketed kettles, LMTD, parallel and counter flow heat exchangers, shell and tube and plate heat exchangers, heat exchanger design; Application of different types of heat exchangers in dairy and food industry; Mass transfer: Fick's law of diffusion, steady state diffusion of gases and liquids through solids Mass transfer coefficient, application in dairy and food industry.

Practicals

Heat transfer analysis during conduction and convection; Study on various types of heat exchangers used in food industry;Preparation and calibration of thermocouples; Determination of thermal conductivity of different food products; Study of working principle and constructional details of plate heat exchanger; Study of working principle and constructional details of shell and tube heat exchanger.Determination of overall heat transfer coefficient of shell and tube, plate heat exchangers, jacketed kettle used in food industry.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	No. of Lectures	% Syllabus Covered
1-2	Basic heat transfer processes	2	7
3-4	Heat transfer coefficients, properties related to heat transfer; One-dimensional steady state conduction	2	7
5-7	Theory of heat conduction, Fourier's law and its derivation	3	9
8-10	Heat transfer through composite walls one-dimensional steady state heat conduction with heat generation	3	9
11-13	Heat flow through slab, hollow sphere and cylinder with linear heat transfer	3	9
14-15	Convection: Forced and free convection	2	6
16-18	Use of dimensional analysis for correlating variables affecting convection heat transfer	3	9
19-21	Concept of Nusselt number, Prandtl number, Reynolds number, Grashoff number, some important empirical relations used for determination of heat transfer coefficient	3	9
22-23	Radiation: Heat radiation, emissivity, absorptivity, transmissivity, radiation through black and grey surfaces	2	7
24-26	Heat Exchangers: General discussion, fouling factors, jacketed kettles, LMTD, parallel and counter flow heat exchangers, shell and tube and plate heat exchanger, heat exchanger design	3	9
27-28	Application of different types of heat exchangers in dairy and food industry	2	7
29-31	Mass transfer: Fick's law of diffusion, steady state diffusion of gases	3	9

	and liquids through solids		
32	Mass transfer coefficient, application in dairy and food industry	1	3
	Total	**32**	**100**

Practical Exercises

No. of Units	**Topics**	**No. of Experiments**
1.	Heat transfer analysis during conduction	1
2.	Numericals for rate of heat transfer during conduction in different system (plane wall, composite wall and sphere)	1
3.	Study of heat transfer through composite wall apparatus	1
4.	Heat transfer analysis by convection	1
5.	Study of heat transfer by natural / forced convection apparatus	1
6.	Numericals for rate of heat transfer in convection	1
7.	Preparation and calibration of thermocouples	1
8.	Determination of thermal conductivity of solid food product	1
9.	Determination of thermal conductivity of liquid food	1
10.	Study of principle and working of double pipe heat exchanger	1
11.	Study of principle and working of shell and tube heat exchanger	1
12.	Study of principle and working of plate and mechanical aided heat exchanger	1
13.	Study of heat transfer rate in plate heat exchanger type apparatus	1
14.	Determination of OHTC in shell and tube and plate heat exchanger	1
15.	Numericals on rate of heat transfer in radiation	1
16.	Numericals on rate of mass transfer	1
	Total	**16**

TEXT BOOK

Sr. No.	**Name of Book**	**Author**	**Publisher**
1	Heat and Mass Transfer	Nag P	McGraw Hill, 2011
2	Heat and Mass Transfer – Fundamentals and Applications	Yunus AC and Afshin JG	McGraw Hill, 2015
3	Heat Transfer	Gupta CP	Prentice Hall of Media, New Delhi 1994
4	Heat Transfer	J.P. Holman	10th Ed. McGraw-Hill Book Co., Boston, USA. 2010

REFERENCE BOOKS

Sr. No.	**Name of Book**	**Author**	**Publisher**
1	Heat Transfer in Process Engineering.	Eduardo Cao	The McGraw-Hill Companies, Inc., New York, USA. 2010
2	A Heat Transfer Textbook	John HL and John HL	Phlogiston Press, Cambrige, MA, USA. 2008
3	Unit Operations of Chemical Engineering	Warren LM, Julian S. and Peter H.	7th Ed. McGraw-Hill, Inc., NY, USA. 2004
4	Transport Processes and Separation Process Principles (Includes Unit Operations)	Christie John Geankoplis	4th Ed. Prentice-Hall, NY, USA. 2003

FE-125 STATISTICAL METHODS AND NUMERICAL ANALYSIS 2 (1+1)

Theory

Statistical methods: testing of hypothesis, concepts; Testing of significance based on Z-test, t-test, F-test, Chi-square test, contingency table Correlation, regression, testing of significance of correlation and regression, ANOVA, one-way and two-way classifications; Numerical analysis: Finite differences, various difference operators and their relationships, Factorial notation, interpolation with equal intervals, Newton's forward and backward interpolation formulae, Numerical integration, numerical integration by Trapezoidal, Simpson's and Weddle's rules; Laplace transforms: Definition of Laplace transform, Laplace transforms of elementary functions, Properties of Laplace transforms, inverse Laplace transforms Transforms of derivatives Integrals, Transform of function multiplied by tn, transform of function divided by t, Convolution theorem, application of Laplace transforms to solve ordinary differential equations

Practicals

Problems on one sample, two sample Z-tests when population S.D. is known and unknown; Problems on one sample, two sample and paired t-test; Chi-square test – 2×2 and m×n; Contingency table and F-test;Calculation of correlation coefficient and its testing;ANOVA: One way/two way; Problems on Newton's forward and backward interpolation formula for equal intervals; Problems on trapezoidal rule;Problems on Simpson's 1/3 and 3/8 rules; Problems on Laplace transforms; Problems on inverse transformations.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1	Statistical methods: testing of hypothesis, concepts	6
2-3	Testing of significance based on Z-test, t-test, F-test, Chi-square test, contingency table	13
4	Correlation, regression, testing of significance of correlation and regression	7
5	ANOVA, one-way and two-way classifications	6
6	Numerical analysis: Finite differences, various difference operators and their relationships	6
7	Factorial notation, interpolation with equal intervals, Newton's forward and backward interpolation formulae	6
8-9	Numerical integration, numerical integration by Trapezoidal, Simpson's and Weddle's rules	13
10-11	Laplace transforms: Definition of Laplace transform, Laplace transforms of elementary functions	13
12	Properties of Laplace transforms, inverse Laplace transforms	6
13	Transforms of derivatives	6
14	Integrals, Transform of function multiplied by tn, transform of function divided by t,	6
15	Convolution theorem	6
16	Application of Laplace transforms to solve ordinary differential equations,	6
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Problems on one sample, two sample Z-tests when population S.D. is known and unknown	2
2.	Problems on one sample, two sample and paired t-test	2
3.	Chi-square test – 2×2 and m×n; Contingency table and F-test	2
4.	Calculation of correlation coefficient and its testing	3
5.	ANOVA: One way/two way	2
6.	Problems on Newton's forward and backward interpolation formula for equal intervals; Problems on trapezoidal rule	3
7.	Problems on Simpson's 1/3 and 3/8 rules; Problems on Laplace transforms; Problems on inverse transformations	2
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers Delhi. 2004
2	Higher Engineering Mathematics	B.S. Grewal.	Khanna Publishers Delhi. 2004
3	Differential Calculus	Shanti Narayan	S. Chand and Co. Ltd., New Delhi. 2004
4	Integral Calculus	Shanti Narayan	S. Chand and Co. Ltd., New Delhi. 2004
5	A Textbook of Vector Calculus	Shanti Narayan	S. Chand and Co. Ltd., New Delhi. 2004

