COURSE SYLLABUS
for
Ph.D (Agril. Engg.)
in
Processing and Food Engineering

(Approved by Academic Council vide resolution No. 7644, dat. 07.12.2022)

ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR-751003

SEMESTER WISE COURSES TO BE TAKEN FOR THE Ph.D. (AG. ENGG.),
PROCESSING AND FOOD ENGINEERING (2022 onwards)

Course No.	Course Title	Credit hours		
		Major	**Minor**	**Supporting**
SEMESTER-I				
*PFE601	Advances in Food Process Engineering	2+1		
*PFE602	Drying and Dehydration of Food Materials	2+1		
PFE603	Textural and Rheological Characteristics of Food Materials	2+1		
REE 602	Thermochemical Conversion of Biomass		2+1	
ASCE 601	Environmental Engineering for Plants and Animals			**3+0**
PGS-501	***Library and Information service***	***1+0 (NC)***		
PGS-504	***Basic concepts of laboratory techniques***	***0+1 (NC)***		
SEMESTER-II				
PFE604	Agricultural Waste and By-Products Utilization	2+1		
REE 609/ FMPE 503	Energy planning management & economics/ Ergonomics and Safety in Farm Operations		3+0/ 2+1	
STAT 601	Theory of Designs and Analysis of Experiments			**2+1**
PFE -699	**Research for thesis**		**0+5**	
PGS-502	***Technical writing and communication skills***	***0+1 (NC)***		
PGS-505	***Agricultural research, research ethics and rural development***	***1+0 (NC)***		
SEMESTER-III				
*CPE-RPE	Research and Publication Ethics			**1+1**
PFE -699	**Research for thesis**	**0+10**		
PGS-503	***Intellectual property and its management***	***1+0 (NC)***		
SEMESTER-IV				
PFE 699	**Research for Thesis**	**0+20**		
SEMESTER-V				
PFE 699	**Research for Thesis**	**0+20**		
PFE -691	**Doctoral Seminar 1**	**0+1**		
SEMESTER-VI				
PFE 699	**Research for Thesis**	**0+20**		
PFE 692	**Doctoral Seminar 2**	**0+1**		

- **NC: Non Credit (italic) courses are exempted if undergone during masters' programme.**

Type of course	Minimum credit hours
A. Course Work	
i) Major course	**12**
ii) Minor course	**06**
iii) Supporting course	**05**
iv) Non-credit compulsory course	**--**
v) Seminar	**02**
Sub-Total	25
B. Thesis	**75**
Grand Total	100

Course Contents

Ph.D. in Processing and Food Engineering

I. Course Title : Advances in Food Process Engineering

II. Course Code : PFE 601

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip the students with the modern and latest techniques of food engineering.

V. Theory

Unit I

Preservation of foods: Physical and chemical methods, microbiological aspects, thermo bacteriology, process calculation and selection. Thermal processing of canned foods: Introduction, commercial sterilization systems, thermal inactivation, kinetics of bacterial spores, heat transfer in canned foods, process calculations, numerical computer simulation of heat transfer, aseptic processing.

Unit II

Low temperature preservation; Cooling and cold storage. Hurdle technology: Principles and applications. Food irradiation: Advantages and applications, beneficial chemical and biological effects on foods, mechanisms of food irradiation, sources of food irradiation, criteria for judging the efficacy, dosimetry, radiation tolerance of foods, upper irradiation dose for foods, safety of irradiated foods. Microwave processing: Interaction with food materials, microwave equipment. Hydrostatic pressure treatment of food: Equipment, processing and effect on microorganisms. High pressure processing: Introduction, equipment and operation principles. Chemical and thermodynamic principles. Applications of HP to foods. Commercial high pressure equipment and applications. Membrane concentration of liquid foods: Principles, thermodynamics and osmotic pressure, mechanisms of membrane transport, membrane transport models.

Unit III

Application of heat energy and ultrasound; Effects of different environmental factors on microbial ultrasonic resistance, effects of treatment parameters on lethal effect of ultrasound, mechanism of action of inactivation of microorganisms and enzymes, cavitation. Electrical resistance heating of food: Heat generation. Ohmic heating and moderate electric field: Introduction, microbial death kinetics, electrolytic effects, applications, ohmic heater, heating models. Pulsed electric field preservation: Principles and application, microbial inactivation mechanism, determinant factors in PFE technology, influence on food ingredients, pulsed electric field treatment unit, modeling PFE microbial inactivation, alternative applications of PFE technology, decontamination of microorganisms by surface treatment.

