NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

B. Tech.

in

Food Engineering and Technology

(Effective from 2026-27)

Department of Food Engineering and Technology

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY
UNDER THE MINISTRY OF EDUCATION, GOVERNMENT OF INDIA
(DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956)
ARUNACHAL PRADESH: 791109

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

VISION

To produce professionals with competency for pursuing excellence in Science and Technology Education, Research, and Entrepreneurship with ethical values and social sensitivity for offering specialized services to society meeting the global requirements and standards in a multicultural environment.

MISSION

1. Creating a niche in the field of science and technology education and research through an innovative modular system.
2. Producing globally competitive technical and scientific manpower in different disciplines with high ethical values and with reference to the North Eastern region.
3. Inducing in engineers/technologists and trainees a mind-set full of creativity to pursue excellence with focus on stakeholders, accountability, environment and people.
4. Developing collaborations with world class R&D organizations, industries, and educational institutions in India and abroad for attaining excellence in teaching, research and consultancy practices.

Department of Food Engineering and Technology

VISION

To establish excellence in Food Engineering and Technology by fostering skilled professionals through education and research, dedicated to building a sustainable food system and promoting entrepreneurship, with a special focus on empowering youth from the North Eastern States and beyond through strong industry-academia collaboration.

MISSION

1. To build a vibrant ecosystem of education, research, and innovation in food engineering, fostering technological advancement, industrial collaboration, and global competitiveness in food processing.
2. To foster interdisciplinary research and innovation in food product and process development, addressing industrial challenges and contributing to evidence-based policymaking for the food sector.
3. To support inclusive development by delivering technological solutions and manpower training tailored to local agro-climatic and socio-economic conditions.
4. To promote entrepreneurship and empower local communities through skill development, incubation support, and value-added utilization of indigenous resources, thereby enhancing income generation and fostering self-reliance across the region.

Department of Food Engineering and Technology:

About the Department:

The Department of Food Engineering and Technology is established in 2025 and offering B.Tech. and Ph.D programmes in Food Engineering and Technology (FET) from the academic year 2026–27. The department focuses on advancing food science and technology by providing engineering-based solutions for better processing and preservation of food.

Its core activities include delivering high-quality education, research and development, capacity building, consultancy services, and fostering industry collaboration to address national challenges and support food security. The curriculum is designed with a balanced emphasis on theory, practical, and project-based learning. As part of academic exposure, students undertake visits to food processing industries and equipment manufacturing plants.

The department has a dedicated faculty with strong academic and research backgrounds, and national and international exposure. It also provides academic and research opportunities to students from the North-East region and across India, while actively engaging with industry to nurture future-ready professionals and foster innovation in the food sector.

List of Programs offered by the Department:

Name of the Program	Title of the Program
B.Tech.	Food Engineering and Technology
Ph.D.	Food Engineering and Technology

Note: Refer to the following weblink for Rules and Regulations of B.Tech. program:

PROGRAM EDUCATIONAL OBJECTIVES

PEO1	Provide students with a sound knowledge in mathematics, science and engineering science required to solve problems related to food processing.
PEO2	Effectively identify and design sustainable solutions to address issues and global opportunities
PEO3	Have successful professional careers in food industries, government organization, educational/ research/extension institute.
PEO4	Demonstrate strong leadership skills, ethical integrity, and professional engagement.
PEO5	Continue to learn to adapt in a world of evolving technology.

Program Articulation Matrix

Mapping of Mission statements with program educational objectives

Mission Statement	PEO1	PEO2	PEO3	PEO4	PEO5
MS1	2	3	3	1	2
MS2	3	1	2	2	2
MS3	1	2	1	2	3
MS4	2	3	2	3	2

1-Slightly, 2-Moderately, 3-Substantially.

Department of Food Engineering and Technology
PROGRAM OUTCOMES

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and IC design and technology concepts towards modelling and prototyping Integrated systems.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	Design/development of solutions: Design methodology to offer hardware solutions to public health, safety and agriculture, consumer electronics along with cultural, societal, and environmental considerations.
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO8	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO9	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehended write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO10	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply the set one‘s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO11	Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1	Identify and design sustainable solutions to solve food engineering problems applying the knowledge of basic and engineering sciences.
PSO2	Pursue successful professional career in food-industries, government organization, educational/ research/ extension institute adopting appropriate technology, resources and modelling.
PSO3	Adapt in a world of evolving technology with professional ethics and take lead roles in development of agricultural engineering and allied enterprises for betterment of society.