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Advanced Engineering Mathematics	Erwin Kreyszig	9th Ed. John Wiley & Sons, New York, USA. 2006
2	Calculus of Finite Differences and Numerical Analysis.	P.P. Gupta and C.C. Malik	Krishna Prakash Mandor, Meerut. 1993
3	Engineering Mathematics	B.V. Ramana	Tata McGraw-Hill Book Co., Delhi. 2008
4	A Textbook of Matrices	Shanti Narayan	S. Chand and Co. Ltd., New Delhi. 2004
5	Engineering Mathematics	Pal and Bhunia	Oxford University Press, UK 2015

FE-236 ENERGY GENERATION AND CONSERVATION 3 (2+1)

Theory

Basic concepts: systems, processes, cycles, energy, The Zeroth Law of Thermodynamics Ideal gases: Equation of state, Compression and expansion of gases, The first Law of Thermodynamics: Internal energy, enthalpy Renewable energy sources like solar, wind and biogas and their utilization in food processing, Related equipment and machineries to renewable energy sources, Fuels : Chemical properties, air for combustion, Calorific value and its determination, Properties of steam: Wet, dry saturated, superheated steam Steam generators: Fire tube boilers, Water tube boilers Boiler mountings and Boiler accessories, Measurement of Height of boiler chimney, Condensers; Layout of pipe-line and expansion joints, Air Compressors: Reciprocating, Single and two stage air compressors

Practicals

Determination of calorific value of fuel;Determination of dryness fraction of steam; To study the boiler installed in Model Plant, Babcock and Wilcox boiler, Electrode boiler; Boiler mounting; Visit to sugar mill or rice mill plant with steam utilization; Study of solar water heater and biogas plants and appliances

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-3	Basic concepts : systems, processes, cycles, energy, The Zeroth Law of Thermodynamics	9
4-6	Ideal gases : Equation of state, Compression and expansion of gases	9
7-9	The first Law of Thermodynamics: Internal energy, enthalpy	9
10-12	Renewable energy sources like solar, wind and biogas and their utilization in food processing	9
13-15	Related equipment and machineries to renewable energy sources	9
16-18	Fuels : Chemical properties, air for combustion, Calorific value and its determination	9
19-21	Properties of steam: Wet, dry saturated, superheated steam	9
22-23	Steam generators: Fire tube boilers, Water tube boilers	7
24-26	Boiler mountings and boiler accessories	9
27-28	Measurement of height of boiler chimney	7
29-30	Condensers; layout of pipe-line and expansion joints	7
31-32	Air compressors: Reciprocating, single and two stage air compressors	7
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Determination of calorific value of fuel	1
2.	Determination of air requirement for combustion of fuel	1
3.	Numericals on calorific value of air requirement of fuel	1
4.	Determination of dryness fraction of steam by throttling calorimeter	1
5.	Determination of dryness fraction of steam by separating calorimeter	1
6.	To study the principle and working of fire tube boiler	1
7.	To study the principle and working of water tube boiler	1
8.	To study the parts, principle and working of Babcock and Wilcox boiler	1
9.	To study the parts, principle and working of Multi drum boiler	1
10.	To study the function and working of boiler mounting	1
11.	To study the function and working of boiler accessories	1
12.	To study the different renewable energy sources	1
13.	To study the solar operated machineries	1
14.	To study the principle and working of wind mill	1
15.	Visit to sugar or rice mill plant with steam utilization	1
16.	Visit to power plant/ industry using renewable energy sources	1
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Engineering Thermodynamics	C.P. Gupta and Rajendra Prakash	Nemi Chand and Sons, Roorkee 1991
2	Thermal Engineering	Ballaney P.L.	Khanna Publishers, New Delhi, 1985
3	Electric Energy-Generation, Utilization and Conservation	S. Sivanagaraju, M. Balasubba Reddy, D. Srilatha	Pearson Education, India 2015
4	Energy Management and Conservation	Sharma KV and Venkateseshaiah P.	I K International Publishing, 2011
5	Energy generation	Diwan and Dwivedi	Pentagon Press, 2008

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	N.C. Pandya & C.S. Shah.	Elements of Heat Engines	Charotar Publishing House, Anand 1990
2	Indian Boiler Regulation Codes		Indian Boiler Regulation Codes, 1991
3	Generation of Electrical Energy	Gupta BR	S. Chand Publishing, New Delhi 2010

FE-237 UNIT OPERATIONS IN FOOD PROCESSING – I 3 (2+1)

Theory

Size reduction: Benefits, classification, sieve/screen analysis, principle and mechanisms of comminution of food, Rittinger's, Kick's and Bond's equations, work index, energy utilization; Size reduction equipment: Principal types, hammer mills and impactors, attrition mills, buhr mill, tumbling mills, tumbling mills, colloid mill, cutting machines (slicing, dicing, shredding, pulping); Mixing: Theory of solids mixing, criteria of mixer effectiveness and mixing indices, rate of mixing, Theory of liquid mixing, power requirement for liquids mixing; Mixing equipment: Mixers for low- or medium-viscosity liquids (paddle agitators, impeller agitators, powder-liquid contacting devices, other mixers), Mixers for high viscosity liquids and pastes, mixers for dry powders and particulate solids; Mechanical Separations: Theory, centrifugation, liquid-liquid centrifugation, liquid-solid centrifugation, clarifiers, desludging machines; Filtration: Theory of filtration, rate of filtration, pressure drop during filtration, applications Filtration equipment; plate and frame filter press, rotary filters, centrifugal filters and air filters, filter aids; Membrane separation: General considerations, materials for membrane construction, Ultra-filtration, processing variables, membrane fouling, Applications of ultra-filtration in food processing, reverse osmosis, mode of operation, and applications, Membrane separation methods, gel filtration, ion exchange, per-evaporation and micro filtration.