Unit IV

Extrusion cooking: Rheology of extrudates, newtonian models of single-screw extruder performance, non-newtonian models of single-screw extruder performance, single-screw extruder leakage flows, extruder die and its interaction with extruder behaviour, screw power demand, non-isothermal screw operation, feed zone, behaviour of more complex single-screw designs, multiple-screw extruders, partially filled screws, analysis of complex screws, heat transfer in extruders, extruder residence time

distributions, recent developments, methods, equipment, design criteria of extruders.

VI. Practical

Thermal processing of foods, sterilization, irradiation, membrane concentration, ultrasound, ohmic heating, pulsed electric field preservation, extrusion cooking, product quality determination. Visit of related food industries.

VII. Learning outcome

Student's capability to process and preserve food products using advance techniques as per requirement of food industries.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	Preservation of foods; Physical and chemical methods, microbiological aspects, thermo bacteriology, process calculation and selection.	3
2	Thermal processing of canned foods: Introduction, commercial sterilization systems, thermal inactivation, kinetics of bacterial spores, heat transfer in canned foods, process calculations, Numerical computer simulation of heat transfer, aseptic processing.	4
3	Low temperature preservation: Cooling, cold storage and CA storage.	3
4	Hurdle technology; Principles and applications.	2
5	Food irradiation: Advantages and applications, beneficial chemical and biological effects on foods, mechanisms of food irradiation, sources of food irradiation, criteria for judging the efficacy, dosimetry, radiation tolerance of foods, upper irradiation dose for foods, safety of irradiated foods.	2
6	Microwave processing; Interaction with food materials, microwave equipment.	2
7	Hydrostatic pressure treatment of food; Equipment, processing and effect on microorganisms. High pressure processing: Introduction, equipment and operation principles. Chemical and thermodynamic principles. Applications of HP to foods. Commercial high pressure equipment and applications.	2
8	Membrane concentration of liquid foods; Principles, thermodynamics and osmotic pressure, mechanisms of membrane transport, membrane transport models.	2
9	Application of heat energy and ultrasound; Effects of different environmental factors on microbial ultrasonic resistance, effects of treatment parameters on lethal effect of ultrasound, mechanism of action of inactivation of microorganisms and enzymes, cavitation	2
10	Electrical resistance heating of food: Heat generation. Ohmic heating and moderate electric field: Introduction, microbial death kinetics, electrolytic effects, applications, ohmic heater, heating models.	2
11	Pulsed electric field preservation; Principles and application, microbial inactivation mechanism, determinant factors in PFE technology, influence on food ingredients, pulsed electric field treatment unit, modeling PFE microbial inactivation, alternative applications of PEF technology, decontamination of microorganisms by surface treatment.	2
12	Extrusion cooking; Rheology of extrudates, Newtonian and non-Newtonian models of single-screw extruder performance, extruder leakage flows, extruder die and its interaction with extruder behaviour, screw power demand, non-isothermal screw operation, single-screw designs, multiple-screw extruders, partially filled screws,	4

	analysis of complex screws, heat transfer in extruders, extruder residencetime distributions, recent developments, design criteria of extruders.	
	Total	**30**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1	Study of thermal processing of foods and equipment, viz. pasteurization and sterilization and tutorials.	2
2	Study of different irradiation processes and equipments.	1
3	Study of different membrane separation processes and equipments.	1
4	Study of different ultrasound processes and equipments	1
5	Study of different ohmic heating method and equipments.	1
6	Study of different pulsed electric field preservation processes and equipments.	1
7	Study of different extrusion cooking method and equipments.	2
8	Product quality determination	2
9	Visit of various food industries.	3
10	Development of experimental setup by students	1
	Total	**15**

X. Suggested Reading

• Brennan JG, Butters JR, Cowell ND and Lilly AEI. 1990. Food Engineering Operations. Elsevier Publications.
• Fellows P. 1988. Food Processing Technology: Principle and Practice. VCH Publications.
• Geankoplis J Christie. 1999. Transport Process and Unit Operations. Allyn & Bacon.
• Henderson S and Perry SM. 1976. Agricultural Process Engineering. 5th Ed. AVI Publishing Company.
• McCabe WL and Smith JC. 1999. Unit Operations of Chemical Engineering. McGraw Hill.
• Sahay KM and Singh KK. 1994. Unit Operation of Agricultural Processing. Vikas Publishing House Pvt Ltd.
• Singh RP and Heldman DR. 1993. Introduction to Food Engineering. Academic Press.
• Singh RP. 1991. Fundamentals of Food Process Engineering. AVI Publishing Company.