Mapping Program Outcomes with Program Educational Objectives

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PEO1	3	2	3	3	1	1	1	1	1	2	2
PEO2	2	3	3	3	3	2	2	1	1	2	2
PEO3	1	3	2	2	2	3	3	3	3	3	2
PEO4	1	2	2	2	3	3	3	3	2	1	3
PEO5	3	2	2	2	1	2	1	1	1	3	3

Note:

Category Code	Course Category
BSC	Basic Science Courses
ESC	Engineering Science Courses including workshop, drawing, basics of electrical, mechanical, computer etc.
HSMC	Humanities and Social Sciences including Management courses (Ability enhancement and Value-added courses)
PCC	Professional Core Courses
PEC	Professional Elective Courses
OEC	Multidisciplinary Open Elective Courses
Project	Research project and Seminar
Internship	Summer internship

SCHEME OF INSTRUCTION
B.Tech. in Food Engineering and Technology - Course Structure

I – Year **I –Semester**

S. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
Three Weeks Compulsory Student Induction Programme (UHV – I)							
1	FEPC101	Introduction to Food Engineering and Technology	2	1	0	3	PCC
2	FEPC102	Basic Food Microbiology	2	0	0	2	PCC
3	FEPC103	Basic Food Microbiology Lab	0	0	2	1	PCC
4	PHBS101	Engineering Physics	3	0	0	3	BSC
5	PHBS102	Engineering Physics Lab	0	0	2	1	BSC
6	MABS101	Mathematics – 1	3	0	0	3	BSC
7	EEES101	Basic Electrical Engineering	2	0	0	2	ESC
8	EEES102	Basic Electrical Engineering Lab	0	0	2	1	ESC
9	CEES102	Engineering Drawing	0	0	4	2	ESC
10	HSSM101	Communication Skills	2	0	0	2	HSMC
11	HSSM102	Communication Skills Lab	0	0	2	1	HSMC
12	HSAU101	Essence of Indian Knowledge and Tradition	2	0	0	0	MNC/AU
13	SNAU102	Sports/Yoga or NSS/NCC (Audit)	0	0	2	0	MNC/AU
Total			16	1	14	**21**	

Category	BSC	ESC	HSMC	PCC	PEC	OEC	Project	Internship	Total
Sem Credit	7	5	3	6	0	0	0	0	21
Cumulative Sum	7	5	3	6	0	0	0	0	**21**

SCHEME OF INSTRUCTION

B.Tech. in Food Engineering and Technology - Course Structure

I – Year **II –Semester**

S. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	FEPC201	Thermodynamics in Food Processing	2	1	0	3	PCC
2	FEPC202	Fluid Mechanics	2	0	0	2	PCC
3	FEPC203	Fluid Mechanics Lab	0	0	2	1	PCC
4	CYBS201	Engineering Chemistry	3	0	0	3	BSC
5	CYBS202	Engineering Chemistry Lab	0	0	2	1	BSC
6	MABS201	Mathematics - II	3	0	0	3	BSC
7	CSES201	Programming for Problem Solving	2	0	0	2	ESC
8	CSES202	Programming for Problem Solving Lab	0	0	4	2	ESC
9	MEES202	Workshop Practices	0	0	4	2	ESC
10	UHVA201	Universal Human Values	2	1	0	3	HSMC
11	CEAU201	Environmental Science	2	0	0	0	MNC/AU
12	SNAU202	Sports/Yoga or NSS/NCC	0	0	2	0	MNC/AU
Total			16	2	16	**22**	

Category	BSC	ESC	HSMC	PCC	PEC	OEC	Project	Internship	Total
Sem Credit	7	6	3	6	0	0	0	0	22
Cumulative Sum	14	11	6	12	0	0	0	0	**43**

SCHEME OF INSTRUCTION

B.Tech. in Food Engineering and Technology - Course Structure

II – Year **III –Semester**

S. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1.	FEPC301	Transport Phenomena in Food Processing	2	1	0	3	PCC
2.	FEPC302	Food Engineering Operations-I	2	0	0	2	PCC
3.	FEPC303	Food Engineering Operations-I Lab	0	0	2	1	PCC
4.	FEPC304	Food Chemistry	3	0	0	3	PCC
5.	FEPC305	Food Chemistry Lab	0	0	2	1	PCC
6.	FEPC306	Principles of Food Processing and Preservation	3	0	0	3	PCC
7.	MABS301	Mathematics -III	3	0	0	3	BSC
8.	FRBS301	Biology for Engineers	2	1	0	3	BSC
9.	ECES301	Basic Electronics Engineering	3	0	0	3	ESC
10.	ECES302	Basic Electronics Engineering Lab	0	0	2	1	ESC
Total			18	2	6	**23**	

Category	BSC	ESC	HSMC	PCC	PEC	OEC	Project	Internship	Total
Sem Credit	6	4	0	13	0	0	0	0	23
Cumulative Sum	20	15	6	25	0	0	0	0	**66**

SCHEME OF INSTRUCTION
B.Tech. in Food Engineering and Technology - Course Structure