Practicals

Determination of reduction ratio of different size reduction machinaries;; Determination of mixing index of a feed mixer; Power requirement in size reduction of grain using Rittinger's law, Kick's law and Bond's law.; Performance evaluation of hammer mill; Performance evaluation of attrition mill; Study of centrifugal separator; Study of freeze dryer and freeze drying process; Study on osmosis in fruits; Study of reverse osmosis process;Study of ultra filtration/membrane separation process.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-2	Size reduction: Benefits, classification, sieve/screen analysis, principle and mechanisms of comminution of food	7
3-5	Rittinger's, Kick's and Bond's equations, work index, energy utilization;	9
6-8	Size reduction equipment: Principal types, hammer mills and impactors, attrition mills, buhr mill, tumbling mills, tumbling mills, colloid mill, cutting machines (slicing, dicing, shredding, pulping);	9
9-11	Mixing: Theory of solids mixing, criteria of mixer effectiveness and mixing indices, rate of mixing, theory of liquid mixing, power requirement for liquids mixing;	9
12-14	Mixing equipment: Mixers for low- or medium-viscosity liquids (paddle agitators, impeller agitators, powder-liquid contacting devices, other mixers),	9
15-16	Mixers for high viscosity liquids and pastes, mixers for dry powders and particulate solids;	7
17-19	Mechanical Separations: theory, centrifugation, liquid-liquid centrifugation, liquid-solid centrifugation, clarifiers, desludging machines;	9
20-22	Filtration: theory of filtration, rate of filtration, pressure drop during filtration, applications	9
23-24	Filtration equipment; plate and frame filter press, rotary filters, centrifugal filters and air filters, filter aids;	7

25-26	Membrane separation: General considerations, materials for membrane construction,	7
27-28	Ultra-filtration, processing variables, membrane fouling,	6
29-30	Applications of ultra-filtration in food processing, reverse osmosis, mode of operation, and applications;	6
31-32	Membrane separation methods, gel filtration, ion exchange, per-evaporation and micro filtration.	6
	Total	100

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Study of Principle, working and demonstration of hammer mill and crushing roll	1
2.	Study of Principle, working and demonstration of attrition mill	1
3.	Study of Principle, working and demonstration of colloidal mill	1
4.	Study of Principle, working and demonstration of modern house mill/ magnum mill	1
5.	Determination of reduction ratio of different size reduction machineries	1
6.	Study of different disintegration operations (slicing, dicing, shredding and pulping)	1
7.	Determination of mixing index of a food mixer	1
8.	Power requirement in size reduction of grain using Rittinger's law, Kick's law and Bond's law	1
9.	Study of centrifugal separation (centrifugal cream separation, centrifugal machine)	1
10.	Study of principle and working of roller dryer, cabinet dryer	1
11.	Study of principle and working of freeze dryer and vacuum dryer	1
12.	Study on osmosis of fruit	1
13.	Study on reverse osmosis	1
14.	Study of filtration operation (ultrafiltration)	1
15.	Study of membrane separation	1
16.	Study of plate and frame filter press	1
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Food Engineering Operation	Brenan JG, Butters JR,	Elsevier Applied Science London. 1990
2	Unit Operations in Food Processing	Earle RL	Elsevier, 2013
3	Unit Operations in Food Processing	Ibarz A. and Gustavo VBC	CRC Press, 2002

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Unit Operations of Chemical Engineering	Warren LM, Julian Smith, Peter Harriott	7th Ed. McGraw-Hill, Inc., NY, USA. 2004
2	Transport Processes and Separation Process Principles	Christie John Geankoplis	4th Ed. Prentice-Hall, NY, USA. 2003
3	Handbook of Food Processing Equipment	Saravacos GD and Athanasios EK	Springer Science+Business Media, New York, USA. 2002

FE-248 UNIT OPERATIONS IN FOOD PROCESSING – II 3 (2+1)

Theory

Evaporation: Principles of evaporation, mass and energy balance, factors affecting rate of evaporation, thermodynamics of evaporation (phase change, boiling point elevation, Dühring plot Heat and mass transfer in evaporator, factors influencing the overall heat transfer coefficient, influence of feed liquor properties on evaporation; Evaporation equipment: Natural circulation evaporators, horizontal/vertical short tube, natural circulation with external calandria, long tube, forced circulation; Evaporator ancillary plant, design of evaporation systems, single effect, multiple effect evaporators, feeding methods of multiple effect evaporation systems, feed preheating, vapour recompression systems; Fouling of evaporators and heat exchanges; Recompression heat and mass recovery and vacuum creating devices; Food freezing: Introduction, Principles of food freezing, Freezing systems; Direct contact systems, air blast immersion; Changes in foods; Frozen food properties; freezing time, factors influencing freezing time, freezing/thawing time; Frozen food storage: Quality changes in foods during frozen storage Freeze drying: equipment and practice Expression and Extraction: liquid-liquid extraction processes, types of equipment and design for liquid-liquid extraction, continuous multistage counter current extraction; Crystallization and dissolution: Theoryand principles, kinetics, applications in food industry, equipment for crystallization Distillation: Principles, vapour-liquid equilibrium, continuous flow distillation, batch/differential distillation, fractional distillation, steam distillation, distillation of wines and spirits Baking: Principles, baked foods, baking equipment; Roasting: Principles of roasting, roasting equipment Pasteurization: Purpose, microorganisms and their reaction to temperature and other influences, methods of heating, design and mode of operation of heating equipment, plate heat exchanger Sterilization: Principles, design of batch and continuous sterilization, different methods and equipments; UHT sterilization, in the package sterilization, temperature and pressure patterns, equipment for sterilizing goods in the package Aseptic processing: principles, analysis of thermal resilience, duration mathematics of conduction heating; Blanching: principle and equipment; Homogenization, Emulsification