I. Course Title : Drying and Dehydration of Food Materials

II. Course Code : PFE 602

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip the students with the latest technologies of dehydration of food products and the design features of different dryers.

V. Theory

Unit I

Importance of drying, principles of drying, moisture determination, equilibrium moisture content, etermination of EMC, methods and isotherm models. Psychrometry; Psychrometric terms, construction and use of psychrometric charts.

Unit II

Air flow and resistance, principles and equipment for air movement and heating, drying methods and theory of drying, dryers, classification and other allied equipment, thin layer drying of cereal grains, deep bed and continuous flow drying, drying models.

Unit III

Heat requirements and thermal efficiency of drying system, aeration, tempering and dehydration, operation of dryers and their controls, selection of dryers, performance testing of grain dryers, drying characteristics of cereals, pulses and oilseeds, microwave drying, radio frequency drying and tunnel drying, principles and equipment.

Unit IV

Drying of liquid foods, spray drying, drum drying, freeze drying, foam mat drying, heat pump drying, efractance window drying, infrared drying osmotic dehydration. Principles, methods, construction and adjustments, selection of dryers, heat utilization factor and thermal efficiency.

VI. Practical

Experiments on batch type thin layer dryer, fluidized bed dryer, continuous flow mixing type dryer, continuous flow non mixing type dryer, sand medium dryer (conduction type drying), agricultural waste fired furnace dryer, spray dryer, drum dryer, foam mat drying and osmotic dehydration to evaluate the thermal efficiency
and heat utilization factor.

VII. Learning outcome

Student's capability to develop dehydrated food products with higher retention of nutrients using different drying techniques and equipments.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	Importance of drying, principles of drying, moisture content determination, equilibrium moisture content, determination of EMC.	2
2	Basic concepts associated with drying – Intermolecular forces, Water activity, Molecular mobility, Glass transition temperature, Isotherm models – Langmuir, BET Isotherm	3
3	Psychrometry; Psychrometric terms, construction and use of psychrometric charts.	3
4	Air flow and resistance, principles and equipment for air movement and heating	3
5	Theory of drying, Dryers, Classification and other allied equipment	2
6	Thin layer drying of cereal grains, deep bed and continuous flow drying, drying models.	3
7	Heat requirements and thermal efficiency of drying system, aeration, tempering and dehydration	3
8	Operation of dryers and their controls, selection of dryers, performance testing of grain dryers Drying characteristics of cereals, pulses and oilseeds,	3
9	Microwave drying, radio frequency drying and tunnel drying, principles and equipment.	2
10	Drying of liquid foods, spray drying, drum drying. Principles, methods, construction and adjustments.	2
11	Freeze drying, foam mat drying, heat pump drying, refractance window drying, infrared drying, and osmotic dehydration. Principles, methods, construction and adjustments.	3
12	Selection of dryers, heat utilization factor and thermal efficiency.	1

	Total	**30**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1	Determination of moisture content with Oven method.	1
2	Determination of moisture content (w.b.) with Universal/Digital moisture meter.	1
3	Determination of moisture content (w b) with Infrared moisture meter.	1
4	Determination of Equilibrium moisture content of grains.	1
5	Drying of grains in a batch type thin layer dryer to evaluate the thermal efficiency and heat utilization factor.	1
6	To evaluate the performance of fluidized bed dryer in terms of thermal efficiency and heat utilization factor.	1
7	To draw a drying rate curve for wet grains in Satake test dryer i.e. Compartment type dryer.	1
8	Drying of food materials in a solar assisted mechanical tray drying system.	1
9	To dry grains in continuous flow mixing type dryer.	1
10	To evaluate the performance of conduction type dryer.	1
11	To determine the drying efficiency of agricultural waste fired furnace dryer.	1
12	Drying of liquid food material in a spray dryer and evaluate its thermal efficiency and heat utilization factor.	1
13	To evaluate the performance of a drum dryer.	1
14	Experimentation on foam mat drying process.	1
15	Experiment on osmotic dehydration of grapes.	1
	Total	**15**

X. Suggested Reading

• Bala BK. 1998. Drying and Storage of Cereal Grains. Oxford and IBH.