II – Year **IV –Semester**

S. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	FEPC401	Food Engineering Operations-II	2	0	0	2	PCC
2	FEPC402	Food Engineering Operations-II Lab	0	0	2	1	PCC
3	FEPC403	Engineering Properties of Food Materials	2	0	0	2	PCC
4	FEPC404	Engineering Properties of Food Materials Lab	0	0	2	1	PCC
5	FEPC405	Instrumentation and process control in food industry	2	1	0	3	PCC
6	FEPC406	Food Biochemistry and Nutrition	2	0	0	2	PCC
7	FEPC407	Food Biochemistry and Nutrition Lab	0	0	2	1	PCC
8	FEPC408	Processing Technology of Fruits and Vegetables	2	0	0	2	PCC
9	FEPC409	Processing Technology of Fruits and Vegetables Lab	0	0	2	1	PCC
10	HSSM401	Entrepreneurship and Startups	3	0	0	3	HSMC
11	HSAU401	Indian Constitution	2	0	0	0	MNC/AU
			15	1	8	**18**	

Category	BSC	ESC	HSMC	PCC	PEC	OEC	Project	Internship	Total
Sem Credit	0	0	3	15	0	0	0	0	18
Cumulative Sum	20	15	9	40	0	0	0	0	**84**

SCHEME OF INSTRUCTION
B.Tech. in Food Engineering and Technology - Course Structure

III – Year **V –Semester**

S. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	FEPC501	Food Packaging and Storage Engineering	2	0	0	2	PCC
2	FEPC502	Food Packaging and Storage Engineering Lab	0	0	2	1	PCC
3	FEPC503	Food Refrigeration and Cold Chain Management	2	1	0	3	PCC
4	FEPC504	Biochemical Engineering	2	0	0	2	PCC
5	FEPC505	Biochemical Engineering Lab	0	0	2	1	PCC
6	FEPC506	Food Safety and Quality Assurance	2	1	0	3	PCC
7	FEPC507	Processing Technology of Milk and Milk Products	2	0	0	2	PCC
8	FEPC508	Processing Technology of Milk and Milk Products Lab	0	0	2	1	PCC
9	FEPC509	Processing Technology of Cereal, Pulses and Oilseeds	2	0	0	2	PCC
10	FEPC510	Processing Technology of Cereal, Pulses and Oilseeds Lab	0	0	2	1	PCC
11	HSSM501	Principles of Economics	3	0	0	3	HSMC
Total			15	2	8	**21**	

Category	BSC	ESC	HSMC	PCC	PEC	OEC	Project	Internship	Total
Sem Credit	0	0	3	18	0	0	0	0	21
Cumulative Sum	20	15	12	58	0	0	0	0	**105**

SCHEME OF INSTRUCTION
B.Tech. in Food Engineering and Technology - Course Structure

III – Year **VI–Semester**

S. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	FEPC601	Marketing Management and International Trade	2	1	0	3	PCC
2	FEPC602	Instrumental Techniques in Food Analysis	2	0	0	2	PCC
3	FEPC603	Instrumental Techniques in Food Analysis Lab	0	0	2	1	PCC
4	FEPC604	Technology for Bakery and Confectionery	2	0	0	2	PCC
5	FEPC605	Technology for Bakery and Confectionery Lab	0	0	2	1	PCC
6	FEPC606	Food Process & Equipment design	2	1	0	3	PCC
7	FEPC607	Food Plant Utilities	2	0	0	2	PCC
8	FEPE6X/XPE6XX/ MOPE6XX	Professional Elective Course -1 (Dept/Other Dept/MOOC)	3	0	0	3	PEC
9	MOOE601	Multidisciplinary Open Elective Course -1 (Only MOOC)	3	0	0	3	OEC
Total			16	2	4	**20**	

(*): Students are permitted to take (*) marked courses from MOOC and credit transfer will take place.

Category	BSC	ESC	HSMC	PCC	PEC	OEC	Project	Internship	Total
Sem Credit	0	0	0	14	3	3	0	0	20
Cumulative Sum	20	15	12	72	3	3	0	0	**125**

SCHEME OF INSTRUCTION
B.Tech. in Food Engineering and Technology - Course Structure

IV – Year **VII –Semester**

S. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	FEPC701	AI in Food Processing	2	1	0	3	PCC
2	FEPC702	Statistical Methods in Food and Consumer Research	2	1	0	3	PCC
3	FEPC703	Processing Technology of Meat, Fish and Poultry	2	0	0	2	PCC
4	FEPC704	Processing Technology of Meat, Fish and Poultry Lab	0	0	2	1	PCC
5	FEE7XX /XXPE7XX /MOPE701	Professional Elective Course - 2 (Dept. /Other Dept/ MOOC)	3	0	0	3	PEC
6	FEIN701	Summer Internship (1 Month) (#)	0	0	0	2	Internship
7	FEPR701	Final year project- I / Internship	0	0	0	6	Project
Total			9	2	2	**20**	

(#): The grade of Summer internship taken up during summer after VI semester, will be reflected in the grade sheet of VII semester.