Practicals

Study of working principle open pan and vacuum evaporator;Study of single effect evaporator; Study of sterilizer;Study of freezers; Freezing of foods by different methods; Effect of sample particle size and time on solvent extraction process; Study of blancher, pasteurizers, fryers, Homogenizers, irradiators; Determination of oil uptake by the food product during frying; Study on qualitative changes in the fried food product; Visit sugar processing industry.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-3	Evaporation: Principles of evaporation, mass and energy balance, factors affecting rate of evaporation, thermodynamics of evaporation (phase change, boiling point elevation, Dühring plot	9
4-5	Heat and mass transfer in evaporator, factors influencing the overall heat transfer coefficient, influence of feed liquor properties on evaporation	7
6-7	Evaporation equipment: Natural circulation evaporators, horizontal/vertical short tube, natural circulation with external calandria, long tube, forced circulation	7
8-10	Evaporator ancillary plant, design of evaporation systems, single effect, multiple effect evaporators, feeding methods of multiple effect evaporation systems, feed preheating, vapour recompression systems; Fouling of evaporators and heat exchanges; Recompression heat and mass recovery and vacuum creating devices	9
11-13	Food freezing: Introduction, Principles of food freezing, Freezing systems; Direct contact systems, air blast immersion; Changes in foods;	9
14-16	Frozen food properties; freezing time, factors influencing freezing time, freezing/thawing time; Frozen food storage: Quality changes in foods during frozen storage	9
17-18	Freeze drying: equipment and practice	7
19-20	Expression and Extraction: liquid-liquid extraction processes, types of equipment and design for liquid-liquid extraction, continuous multistage counter current extraction	7
21-22	Crystallization and dissolution: theory and principles, kinetics, applications in food industry, equipment for crystallization	6
23-24	Distillation: Principles, vapour-liquid equilibrium, continuous flow distillation, batch/differential distillation, fractional distillation, steam distillation, distillation of wines and spirits	6
25-26	Baking: Principles, baked foods, baking equipment; Roasting: Principles of roasting, roasting equipment	6
27-28	Pasteurization: Purpose, microorganisms and their reaction to temperature and other influences, methods of heating, design and mode of operation of heating equipment, plate heat exchanger	6
29-30	Sterilization: Principles, design of batch and continuous sterilization, different methods and equipments; UHT sterilization, in the package sterilization, temperature and pressure patterns, equipment for sterilizing goods in the package	6
31-32	Aseptic processing: principles, analysis of thermal resilience, duration mathematics of conduction heating; Blanching: principle and equipment; Homogenization, Emulsification	6
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Study of cleaners for grains (Screening, aspiration, abrasion and magnetic cleaning)	1
2.	Study of washers for fruits and vegetables (soaking tank, belt washer)	1
3.	Study of crop dryer, hot air dryer and vacuum dryer	1
4.	Study of principle and working of spray dryer	1

5.	Study of principle and working of roller drum dryer and fluidized bed dryer	1
6.	Study of freeze drying process and freeze dryer	1
7.	Study of graders for grains	1
8.	Study of graders for fruits and vegetables	1
9.	Study of different components of flour mill	1
10.	Study of different material handling equipments	1
11.	Layout, design, sizing capacity and drawing of traditional storage structures	1
12.	Visit to traditional storage structure	1
13.	Design of cold storage for particular capacity and commodity	1
14.	Design of CAS and MAP for particular capacity and commodity	1
15.	Visit to CA storage	1
16.	Visit to evaporative cooling system for storage	1
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Food Engineering Operation	Brenan, Butters, Cowell and Lilly	Elsevier Applied Science London. 1990
2	Unit Operations in Food Engineering.	Albert Ibarz and Gustavo V. Barbosa-Cánovas	CRC Press, Boca Raton, FL, USA. 2003
3	Unit Operations in Food Processing	Earle RL	Elsevier, 2013
4	Introduction to Food Engineering,	R. Paul Singh and Dennis R. Heldman.	2014. 5th Ed. Elsevier, Amsterdam, The Netherlands.
5	Unit Operations of Chemical Engineering	Warren L. McCabe, Julian Smith, Peter Harriott	7th Ed. McGraw-Hill, Inc., NY, USA. 2004

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Transport Processes and Separation Process Principles (Includes Unit Operations),	Christie John Geankoplis	4th Ed. Prentice-Hall, NY, USA. 2003
2	Handbook of Food Processing Equipment	George D. Saravacos and Athanasios E. Kostaropoulos	Springer Science+Business Media, New York, USA. 2002
3	Coulson & Richardson's Chemical Engineering, Vol. 2, Particle Technology and Separation Processes,	J. F. Richardson, J. H. Harker and J. R. Backhurst	5th Ed. Butterworth–Heinemann, Oxford, UK. 2002
4	Handbook of Food Engineering Practice.	Kenneth J. Valentas, Enrique Rotstein and R. Paul Singh	CRC Press, Boca Raton, FL, USA. 1997

FE-249 POST HARVEST AND STORAGE ENGINEERING 3 (2+1)

Theory

Overview of post harvest technology: Concept and science, production and post harvest losses, reasons for losses, importance of loss reduction; Post Harvest Handling operations; Cleaning: Cleaning of grains, washing of fruits and vegetables, types of cleaners, screens, types of screens, rotary screens, vibrating screens, machinery for cleaning of fruits and vegetables (air cleaners, washers), Sorting and grading: Sorting, grading, methods of grading; Grading- Size grading, colour grading, screening, equipment for grading of fruits and vegetables, grading efficiency, Materials handling: Introduction to different conveying equipments used for handling of grains, fruits and vegetables Scope and importance of material handling devices, Study of different material handling systems: Classification, principles of operation, conveyor system selection/design, Belt conveyor: Principle, characteristics, design, capacity, inclined belt conveyors, idler spacing, Chain conveyor: Principle of operation, advantages, disadvantages, capacity, Screw conveyor: Principle of operation, capacity, power, loading and discharge, Bucket elevator: Principle, classification, operation, advantages, disadvantages, capacity Pneumatic conveying system: Capacity and power requirement, types, air/product separators, Storage: Importance of scientific storage systems, post harvest physiology of semi-perishables and perishables Damages: Direct damages, indirect damages, causes of spoilage in storage (moisture, temperature, humidity, respiration loss, heat of respiration, sprouting), destructive agents (rodents, birds, insects, etc.), sources of infestation and control; Storage structures: Traditional storage structures, improved storage structures, modern storage structures; Farm silos: Horizontal silos, tower silos, pit silos, trench silos, size and capacity of silos; Storage of perishables: cold storage, controlled and modified atmospheric storage, hypobaric storage, Evaporative cooling storage, conditions for storage of perishable products, control of temperature and relative humidity inside storage.