• Brooker DB, Bakker Arkema FW and Hall CW. 1974. Drying Cereal Grains. The AVI Publishing Company.

• Chakraverty A and De DS. 1999. Post-Harvest Technology of Cereals, Pulses and Oilseeds. Oxford & IBH.

• Hall CW. 1970. Drying Farm Crops. Lyall Book Depot.

• Kudra and Mujumdar. 2009. Advanced Drying Technologies. CRC press

I. Course Title : Textural and Rheological Characteristics of Food Materials

II. Course Code : PFE 603

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip the students with advances in measurement of textural and rheological characteristics affecting the food quality.

V. Theory

Unit I

Rheological properties of foods; Food rheology, physical states of materials, classical ideal material, rheological models, elements in the models, electrical equivalence, maxwell model, Kelvin model and four element burger's model, stress-strain behavior. Elastic–plastic behavior, visco-elastic behavior, creep behavior, dynamic visco-elastic behavior, flow behavior of fluids, creep, stress

relaxation.

Unit II

Viscometry; Capillary viscometry, casson model, flow rate equation, friction losses in pumping, turbulent flow, newtonian fluid, power law fluid, cone and plate viscometry, parallel plate viscometry, mixer viscometry. Flow through a converging die, cogswell's equations, gibson's equations, empirical method. Applications of stress and strain, shear modulus and shear loss modulus, storage compliance and loss compliance, comparison of moduli and compliances.

Unit III

Objective and subjective measurements of texture; Texture classification, relation of food texture with structure and rheology, principles and practices of objective or instrumental texture measurements, fundamental rheological tests, physiological aspects, mechanical aspects and viscosity measurements and relationship between fundamental tests and sensory evaluation. Imitative and empirical measurements
of texture; Tenderometer, brabender farinograph, firmness meter, texture profile method, dynamic methods for evaluation of food texture, dimensional analysis of food texture, firmness and hardness measurement.

Unit IV

Mathematical models and their application along with pipe line design and pump selection for non-newtonian fluids. Recent advances in textural, rheological and viscoelastic characteristics of foods and their associated mathematical models.

VI. Practical

Determination of viscosity of liquid foods, gumminess, chewiness, springiness and hardness of various fruits, vegetables and processed foods using texture profile analysis. Determination of force-distance relationship. Sensory evaluation/ subjective measurement and correlation between subjective and objective measurements of foods.

VII. Learning outcome

Student's capability to determine textural and rheological properties of food materials and their application in control of food processing operations.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	Objective and subjective measurements of texture: Texture classification, relation of food texture with structure and rheology.	3
2	Principles of Objective Texture Measurement	2
3	Practices of objective or instrumental texture measurements.	2
4	Fundamental rheological tests, physiological aspects, mechanical aspects and viscosity measurements and relationship between fundamental tests and sensory evaluation.	2
5	Imitative and empirical measurements of texture: Tenderometer, brabender farinograph, firmness meter, texture profile method, dynamic methods for evaluation of food texture, dimensional analysis of food texture, firmness and hardness measurement.	2
6	Rheological properties of foods: Food rheology, physical states of materials, classical ideal material.	2
7	Elastic–plastic behavior, visco-elastic behavior, creep behavior, dynamic	2

	visco-elastic behavior, flow behavior of fluids, creep, stress relaxation.	
8	Rheological models, elements in the models, electrical equivalence, maxwell model, Kelvin model and four element burger's model, stress-strain behavior.	2
9	Viscometry; Capillary viscometry, casson model, flow rate equation, friction losses in pumping, turbulent flow, newtonian fluid, power law fluid, cone and plate viscometry, parallel plate viscometry, mixer viscometry.	2
10	Flow through a converging die, cogswell's equations, gibson's equations, and empirical method.	2
11	Applications of stress and strain, shear modulus and shear loss modulus, storage compliance and loss compliance, comparison of moduli and compliances.	2
12	Correlation between physical measurements and sensory assessments of texture and viscosity.	2
13	Mathematical models and their application along with pipe line design and pump selection for non-newtonian fluids.	2
14	Recent advances in textural, rheological and viscoelastic characteristics of foods and their associated mathematical models.	2
	Total	**30**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1	Introduction to Texture analyzer	1
2	Study of different attachments of texture analyzer used in texture analysis of various agricultural commodities.	1
3	To study the texture profile curve for food material	1
4	To study the textural profile kinetics of various fruits	2
5	To study the textural profile kinetics of various vegetables	2
6	To study the textural profile kinetics of various processed foods	2
7	To study the textural properties of liquid food	1
8	To study the Compression, puncture, elongation and bending tests for food materials	3
9	Introduction to Rapid Visco analyser	2
10	Subjective measurement and correlation between subjective and objective measurements of foods.	1
	Total	**16**