Note: If students undergo for 6 month internship in 7th Semester, they will be allowed to do self-study and appear in the Exam directly.

Category	BSC	ESC	HSMC	PCC	PEC	OEC	Project	Internship	Total
Sem Credit	0	0	0	9	3	0	6	2	20
Cumulative Sum	20	15	12	81	6	3	6	2	**145**

SCHEME OF INSTRUCTION
B.Tech. in Food Engineering and Technology - Course Structure

IV – Year **VIII –Semester**

S. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	FEPE8XX/XXPE8XX MOPE801	Professional Elective Course - 3 (Dept. /Other Dept/ MOOC) (**)	3	0	0	3	PEC
2	FEPE8XX/XXPE8XX/MOPE803	Professional Elective Course - 4 (Dept. /Other Dept./ MOOC) (**)	3	0	0	3	PEC
3	MOOE801	Multidisciplinary Open Elective Course - 2 (**Only MOOC**)	3	0	0	3	OEC
4	XXOE8XX/ MOOE802	Multidisciplinary Open Elective Course - 3 (Other Dept. as well as MOOC) (**)	3	0	0	3	OEC
5	FEEA802	Co/Extra-curricular Activities/Hackathon/NCC/NSS/Technical Events	0	0	0	2	HSMC
6	FEPR801	Final year project- II/ Internship	0	0	0	8	Project
Total			12	0	0	**22**	

(**): Students are permitted to take (**) marked courses from MOOC in 8th Semester only if they undergo 6-months internship.

Category	BSC	ESC	HSMC	PCC	PEC	OEC	Project	Internship	Total
Sem Credit	0	0	2	0	6	6	8	0	22
Cumulative Sum	20	15	14	81	12	9	14	2	**167**

Semester wise Curriculum Components

Category Code	Course Category	Credit				
		First	Second	Third	Fourth	**Total**
BSC	Basic Science Courses	14	6	0	0	**20**
ESC	Engineering Science Courses including workshop, drawing, basics of electrical, mechanical, computer etc.	11	4	0	0	**15**
HSMC	Humanities and Social Sciences including Management courses (Ability enhancement and Value-added courses)	6	3	3	2	**14**
PCC	Professional Core Courses	12	28	32	9	**81**
PEC	Professional Elective Courses	0	0	3	9	**12**
OEC	Multidisciplinary Open Elective Courses	0	0	3	6	**9**
Project	Research project, Seminar and Case Study	0	0	0	14	**14**
Internship	Summer internship	0	0	0	2	**2**
Total		**43**	**41**	**41**	**42**	**167**

Professional Elective Courses

Course Code	Course Title	L	T	P	Course Credit	Sem	Elect. No
FEPE601	Food Process Calculation	3	0	0	3	VI	E1
FEPE602	Processing of Spices and Plantation Crops	3	0	0	3	VI	E1
FEPE603	Food Regulations & Safety Management System	3	0	0	3	VI	E1
FEPE701	Functional Foods and Nutraceuticals	3	0	0	3	VII	E2
FEPE702	Food Plant Sanitation	3	0	0	3	VII	E2
FEPE703	Principles of Food Product Development	3	0	0	3	VII	E2
FEPE801	Waste and By-product Utilization	3	0	0	3	VIII	E3
FEPE802	Renewable Energy in Food Processing	3	0	0	3	VIII	E3
FEPE803	Operations Research and Management	3	0	0	3	VIII	E3
FEPE804	Food Plant Design and Layout	3	0	0	3	VIII	E4
FEPC805	Process Modeling and Simulation	3	0	0	3	VIII	E4
FEPC806	Food Business Management and Entrepreneurship Development	3	0	0	3	VIII	E4
FEPC807	Emerging Technologies in Food Processing	3	0	0	3	VIII	E4

Exit Courses

After First year to exit with UG Certificate (Total 6 Credits)					
Course Code	**Course Title**	**L**	**T**	**P**	**Course Credit**
FEEX201	Food Supply Chain Management	3	0	0	3
FEEX202	Operation and Maintenance of Food Processing Equipment	3	0	0	3
FEEX203	Unit Operations in Food Processing	3	0	0	3
FEIN201	Internship (Six weeks)	0	0	0	6
After Second year to exit with UG Diploma (Total 6 Credits)					
FEEX401	Bakery and Confectionary Products	3	0	0	3
FEEX402	Food Enterprise Development	3	0	0	3
FEIN401	Internship (Six weeks)	0	0	0	6
After Third year to exit with B. Voc. (Total 6 Credits)					
FEEX601	Primary Processing, Value Addition and Cold Chain Logistics	3	0	0	3
FEEX602	Processing Technology of Beverages	3	0	0	3
FEIN601	Internship (Six weeks)	0	0	0	6