Practicals

Study of cleaners for grains; Study of washers for fruits and vegetables;.Study of crop dryers; Study of hot air dryer; Study of vacuum dryer; Study of working principle of spray dryer and spray drying process; Study of graders for grains; Study of graders for fruits and vegetables; Study of drum dryer and liquid food dehydration using drum drying; Study of fluidized bed dryer and drying process; Study of freeze dryer and freeze drying process; Study of different components of flour mill; Study of different materials handling equipment; Visits to traditional storage structures; Layout design, sizing, capacity and drawing of traditional storage structures; Visits to cold storage;. Design of cold storage for particular capacity and commodity; Visits to CA storage; Design of CA storage for particular capacity and commodity; Visits to evaporative cooling system for storage; Storage study in the MAP.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-2	Overview of post harvest technology: Concept and science, production and post harvest losses, reasons for losses, importance of loss reduction; Post Harvest Handling operations	7
3-5	Cleaning: Cleaning of grains, washing of fruits and vegetables, types of cleaners, screens, types of screens, rotary screens, vibrating screens, machinery for cleaning of fruits and vegetables (air cleaners, washers)	9
6-7	Sorting and grading: Sorting, grading, methods of grading; Grading- Size grading, colour grading, screening, equipment for grading of fruits and vegetables, grading efficiency	7
8-9	Materials handling: Introduction to different conveying equipments used for handling of grains, fruits and vegetables	7
10-12	Scope and importance of material handling devices	9
13-15	Study of different material handling systems: Classification, principles of operation, conveyor system selection/design	9
16-17	Belt conveyor: Principle, characteristics, design, capacity, inclined belt conveyors, idler spacing. Chain conveyor: Principle of operation, advantages, disadvantages, capacity	7
18-19	Screw conveyor: Principle of operation, capacity, power, loading and discharge, Bucket elevator: Principle, classification, operation, advantages, disadvantages, capacity	6
20-21	Pneumatic conveying system: Capacity and power requirement, types, air/product separators	6
22-23	Storage: Importance of scientific storage systems, post harvest physiology of semi-perishables and perishables	6
24-26	Damages: Direct damages, indirect damages, causes of spoilage in storage (moisture, temperature, humidity, respiration loss, heat of respiration, sprouting), destructive agents (rodents, birds, insects, etc.), sources of infestation and control	9
27-28	Storage structures: Traditional storage structures, improved storage structures, modern storage structures; Farm silos: Horizontal silos, tower silos, pit silos, trench silos, size and capacity of silos	6
29-30	Storage of perishables: cold storage, controlled and modified atmospheric storage, hypobaric storage	6
31-32	Evaporative cooling storage, conditions for storage of perishable products, control of temperature and relative humidity inside storage	6
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Study of cleaners for grains	1
2.	Study of graders for grains	1
3.	Study of washers for fruits and vegetables	1
4.	Study of graders for fruits and vegetables	1
5.	Study of hot air dryer; Study of vacuum dryer; Study of working principle of spray dryer and spray drying process;	1
6.	Study of drum dryer and liquid food dehydration using drum drying	1
7.	Study of fluidized bed dryer and drying process	1
8.	Study of freeze dryer and freeze drying process	1
9.	Study of different components of flour mill; Study of different materials handling equipment	1
10.	Visits to traditional storage structures; Layout design, sizing, capacity and drawing of traditional storage structures	1
11.	Design of cold storage for particular capacity and commodity	1
12.	Visits to cold storage	1
13.	Design of CA storage for particular capacity and commodity	1
14.	Visits to CA storage	1
15.	Visits to evaporative cooling system for storage;	1
16.	Storage study in the MAP.	1
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Handbook of Farm, Dairy, and Food Machinery	Myer Kutz	William Andrew, Inc., Norwich, NY, USA. 2007
2	Principles and Practices of Agricultural Structures and Environmental Control	P.H. Pandey	Kalyani Publishers, Ludhiana 2014
3	Post Harvest Technology of Cereals, Pulses and Oilseeds	A. Chakraverty	3rd Ed. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 2008
4	Perry's Chemical Engineers' Handbook.	Don W. Green and Robert H. Perry	McGraw-Hill Co., Inc., NY, USA. 2008
5	Food Processing Handbook	James G. Brennan	Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany. 2006

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Unit Operations of Agricultural Processing	K.M. Sahay and K.K. singh	Vikas Publishing House Pvt. Ltd., Noida, UP. 2001
2	Grain Handling and Storage	G. Boumans	Elsevier Science Publishers, Amsterdam, The Netherlands. 1985
3	Unit operations in Food Processing	R.L. Earle	Pergamon Press, New York, USA. 1983
4	Drying and Storage of Agricultural Crops	C.W. Hall	The AVI Publishing Company, Inc., Westport, Connecticut, USA. 1980

FE-3510 BIOCHEMICAL ENGINEERING 3 (2+1)

Theory

Biochemical Engineering and their scope: Definition, necessity, value engineering, good manufacturing practices, Standard operating procedures, good laboratory practices, History of Biochemical Engineering:Theory of scientists Pfizer, Alexander Fleming, Salman Waksmen, Instrumentation and their control, physical and chemical parameters Role of biochemical engineering in development of modern fermentor: Scale up, management of cellular process, design, operation and their problems, Basis for biochemical engineering in fermentation industry:Unit operation, unit process, process design, chemical reaction kinetics, process variables, biochemical properties, process control, Kinetics of microbial growth and death: Definition, fermentation kinetics rate of cell synthesis, product formation and effect of environment. Types of kinetics, Batch and continuous type, control measures, Simple enzyme kinetics: Simple kinetics model for enzyme substrate interaction. Derive the equation of Michelin Menton, for reaction rate, product formation, calculation of Km and V max values, Complex enzyme kinetics: Oxidation – reduction form of enzymes, observed apparent rate constant, factors affecting the inhibition, competitive, non competitive inhibition, substrate interaction, Kinetics pattern of various fermentations: Classification of kinetics pattern, as per different scientists, simple, simultaneous, consecutive, stepwise, complex reactions and their examples, Media and air sterilization: Definition, thermal death time, media heat sterilization, advantages of continuous sterilization, Aeration and agitation, Product recovery of different process: Mass transfer resistance, extraction, leaching, drying and evaporation, sorption and storage, permeability law, Product formation for value added products using bioconversions techniques Production of single cell protein, alcohol, raw material for required for product formation, production of antibiotics, economic process, utilization of damaged grain through bioconversion, present mode of utilization and their nutritional value.