X. Suggested Reading

• Bourne MC. 2002. Food Texture and Viscosity: Concept and Measurement. Academic Press.
• Deman JM. 1976. Rheology and Texture in Food Quality. AVI Publications.
• Mohsanin NN. 1989. Physical Properties of Plant and Animal Material. Vol. I, II. Gordon and

Breach Science Publications.
• Steffe JF. 1992. Rheology and Texture in Food Quality. AVI Publications.

I. Course Title : Agricultural Waste and By-Products Utilization

II. Course Code : PFE 604

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip the students with the techniques of utilization of agricultural waste and by-products and also about development of value added products from wastes.

V. Theory

Unit I

Conversion processes: Thermo-chemical conversions, densification, combustion and gasification, extraction, biological conversions, anaerobic digestion, biochemical digestion process, digestion systems, energy from anaerobic digestion, cellulose degradation, fermentation process. Agricultural wastes as paper, boards and fuel.

Unit II

Briquetting: Briquetted fuel from husk, hull and other wastes selection, design of briquetting machines. Utilization of shell, stem and stalk: Production of activated carbon. By-products of agro-industries: Rice mill, oil mill, cattle feed mill, valuable constituents and composition. Utilization of rice husk: Production of silica and cement from rice husk. Stabilization and storage of rice bran, extraction of rice bran oil.

Unit III

By-products of oil refining: Fatty acids/soap stock, wax and gum, characteristics and utilization. Rice germ and broken rice. Production of starch and infant food, industrial uses of starch. By-products of oil milling: Oil cake and defatted oil cake, cattle feed and industrial uses. Utilization of starch and other industrial wastes:

Microcrystalline cellulose, production of ethanol, wastes of tapioca starch industries, thippi-utilization as fuel, extraction of starch by hydrolysis, utilization of starch for food, adhesives and feed purposes.

Unit IV

By-products of sugar industry: Sugarcane tops, bagasse, molasses and pressmud, utilization as animal feed. By-products of fruits and vegetables based agro-industries: Mango seed kernel and pineapple waste.

VI. Practical

Exercises on stepped grate and fixed grate rice husk furnaces, waste fired furnace, briquette machine, production of alcohol from waste materials, production and testing of paperboards and particleboards from agricultural wastes.

VII. Learning outcome

Student's capability to develop processes for effective utilization of wastes generated through milling and processing of food materials.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	Introduction to by-products and waste generation in agricultural	2

	production and processing system. Generation of agricultural and agro industrial by-products/ wastes, their properties, on site handling, storage and processing.	
2	Thermo-chemical conversions, biological conversions, anaerobic digestion, biochemical digestion process, digestion systems, energy from anaerobic digestion, cellulose degradation, fermentation process.	3
3	Combustion and its types, theory, basic requirements for combustion, extraction.	**2**
4	Gasification process, gasifiers- types and their functioning, factors affecting gasification process.	**2**
5	Densification process, methods to densify mateials, factors to be considered.	**1**
6	Utilization of wastes for paper production, production of particle board.	**1**
7	Briquetting process, methods, design of machinery used for briquette formation, basic requirements, factors affecting briquetting from husk, hull and other wastes selection.	**2**
8	Utilization of rice husk: Production of silica and cement from rice husk, Stabilization and storage of rice bran, extraction of rice bran oil.	**2**
9	Utilization of shell, stem and stalk: Production of activated carbon.	**1**
10	By-products from rice milling operations, rice husk, rice bran, utilization in different materials.	**3**
11	Waste from oil mill, cattle feed mill, their valuable constituents and composition, utilization.	**2**
12	By-products of oil refining: Fatty acids/soap stock, wax and gum, characteristics and utilization.	**1**
13	Rice germ and broken rice. Production of starch and infant food, industrial uses of starch.	**1**
14	By-products of oil milling: Oil cake and defatted oil cake, cattle feed and industrial uses.	**1**
15	Utilization of starch and other industrial wastes: Microcrystalline cellulose, production of ethanol, wastes of tapioca starch industries.	**2**
16	Thippi-utilization as fuel, extraction of starch by hydrolysis, utilization of starch for food, adhesives and feed purposes.	**2**
17	By-products of sugar industry: Sugarcane tops, bagasse, molasses and press mud, utilization as animal feed.	**2**
18	By-products of fruits and vegetables based agro-industries: Mango seed kernel and pineapple waste.	**2**
	Total	**32**