Exit Courses (From MOOC in case of Planned Exit)

Course Code	Based on choice of student	No. of Weeks	Course Credit
MOEX201	From Dept. in the Jan-May Semester/MOOC	12	3
MOEX203		12	3
MOEX401	From Dept. in the Jan-May Semester/MOOC	12	3
MOEX403		12	3
MOEX601	From Dept. in the Jan-May Semester/MOOC	12	3
MOEX603		12	3

Note: Basket of Exit courses for UG Certificate, UG Diploma and BVoC from MOOC will be prepared at the end of November and students (**for planned exit**) can clear any two 12-week courses from the basket during January-April.

Open Elective Courses (For students of other Departments)

Course Code	Course Title	L	T	P	Course Credit	Department	Elect. No
FEOE701	Development of Processed Food Products Lab	0	0	6	3	AE	OE1
FEOE801	Food Packaging Technology	2	1	0	3	AE	OE2

DETAILED SYLLABUS

B. Tech.

Food Engineering and Technology

Year I **Semester I**

Course Code: FEPC101	Introduction to Food Engineering and Technology	Credits 2-1-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand heat, mass & fluid transfer in foods.
CO2	Explain food preservation principles & methods.
CO3	Compare thermal & non-thermal preservation techniques.
CO4	Describe evaporation, drying & advanced heating methods.
CO5	Apply freezing & refrigeration in food processing.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2					2	2		3		
CO2	3	3	2	2					2	2		3		
CO3	3	3	2	2					2	2		3		
CO4	3	3	2	2					2	2		3		
CO5	3	3	2	2					2	2		3		

Syllabus:

Unit I	Definition, scope, and importance of food processing; Overview of Indian and global food industries; role of food engineers; career prospects and entrepreneurship in food sector.	7 lectures
Unit II	Introduction to heat transfer, fluid transfer and mass transfer in food processing,	5 lectures
Unit III	Principles of Food preservation and methods: Pasteurization, sterilization, UHT, canning. Irradiation, cooking and baking.	6 lectures
Unit IV	Evaporation, Drying and dehydration. Microwave and IR heating.	6 lectures
Unit V	Freezing and Refrigeration in food processing and their machineries.	4 lectures

Learning Resources:

Text Books:

1. Geankoplis, C. J. (1993). *Transport processes and unit operations* (3rd ed.). Prentice Hall.
2. McCabe, W. L., Smith, J. C., & Harriott, P. (1993). *Unit operations of chemical engineering* (5th ed.). McGraw-Hill.
3. Toledo, R. T. (1997). *Fundamentals of food process engineering* (2nd ed.). CBS Publishers & Distributors.

Reference Books:

1. Brennan, J. G., Butters, J. R., Cowell, N. D., & Lilley, A. E. V. (1990). *Food engineering operations* (3rd ed.). Elsevier Applied Science.
2. Fellows, P. J. (2000). *Food processing technology: Principles and practice* (2nd ed.). CRC Press.

Online Resources:

1. https://nptel.ac.in/courses/103103026
2. https://nptel.ac.in/courses/103103026

I – Year **I – Semester**

Course Code: FEPC102	Basic Food Microbiology	Credits 2-0-0: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Understand classification, morphology and growth of microbes.
CO2	Use techniques for culture, detection and maintenance of microbes.
CO3	Identify microbial incidence, spoilage and contamination in foods.
CO4	Apply control methods and food safety standards.
CO5	Explain role of microbes in food fermentation and probiotics.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2				2	2				2	2	
CO2	3	3	1									3	2	
CO3	3		3								2	3	3	3
CO4	2			3	2					2	3	2		
CO5	3		3						2			3	3	3

Syllabus:

Units	Topics	No. of Lectures
Unit I	Introduction: Classification, morphology and physiology of microorganisms, kinetics of microbial growth, nutrition and reproduction of microorganisms.	3 lectures
Unit II	Techniques in food microbiology: pure culture techniques and maintenance of cultures, methodologies for detection of food borne microorganisms	7 lectures
Unit III	Incidence of microorganisms in foods: Growth and survival of microorganisms in foods, Intrinsic and extrinsic factors, sources of contamination, spoilage of various food commodities, food borne infections, microbial toxins	6 lectures
Unit IV	Control of microorganisms in food: Principles underlying spoilage and preservation of foods. control of microorganisms through physical, chemical, antibiotic, and other methods. Microbiological standards of foods, food plant sanitation, inspection and control, and personnel hygiene.	6 lectures
Unit V	Microorganisms in food processing: Beneficial microorganisms and their utilization in food fermentation of bread, malt beverages, wines, vinegar, fermented vegetables, and fermented dairy products. Probiotics, prebiotics and synbiotics: definition and products.	6 lectures