Practical

Instrumentation and their control in fermentation industry -physical parameter; Instrumentation and their control in fermentation industry – chemical parameter, metabolic parameters and biosensors in food industry; To study the different parts of 30 lit. laboratory and 1 lakh lit. ; capacity fermentors Comparative study of one lakh liter laboratory fermentor; To study the thermal stability of peroxides enzyme in potato; To assess the amylase activity from given foods sample To measure the microbial growth after; (fermentation thermal death time) To study the mass transfer of solution by dialysis process To study the time temperature relationship for destruction of microorganisms; To study the ethyl alcohol production through bioconversion; To study the vitamin production through bioconversion; Visit to Distillery Plant.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-2	Biochemical Engineering and its scope: Definition, necessity, value engineering,	7
4-5	History of Biochemical Engineering: Theory of scientists Pfizer, Alexander Fleming Salman Waksmen. Instrumentation and their control, physical and chemical parameters.	9
6-8	Role of biochemical engineering in development of modern fermentor: Scale up, management of cellular process, design, operation and their problems	9
9-11	Basis for biochemical engineering in fermentation industry: Unit operation, unit process, process design, chemical reaction kinetics, process variables, biochemical properties, process control	9
12-13	Kinetics of microbial growth and death: Definition, fermentation kinetics rate of cell synthesis, product formation and effect of environment. Types of kinetics, Batch and continuous type, control measures	7
14-16	Simple enzyme kinetics: Simple kinetics model for enzyme substrate interaction. Derive the equation of Michelin Menton, for reaction rate, product formation, calculation of Km and V max values	9
17-19	Complex enzyme kinetics: Oxidation – reduction form of enzymes, observed apparent rate constant, factors affecting the inhibition, competitive, non competitive inhibition, substrate interaction	9
20-22	Kinetics pattern of various fermentations: Classification of kinetics pattern, as per different scientists, simple, simultaneous, consecutive, stepwise, complex reactions and their examples	9
23-24	Media and air sterilization: Definition, thermal death time, media heat sterilization, advantages of continuous sterilization.	7
25-27	Aeration and agitation	9
28-29	Product recovery of different process: Mass transfer resistance, extraction, leaching, drying and evaporation, sorption and storage, permeability law	7
30-32	Product formation for value added products using bioconversions techniques Production of single cell protein, alcohol, raw material for required for product formation, production of antibiotics, economic process, utilization of damaged grain through bioconversion, present mode of utilization and their nutritional value	9
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Instrumentation and their control in fermentation industry -physical parameter	1
2.	Instrumentation and their control in fermentation industry – chemical parameter	1
3.	Study of metabolic parameters and biosensors in food industry	1
4.	Study of different parts of laboratory fermentor	1
5.	Study of commercial fermentor	1
6.	Comparative study of laboratory and commercial fermentor	1
7.	Study of thermal stability of peroxides enzyme in potato	1
8.	Assessment of amylase activity of given food sample	1
9.	Measurement of microbial growth after fermentation (TDT)	1
10.	Determination of turbidity (NTU) of fermented materials	1
11.	Study of mass transfer of solution by dialysis process	1
12.	Study of time, temerpature relationship for destruction of organisms (Z and F_o value)	1
13.	Study of alcohol production from high sugar food material	1
14.	Study of alcohol production from molasses	1
15.	Study of vitamin production through bioconversion	1
16.	Visit to distillery plant	1
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Biochemical Engineering	Alba, Arthur and Millis	CRC Press, 1973
2	Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists	Shigeo, Horiuchi and Yoshida	John Wily and Sons, 2015
3	Biochemical Engineering and Biotechnology	Najafpour GD	Elsevier, 2015
4	Biochemical Engineering	Blanch HW and Clark DS	CRC Press, 1997
5	Fundamentals of Biochemical Engineering	Dutta R.	Springer, 2010

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Biochemical Engineering: A Textbook for Engineers, Chemists and Biologist	Kotah, Horiuchi and Yoshida	Jown Wiley and Sons, 2015
2	Biochemical Engineering	Clark and Blanch	CRC Press, 1997
3	Introduction to Biochemical Engineering	Rao DG	Tata McGraw Hills, 2010
4	Introduction to Biochemical Engineering	Rao DG	Tata McGraw Hill, 2010

FE-3511 FOOD REFRIGERATION AND COLD STORAGE 3 (2+1)

Theory

Principles of refrigeration: Definition, background with second law of thermodynamics, unit of refrigerating capacity, coefficient of performance; Production of low temperatures Common refrigerants and their properties: classification, nomenclature, desirable properties of refrigerants- physical, chemical, safety, thermodynamic and economical Azeotropes; Components of vapour compression refrigeration system, evaporator, compressor, condenser and expansion valve Ice manufacture, principles and systems of ice production, Treatment of water for making ice, brines, freezing tanks, ice cans, air agitation, quality of ice Cold storage: Cold store, design of cold storage for different categories of food resources, size and shape, construction and material, insulation, vapour barriers, floors, frost-heave, interior finish and fitting, evaporators, automated cold stores, security of operations Refrigerated transport: Handling and distribution, cold chain, refrigerated product handling, order picking,refrigerated vans, refrigerated display Air-conditioning: Meaning, factors affecting comfort air-conditioning, classification, sensible heat factor, industrial air-conditioning Problems on sensible heat factor; Winter/summer/year round air-conditioning, unitary air-conditioning systems, central air-conditioning Physiological principles in air-conditioning, air distribution and duct design methods Design of complete air-conditioning systems; humidifiers and dehumidifiers Cooling load calculations: Load sources, product cooling, conducted heat, convected heat, internal heat sources, heat of respiration, peak load; etc

Practical

Study of vapour compression refrigeration system; Determination of COP of vapour compression refrigeration system; Study of various types of compressors, condensers, expansion valves and evaporative coils used in refrigeration systems; Study of refrigerants, their properties and charts; Study of direct and indirect contact freezing equipment for foods; Study of spray freezing process for foods; Study of food cold storage; Estimation of refrigeration load for cold storage; Estimation of refrigeration load for meat and poultry products; Study of refrigeration system of dairy plant; Estimation of refrigeration load for ice-cream; Study of cooling system for bakery and estimation of refrigeration loads; Estimation of refrigeration load during chocolate enrobing process; Study of refrigerated van; Study of deep freezing and thawing of foods; Study of refrigerated display of foods and estimation of cooling load

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-3	Principles of refrigeration: Definition, background with second law of thermodynamics, unit of refrigerating capacity, coefficient of performance; Production of low temperatures, reverse Carnot cycle	10
4-6	Common refrigerants and their properties: classification, nomenclature, desirable properties of refrigerants- physical, chemical, safety, thermodynamic and economical	9
7-9	Azeotropes; Components of vapour compression refrigeration system, evaporator, compressor, condenser and expansion valve;	9
10-12	Ice manufacture, principles and systems of ice production, Treatment of water for making ice, brines, freezing tanks, ice cans, air agitation, quality of ice	9
13-16	Cold storage: Cold store, design of cold storage for different categories of food resources, size and shape, construction and material, insulation, vapour barriers, floors, frost-heave, interior finish and fitting, evaporators, automated cold stores, security of operations	13
17-18	Refrigerated transport: Handling and distribution, cold chain, refrigerated product handling, order picking,refrigerated vans, refrigerated display	7
19-21	Air-conditioning: Meaning, factors affecting comfort air-conditioning, classification, sensible heat factor, industrial air-conditioning	9
22-23	Problems on sensible heat factor; Winter/summer/year round air-conditioning, unitary air-conditioning systems, central air-conditioning	7
24-26	Physiological principles in air-conditioning, air distribution and duct design methods	9
27-29	Design of complete air-conditioning systems; humidifiers and dehumidifiers	9
30-32	Cooling load calculations: Load sources, product cooling, conducted heat, convected heat, internal heat sources, heat of respiration, peak load; etc	9
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Study of vapour compression refrigeration system	1
2.	Determination of COP of vapour compression refrigeration system	1
3.	Study of various types of compressors and condensers used in refrigeration system	1
4.	Study of various types of evaporative coils and expansion valves used in refrigeration system	1
5.	Study of refrigerants, their properties and charts	1
6.	Study of direct and indirect contat freezing equipments for foods	1
7.	Study of spray freezing process for food	1
8.	Study of food cold storage	1
9.	Estimation of refrigeration load for cold storage	1
10.	Estimation of refrigeration load for meat and poultry producer	1
11.	Study of refrigeration system for dairy plant	1
12.	Estimation of refrigeration load for ice cream	1
13.	Study of cooling system for bakery and estimation of refrigeration loads	1
14.	Study of refrigeration system of dairy plant; Estimation of refrigeration load for ice-cream	1
15.	Estimation of refrigeration load during chocolate enrobing process	1
16.	Study of refrigerated display of foods and estimation of cooling load	1
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Refrigeration and Air Conditioning	C.P. Arora	2nd Ed. Tata McGraw-Hill Publishing Co. Ltd., New Delhi. 2000
2	Textbook of Refrigeration and Air Conditioning	R. S. Khurmi & J. K. Gupta	Eurasia Publishing House Pvt. Ltd., New Delhi 1999
3	Basic Refrigeration and Air Conditioning	Ananthanarayan PN	4th Edition, McGraw Hill, Delhi 2013
4	Refrigeration and Air Conditioning	Hundy GF, Trott AR and Welch TC	Elsevier, 2008