IX. List of Practicals

S.No.	**Topic**	**No. of Practicals**
1	To Determine of moisture content of biomass.	1
2	To Determine of ash content of biomass	1
3	To determine Proximate analysis of biomass/waste/residue.	2
4	Exercises on stepped grate and fixed grate rice husk furnaces	2
5	Exercises on waste fired furnaces	1
6	Exercises on combustion calculation	1

7	To study the briquetting machine.	1
8	To study the various quality parameters of briquettes.	1
9	To study the production of alcohol from waste materials.	1
10	To study the production of paper boards and particle boards from agricultural wastes.	2
11	To determine the properties of paper boards and particle boards from agricultural wastes.	2
	Total	**15**

X. Suggested Reading

• ASAE Standards. 1984. Manure Production and Characteristics.
• Bor SL. (Ed.). 1980. Rice: Production and Utilization. AVI Publ.
• Chahal DS. 1991. Food, Feed and Fuel from Biomass. Oxford & IBH.
• Chakraverty A. 1989. Biotechnology and other Alternative Technologies for Utilisation of Biomass/Agricultural Wastes. Oxford & IBH.
• Donald LK and Emert HG. 1981. Fuels from Biomass and Wastes. Ann. Arbor. Science Publ.
• Srivastava PK, Maheswari RC and Ohja TP. 1995. Biomass Briquetting and Utilization. Jain Bros.
• USDA. 1992. Agricultural Waste Management Field Handbook. USDA.

I. Course Title : Mathematical Modeling in Food Processing

II. Course Code : PFE 605

III. Credit Hours : 3+0

IV. Aim of the course

To acquaint and equip the students with the mathematical modeling techniques and their applications in food processing

V. Theory

Unit I

An overview of the modeling process. Introduction to mathematical, correlative and explanatory models. Formulation, idealization and simplification of the problems.

Unit II

Probability models, series and linear mathematical approximation, dynamic and interacting dynamic processes.

Unit III

Applications of mathematical modelling techniques to food processing operations like parboiling, convective drying, pasteurization, dehydration, shelf-life prediction, fermentaiton, aseptic processing, moisture diffusion, deep fat drying, microwave processing, infrared heating and ohmic heating.

Unit IV

Stochastic finite element analysis of thermal food processes. Neural networks approach to modelling food processing operations.

VI. Learning outcome

Student's capability to develop models for food processing operations for prediction and control of operations.

VII. Lecture Schedule

S.No.	Topic	No. of Lectures
1	An overview of the modeling process	2
2	Introduction to mathematical, correlative and explanatory models.	3

	Formulation, idealization and simplification of the problems.	
3	Probability models, series and linear mathematical approximation	3
4	Dynamic Mathematical Model, Analysis of Dynamic Mathematical Models, dynamic and interacting dynamic processes.	3
5	Basic Concepts of Systems Analysis and Simulation.	2
6	Common Heat and Mass Transfer Models Dimensional Analysis.	3
7	Model-based techniques in food processing.	2
8	Applications of mathematical modelling techniques to parboiling of rice, convective drying/ dehydration, deep fat drying etc.	4
9	Applications of mathematical modelling techniques to pasteurization of milk and juices.	4
10	Applications of mathematical modelling techniques to fermentation, aseptic processing, moisture diffusion.	4
11	Applications of mathematical modelling techniques in shelf-life prediction of agricultural commodities.	3
12	Applications of mathematical modelling techniques to microwave heating, infrared heating and ohmic heating.	3
13	Stochastic finite element analysis of thermal food processes.	3
14	Probability models, series and linear mathematical approximation	3
15	Neural networks approach to modelling food processing operations.	3
	Total	**45**

VIII. Suggested Reading

• Fischer M, Scholten HJ and Unwin D. 1996. Spatial Analytical Perspectives on GIS. Taylor & Francis.

• Fish NM and Fox RI. 1989. Computer Application in Fermentation Technology: Modelling and Control of Biotechnological Processes. Elsevier.

• Gold HJ. 1977. Mathematical Modelling of Biological Systems - An Introductory Guidebook. John Wiley & Sons.

• Hunt DR. 1986. Engineering Models for Agricultural Production. The AVI Publ.

• Koeing HE, Tokad Y, Kesacan HK and Hedgers HG. 1967. Analysis of Discrete Physical Systems. McGraw Hill.

• Meyer JW. 2004. Concepts of Mathematical Modeling. McGraw Hill.

• Peart RM and Curry RB. 1998. Agricultural Systems, Modelling and Simulation. Marcel Dekker.

• Tijms HC. 1984. Modelling and Analysis. A Congrtational Approach. Wiley Publ.

I. Course Title : Bioprocess Engineering

II. Course Code : PFE 606

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip the students with the basic principles of biochemical process engineering.

V. Theory

Unit I

Applications of engineering principles: Mass and energy balance, fluid flow principles, Unit operations of process engineering

Unit II

Fundamentals of growth kinetics, maintenance energy and yield concepts, principles of media sterilization, media formulations of industrial fermentation.

Unit III

Aerobic and agitated rheology of fermentative fluids, design and scale-up of bioreactors, enzyme reactors.

Unit IV

Principles of recovery of fermented products in bio-processing, instrumentation, transport phenomenon.

VI. Practical

Kinetics of one substitute reactions, kinetics of growth in batch cultures, design consideration for bioreactors, media preparation and sterilization, microprocessor based monitoring of bioprocess parameters.

VII. Learning outcome

Student's capability to calculate the mass and energy balances in ant process operations, understanding growth kinetics and design bioreactors as per requirement of food industries

VIII. Lectures Schedule

S.No.	Topic	No. of Lectures
1	Basic engineering principles and their applications. Use of units and dimensions.	3
2	Mass balance: steady and unsteady. Problem solving involving blending, separation, drying, growth, recycling etc.	3
3	Energy balance in food processing operations. Use of steam tables in calculation of heat requirements etc.	3
4	Fluid flow principles: Static and dynamic. Concept of viscosity. Types of flow. Flow through pipes. Mass and energy balance in fluid flow. Calculation of pressure drop in pipes.	4
5	Fundamentals of growth kinetics, maintenance energy and yield concepts.	3
6	Principles of media sterilization, media formulations of industrial fermentation.	3
7	Aerobic and agitated rheology of fermentative fluids.	3
8	Design and scale-up of bioreactors, enzyme reactors.	3
9	Principles of recovery of fermented products in bio-processing, instrumentation, transport phenomenon.	5
	Total	**30**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1	To study the instruments used for measurement of temperature, relative humidity, flow rate, pressure, wind velocity, solar radiation etc.	1
2	Use of units, dimensions and basic mathematical applications.	1
3	To judge the students ability for solving mass balance problems.	2
4	To judge the students ability for solving Energy balance problems.	2
5	To study the kinetics of one substitute reactions.	1
6	To assess the kinetics of growth in batch cultures.	1
7	To study the order of reactions involving single/multiple reactants/products.	1
8	To study the various thermal and structural parameters affecting the design of bioreactors.	1

9	To assess the student's ability for design of bioreactors by solving related numerical problems.	2
10	To prepare various media cultures and assess their effectiveness with time.	1
11	To study the mechanism of sterilization of cultures.	1
12	To study the various electronic gadgets for continuous monitoring of bioprocess parameters.	1
	Total	**15**

X. Suggested Reading

• Brennan JG, Butters JR, Cavell ND and Lilly AEI. 1990. Food Engineering Operations. Elsevier.
• Coulson JM and Richadson JF. 1999. Chemical Engineering. Vols. II, IV. The Pergamon Press.
• Greanoplis JC. 1999. Transport Process and Unit Operation. Allyn & Bacon
• Treybal RE. 1981. Mass Transfer Operations. 3rd Ed. Harper & Row.