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Refrigeration and Air Conditioning	W.F. Stoecker and J.W. Jones	2nd Ed. McGraw-Hill Book Co., New York, USA. 1982
2	Refrigeration & Air Conditioning Technology	William C. Whitman, William	6th Ed. Delmar, Cengage Learning, NY, USA. 2017
3	Refrigeration and Air Conditioning	Arora RC	PHI Learning, New Delhi 2010

FE-3612 FOOD PROCESSING EQUIPMENT DESIGN 2 (1+1)

Theory

Materials and properties: Materials for fabrication, Design of pressure and storage vessels: Operating conditions, design conditions and stress; Design of shell and its component, mountings and accessories, Design of heat exchangers:Design of shell and tube heat exchanger, plate heat exchanger, scraped surface heat exchanger, Sterilizer and retort, Design of evaporators: Design of single effect and multiple effect evaporators and its components, Design of rising film and falling film evaporators and feeding arrangements for evaporators, Design of centrifuge separator, Design of dryers: Design of tray dryer, tunnel dryer, fluidized dryer, spray dryer, vacuum dryer, freeze dryer and microwave dryer, Design of extruders: Cold and hot extruder design, design of screw and barrel, design of twin screw extruder, Safety measures in equipment design, pressure relief devices

Practical

Design of pressure vessel; Design of shell and tube heat exchangers and plate heat exchanger; Design of sterilizers and retort;Design of single and multiple effect evaporators; Design of tray dryer; Design of fluidized bed dryer; Design of spray dryer; Design of vacuum dryer; Design of microwave dryer; Design of belt and chain conveyor; Design of screw conveyor; Design of bucket elevator and pneumatic conveyor; Design of twin screw extruder.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1	Materials and properties: Materials for fabrication	6
2-3	Design of pressure and storage vessels: Operating conditions, design conditions and stress; Design of shell and its component, mountings and accessories	12
4	Design of heat exchangers :Design of shell and tube heat exchanger, plate heat exchanger, scraped surface heat exchanger	6
5-6	Sterilizer and retort	12
7	Design of evaporators: Design of single effect and multiple effect evaporators and its components	6
8-9	Design of rising film and falling film evaporators and feeding arrangements for evaporators	13
10	Design of centrifuge separator	6
11-12	Design of dryers: Design of tray dryer, tunnel dryer, fluidized dryer, spray dryer, vacuum dryer, freeze dryer and microwave dryer	13
13-14	Design of extruders: Cold and hot extruder design, design of screw and barrel, design of twin screw extruder	13
15-16	Safety measures in equipment design, pressure relief devices.	13
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1.	Study of design of pressure vessel	1
2.	Study of different types of pressure vessels used in food industry	1
3.	Design of shell and tube heat exchanger	1
4.	Design of plate heat exchanger	1
5.	Design of sterilizers (Batch type)	1
6.	Design of vertical retort	1
7.	Design of single effect evaporator	1
8.	Design of multiple effect evaporator	1
9.	Design of climbing and falling film evaporator	1
10.	Design of tray and fluidized bed dryer	1
11.	Design of spray, vacuum and microwave dryer	1
12.	Design of belt and chain conveyor	1
13.	Design of screw and roller conveyor	1
14.	Design of bucket elevator	1
15.	Design of pneumatic conveyor	1
16.	Design of single screw and twin screw extruder	1
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Handbook of Food Processing Equipment	Sarvacos G and Athanacios EK	2nd Edition, Springer 2016
2	Process Equipment Design	Mahajani and Umarji	Macmillan Publisher India Ltd. 1996
3	Peter F. Stanbury, Allan Whitakar and Stephen J. Hall	Principles of Fermentation Technology	2nd Ed. Elsevier Science Ltd., Burlington, MA, USA. 1995
4	Chemical Engineering, Vol. 3, Chemical & Biochemical Reactors & Process Control	J.F. Richarson and D.G. Peacock	3rd Ed. Elsevier Butterworth-Heinemann, Amsterdam, The Netherlands. 1995

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Introduction to Food Engineering	R. Paul Singh and Heldman DR	5th Ed. Elsevier, Amsterdam, The Netherlands. 2014
2	Unit Operations in Food Engineering	Ibarz A. and Barbosa-Cánovas G	CRC Press, Boca Raton, FL, USA. 2010
3	Chemical Engineering, Vol. 6, Chemical Engineering Design	R. K. Sinnott	3rd Ed. Butterworth-Heinemann, Oxford, UK. 1999
4	Handbook of Food Engineering Practice.	Kenneth JV, Enrique R and RP Singh	CRC Press, Boca Raton, FL, USA. 1997

FE-3613 FOOD PLANT DESIGN AND LAYOUT 3 (2+1)

Theory

Overall design of an enterprise: Plant design, sales planning for plant design, Strength of material – engineering materials, material science, use of various metals, including plastic, glass, etc in food industry, selection and specification – material design, concepts and manufacturing of various equipments and machineries for food processing plant, Plant Location, levels of Plant location, Location of layout: location factors, plant site selection, Location Theory and models, industrial buildings and grounds, Classification of Dairy and Food Plants, farm level collection and chilling centre, space requirement, Preparation of a Plant Layout: Plant Layout problem, importance, objectives, classical types of layouts. Evaluation of Plant Layout, Advantages of good layout. Organizing for Plant Layout, Data forms Common Problems in Plant Layout and Process scheduling,Sitting of Process sections, Equipment selection and capacity determination, Arrangement of process, and service equipment, Estimation of Services and Utilities Office layout, line balancing, Flexibility, Practical Layouts, Maintenance of Food Plant Building, Illumination and ventillation, Cleaning and sanitization, painting and colour coding, Fly and insect control.

Practicals

Preparation of project report; Preparation of feasibility report; Layout of Food storage wares and godowns; Layout and design of cold storage; Layout of preprocessing house; Layout of Milk and Milk product plants; Bakery and related product plant; Fruits processing plants; Vegetable processing plants; Layout of multi-product and composite food Plants; Waste treatment and management of food plant; Visit to Fruit and Vegetables processing plant.

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-2	Overall design of an enterprise : Plant design, sales planning for plant design	7
3-7	Strength of material – engineering materials, material science, use of various metals, including plastic, glass, etc in food industry, selection and specification – material design, concepts and manufacturing of various equipments and machineries for food processing plant	16
8-10	Plant Location, levels of Plant location. Location of layout : location factors, plant site selection. Location Theoryand models, industrial buildings and grounds	9
11-13	Classification of Dairy and Food Plants, farm level collection and chilling centre, space requirement	9
14-16	Preparation of a Plant Layout: Plant Layout problem, importance, objectives, classical types of layouts.	9
17-19	Evaluation of Plant Layout. Advantages of good layout. Organizing for Plant Layout, Data forms	9
20-21	Common Problems in Plant Layout and Process scheduling	7
22-23	Sitting of Process sections, Equipment selection and capacity determination	7

24-26	Arrangement of process, and service equipment. Estimation of Services and Utilities	9
27-29	Office layout, line balancing, Flexibility. Practical Layouts	9
30-32	Maintenance of Food Plant Building, Illumination and ventillation, Cleaning and sanitization, painting and colour coding, Fly and insect control	9
	Total	**100**

Practical Exercises

No. of Units	**Topics**	**No. of Experiments**
1.	Preparation of project report	1
2.	Preparation of feasibility report	1
3.	Layout of food storage wares and godowns	1
4.	Visit to food storage wares and godowns	1
5.	Layout and design of cold storage	1
6.	Visit to cold storage plant	1
7.	Layout of preprocessing house	1
8.	Layout of milk and milk product plant	1
9.	Visit of milk processing plant	1
10.	Layout and design of bakery and related product plant	1
11.	Visit to bakery unit	1
12.	Layout and design of fruit processing plant	1
13.	Layout and design of vegetable processing plant	1
14.	Visit to fruit and vegetable processing plant	1
15.	Design and layout of multiproduct and composite food plant	1
16.	Waste treatment and management of food plant	1
	Total	**16**

TEXT BOOK

Sr. No.	**Name of Book**	**Author**	**Publisher**
1	Milk Plant Layout	H.S. Hall	FAO Pub., Rome 1968
2	Plant Layout and Design	James M.Moore	Mac Millan, New York 1971
3	Textbook of Dairy Plant Layout and Design	---	ICAR, New Delhi 2010
4	Applied guide to process and plant design	Sean Moran	Elsevier, 2015

REFERENCE BOOKS

Sr. No.	**Name of Book**	**Author**	**Publisher**
1	Facility Planning And Layout Design	Chandrashekar Hiregoudar	Technical Publications, 2017
2	Engineering for Dairy and Food Products	A.W. Faral	Rebert E., Kriger Pub Co., New York 1980
3	Practical Plant Layout	Richard Muther	McGraw Hill, 1955

FE-3614 INSTRUMENTATION AND PROCESS CONTROL 3 (2+1)

Theory

Introduction, definition, recorders and monitors, panel boards; General characteristics of instruments, static and dynamic characteristics; Temperature and temp. scales, various types of thermometers - mercury-in-glass, bimetallic, pressure-spring thermometers, thermo couples, resistance thermometers and pyrometers; Pressure and pressure scales, manometers, pressure elements differential pressure; Liquid level measurement, different methods of liquid level measurement; Flow measurement, kinds of flow, rate of flow, total flow differential pressure meters, variable area meters; Transmission, pneumatic and electrical; Control elements, control actions, pneumatic and electrical control system.

Practical

To study instrumentation symbols; Measurement of temperature by different thermometers; Measurement of pressure by 'U' tube manometer, ; (inclined tube manometer); Measurement of liquid level in the tank with the help of Bob and tape; Determination of relative humidity by wet and dry bulb thermometer; Measurement of velocity of fluid by using venturimeter/orifice meter/pilot tube; Measurement of RPM of an electric motor by Tachometer; Measurement of wind velocity by anemometer
Measurement of intensity of sun shine by sunshine recorders

Teaching Schedule - Theory with Weightages (%)

No. of Units	Topics	% Syllabus Covered
1-3	Introduction, definition, recorders and monitors, panel boards	10
4-8	General characteristics of instruments, static and dynamic characteristics	16
9-13	Temperature and temp. scales, various types of thermometers - mercury-in-glass, bimetallic, pressure-spring thermometers, thermo couples, resistance thermometers and pyrometers	16
14-18	Pressure and pressure scales, manometers, pressure elements differential pressure	16
19-22	Liquid level measurement, different methods of liquid level measurement	13
23-26	Flow measurement, kinds of flow, rate of flow, total flow differential pressure meters, variable area meters	13
27-29	pneumatic and electrical Transmission	9
30-32	Control elements, control actions, pneumatic and electrical control systems	10
	Total	**100**

Practical Exercises

No. of Units	Topics	No. of Experiments
1	To study instrumentation symbols	1
2	Measurement of temperature by different thermometers.	1
3	Measurement of pressure by 'U' tube manometer, (inclined tube manometer)	3
4	Measurement of liquid level in the tank with the help of Bob and tape	2
5	Determination of relative humidity by wet and dry bulb thermometer	2
6	Measurement of velocity of fluid by using venturimeter/orifice meter/pilot tube	2
7.	Measurement of RPM of an electric motor by Tachometer	2
8	Measurement of wind velocity by anemometer	1
9	Measurement of intensity of sun shine by sunshine recorders	2
	Total	**16**

TEXT BOOK

Sr. No.	Name of Book	Author	Publisher
1	Process Control Instrumentation Technology	Curtis D. Johnson	7th Ed. Prentice Hall of India Pvt. Ltd., New Delhi. 2003
2	Perry's Chemical Engineers' Handbook	Don W. Green and Robert H. Perry	McGraw-Hill Co., Inc., NY, USA. 2008

REFERENCE BOOKS

Sr. No.	Name of Book	Author	Publisher
1	Transducers and Instrumentation	D.V.S. Murty	Prentice-Hall of India Pvt. Ltd. New Delhi. 2004
2	Instrument Engineer's Handbook	Bela G. Liptak	Vol. I and II, 4th Ed. CRC Press, Boca Raton, FL, USA. 2003