Learning Resources:

Text Books:

1. L. Sherwood, L.M., & Woolverton, C. (2010). Microbiology. McGraw Hill International. 8th edition.
1. Frazier, W. C., & Westhoffs, D.C. (1993). Food Microbiology. TMH. 4th edition.
2. Pelczar Jr., M. J., Chan, E.C.S., & Krieg, N.R. (1993). Microbiology. TMH Book Company. 5th edition.
3. Adams, M. R., McClure, P. J., & Moss, M. O. (2024). Food microbiology. Royal society of chemistry.
4. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2014). Prescott's microbiology. McGraw-Hill.

Reference Books:

1. Forsythe, S. J. (2020). The Microbiology of Safe Food (3rd Ed.). Wiley-Blackwell.

Online Resources:

1. https://www.fao.org/fao-who-codexalimentarius/en/
2. https://www.fao.org/food-safety/en/

I – Year **I – Semester**

Course Code: FEPC103	**Basic Food Microbiology Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand and use basic microbiology lab instruments and techniques.
CO2	Perform staining, isolation, and purification of microbial cultures.
CO3	Analyze microbial presence in water, food, and air samples.
CO4	Evaluate antimicrobial activity and microbial identification tests.
CO5	Assess microbial quality of foods using biochemical and growth tests.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2						2				2	2	
CO2	3	3	1									3	2	
CO3	3		3								2	3	3	3
CO4	2				2					2	3	2		
CO5	3											3	3	3

List of experiments

1. Studying of different instruments used in microbiology lab
2. To perform gram staining of bacteria
3. To perform fungal staining using lactophenol cotton blue
4. To determine the presence of coliform bacteria in a water sample using MPN test
5. Enumeration of microbes from air (Total plate counts for bacteria and yeast and moulds)
6. Enumeration of microbes in water (Total plate counts for bacteria and yeast and moulds)
7. Enumeration of microbes from food using different selective media (pour plate and spread plate methods)
8. Purification of microbial culture using different streaking methods Isolation of pure culture
9. study the antimicrobial activity of selected antibiotics (streptomycin and tetracycline)

10. study the antimicrobial activity of selected antimicrobial agents
11. Study of IMViC test for microbial identification
12. Carbohydrate fermentation test of different bacterial strains (To study which carbohydrate is utilized by a particular bacterial strain for its growth)
13. Methylene Blue Reduction Test (MBRT) to assess the microbiological quality of milk
14. Effect of salt concentration on growth of LAB.

Learning Resources:

Text Books:

1. Frazier, W. C., & Westhoffs, D.C. (1993). Food Microbiology. TMH. 4th edition.
2. Pelczar Jr., M. J., Chan, E.C.S., & Krieg, N.R. (1993). Microbiology. TMH Book Company. 5th edition.
3. Ray, B., & Bhunia, A. K. (2013). Fundamental Food Microbiology (5th Edition). CRC Press.

Reference Books:

1. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). Modern Food Microbiology (7th Edition). Springer.
2. Adams, M. R., & Moss, M. O. (2022). Food Microbiology (5th Edition). Royal Society of Chemistry.
3. Forsythe, S. J. (2020). The Microbiology of Safe Food (3rd Edition). Wiley-Blackwell.

Online Resources:

1. https://www.fao.org/food-safety/en/
2. https://www.fda.gov/food/foodborne-pathogens/bad-bug-book-second-edition

I – Year **I – Semester**

Course Code: PHBS101	Engineering Physics	Credits 3-0-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the basic concept of scalars and vectors along with basic mechanics.
CO2	Understand the basis of heavy body mechanics.
CO3	Understand the concepts of dynamics.
CO4	Understand the basics of modern physics.
CO5	Develop an understanding of the theory of relativity.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1							3		
CO2	3	2	1	1	1							3		
CO3	3	2	1	1	1							3		
CO4	3	2	1	1	1							3		
CO5	3	2	1	1	1							3		

Syllabus:

Unit I	Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton's laws and its completeness in describing particle motion; Form invariance of Newton's Second Law; Solving Newton's equations of motion in polar coordinates; Problems including constraints and friction; Extension to cylindrical and spherical coordinates.	9 lectures
Unit II	Potential energy function; E = - Grad V, equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Elliptical, parabolic and hyperbolic orbits; Kepler problem; Application: Satellite manoeuvres.	8 lectures
Unit III	Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula. Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum. Harmonic oscillator, Damped harmonic motion – over-damped, critically damped and lightly-damped oscillators; Forced oscillations and resonance.	8 lectures
Unit IV	Illumination: laws of illumination, luminous flux, luminous intensity, candle power, brightness, Spontaneous and stimulated emission, Einstein A and B coefficients, Population inversion, He-Ne and Ruby lasers, Ammonia and Ruby masers, Holography-Note, Optical fiber, Physical structure, basic theory, Mode type, input output characteristics of optical fiber and applications.	9 lectures
Unit V	Frame of reference, Inertial & non-inertial frames, Galilean transformations, Michelson Morley experiment, Postulates of special theory of relativity, Lorentz transformations, Length contraction, Time dilation, Velocity addition theorem, Variation of mass with velocity, Einstein's mass energy relation, Relativistic relation between energy and momentum, Massless particle.	8 lectures

Learning Resources:

Text Books:

1. Mehta, N. (2011). *Applied Physics for Engineers*. New Delhi: PHI Learning. ISBN: 9788120342422.
2. Joshi, D. R. (2010). *Engineering Physics*. New Delhi: McGraw Hill Education.
3. Khan, M. M., & Panigrahi, S. (2017). *Principles of Engineering Physics 1*. Cambridge: Cambridge University Press. ISBN: 9781316635643.
4. Maharana, L., Panda, P. K., Dash, S. K., & Ojha, B. (2018). *Lectures on Engineering Physics*. New Delhi: Pearson Education. ISBN: 9789332584754.
5. Bhattacharya, D. K., & Tandon, P. (2015). *Engineering Physics*. New Delhi: Oxford University Press. ISBN: 9780199452811.

Reference Books:

1. Ghatak, A. K. (2020). *Optics* (7th ed.). New Delhi: McGraw Hill Education. ISBN: 9789390113590.
2. Griffiths, D. J. (2023). *Introduction to Electrodynamics* (5th ed.). Cambridge: Cambridge University Press. ISBN: 9781009397759.

3. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). New Delhi: McGraw Hill Education. ISBN: 9780070151550.
4. Swain, B. B., & Jena, P. K. (2011). *Physics-I for Engineering Degree Students* (4th ed.). Cuttack: Kitab Mahal. ISBN: 9789380360393.

Online Resources:

1. https://ocw.mit.edu
2. https://www.feynmanlectures.caltech.edu

I – Year **I – Semester**

Course Code: PHBS102	**Engineering Physics Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Determine the Young's modulus of a given body.
CO2	Determine Young's modulus by bending beams.
CO3	Determine the acceleration due to gravity.
CO4	Understand the laws of vibration.
CO5	Determine the wavelength of LASER using the concept of diffraction.
CO6	Determine the energy band gap of the semiconductor.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2					2	2		3		
CO2	3	3	2	2					2	2		3		
CO3	3	3	2	2					2	2		3		
CO4	3	3	2	2					2	2		3		
CO5	3	3	2	2					2	2		3		
CO6	3	3	2	2					2	2		3		

List of Experiments:

1. Determination of Young's modulus by Searle's method.
2. Determination of Young's modulus by bending of beams.
3. Determination of acceleration due to gravity by Bar pendulum.
4. Verification of laws of vibration of string using a sonometer.
5. Determination of wavelength of laser source by diffraction grating method.
6. Energy gap determination by the Four-Probe method.

Learning Resources:

Books:

1. Panigrahi, S., & Mallick, B. (2015). *Engineering Practical Physics*. New Delhi: Cengage Learning. ISBN: 9788131525203.
2. Arora, C. L. (2010). *B.Sc. Practical Physics* (5th ed.). New Delhi: S. Chand Publishing. ISBN: 9788121909099.
3. Das, S., & Das, M. (2020). *Physics in Laboratory: Electricity & Magnetism, Wave & Optics*. India: ISBN: 9789389332346.

Online Resources:

1. https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham

I – Year **I – Semester**

Course Code: MABS101	Mathematics – I	Credits 3-0-0: 3

Course Outcomes:

After completion of the course students will be able to:

CO1	Understand the concept of differentiation and its application.
CO2	Understand the concept of Infinite series.
CO3	Understand the concept of Applications of definite integral.
CO4	Understand the concept of ordinary differential equations.
CO5	Understand the concept of solution of system of linear equations by matrix method.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1							3		
CO2	3	2	1	1	1							3		
CO3	3	2	1	1	1							3		
CO4	3	2	1	1	1							3		
CO5	3	2	1	1	1							3		

Syllabus:

Unit I	Successive differentiation, Leibnitz theorem, L. Hospital's rule, Limit, Continuity and differentiability of functions of two and three variables, partial differentiation, Euler's theorem for homogenous function. Maxima and Minima function of two variables, Lagrange's multipliers.	10 lectures
Unit II	Infinite series: Comparison test, Ratio test, Cauchy's nth root test, Raabe's test power series, radius of convergence, Taylor's and Maclaurin's series, curvature, curve tracing.	8 lectures
Unit III	Applications of definite integral, area between curves, length of a plane curve, surface area of revolution, volume of solids of revolution, Beta and Gamma functions.	9 lectures
Unit IV	Solution of linear, exact differential equations, differential equation of order one but not of first degree, solvable by x, y, p., application of first order ordinary differential equations.	7 lectures
Unit V	Types of matrices, elementary operations; Echelon form; normal form, rank of a matrix, solution of system of linear equations, eigen values and eigenvectors, Cayley-Hamilton theorem, diagonalization.	8 lectures

Learning Resources:

Text Books:

1. Bali, N. P., & Goyal, M. (2014). *A Textbook of Engineering Mathematics*. New Delhi: Laxmi Publications. ISBN: 9788131808320.

2. Stroud, K. A., & Booth, D. J. (2013). *Engineering Mathematics* (7th ed.). New York: Industrial Press Inc. ISBN: 9780831134709.
3. Thomas, G. B., & Finney, R. L. (1996). *Calculus and Analytic Geometry* (9th ed.). Reading, MA: Addison-Wesley. ISBN: 9780201531749.
4. Hadley, G. (2002). *Linear Algebra* (Reprint ed.). New Delhi: Narosa Publishing House. ISBN: 9788185015811.

Reference books:

1. Spiegel, M. R. (2009). *Schaum's Outline of Vector Analysis* (2nd ed.). New York: McGraw-Hill. ISBN: 9780071615457.

Online Resources:

1. https://tutorial.math.lamar.edu/

I – Year **I – Semester**

Course Code: EEES101	**Basic Electrical Engineering**	**Credits 2-0-0: 2**

Course Outcomes: After completion of the course student will be able to:

CO1	Analyse DC circuits.
CO2	Analyze AC circuits.
CO3	Understand working principle of transformer and parameter determination.
CO4	Understand the working principle of Electrical machines and charateristics
CO5	Understand diode circuits.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	1		2	1					3	1	1
CO2	3	3	2	1		2	1					3	2	2
CO3	3	2	1	1		2	1					3	1	1
CO4	2	2	1	1		2	1					3	1	1
CO5	2	2	1									3	2	2

Syllabus:

Unit I	DC Circuits: Electrical circuit elements: R, L, C. Voltage and Current sources (independent and dependent/controlled sources). DC circuits, KCL, KVL, Mesh and Nodal Analysis, Network Theorems. Response of RL, RC and RLC circuits.	5 Lectures
Unit II	AC Circuits: Phasor analysis of AC circuits, Concepts of real power, reactive power, apparent power, power factor. Three-phase AC circuits.	7 Lectures
Unit III	Transformers: Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency, parameter determination.	6 Lecture
Unit IV	Electrical Machines: Electromechanical energy conversion principles, DC machine and its characteristics, induction motor and its characteristics.	6 lectures
Unit V	Electrical Measuring Instruments: Types and static characteristics, Classification, Measurement of, resistance, inductance, capacitance,	4 Lectures

	power and energy.	

Learning Resources:

Textbooks:

1. Fitzgerald, A. E., Higginbotham, D. E., & Grabel, A. (1981). *Basic Electrical Engineering* (5th ed.). New York: McGraw-Hill. ISBN: 9780070662834.
2. Hambley, A. R. (2017). *Electrical Engineering: Principles and Applications* (6th ed.). Boston: Pearson Education. ISBN: 9780134484143.
3. Guru, B. S., & Hiziroglu, H. R. (2001). *Electric Machinery and Transformers* (3rd ed.). New York: Oxford University Press. ISBN: 9780195138900.

Reference books:

1. K., & Sadiku, M. N. O. (2020). *Fundamentals of Electric Circuits* (7th ed.). New York: McGraw-Hill Education. ISBN: 9781260226409.
2. Hayt, W. H., Kemmerly, J. E., & Durbin, S. M. (2018). *Engineering Circuit Analysis* (9th ed.). New York: McGraw-Hill Education. ISBN: 9781259918951.

Online Resources:

1. https://nptel.ac.in/courses/108105053
2. https://nptel.ac.in/courses/108108076

I – Year **I – Semester**

Course code: EEES102	**Basic Electrical Engineering Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Verify network theorems
CO2	Perform phasor analysis of AC circuits
CO3	Measure three phase power
CO4	Determine characteristics of electrical machines
CO5	Measure resistance, inductance and capacitance.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	1		2	1					3	1	1
CO2	3	3	2	1		2	1					3	2	2
CO3	3	2	1	1		2	1					3	1	1
CO4	2	2	1	1		2	1					3	1	1
CO5	2	2	1									3	2	2

List of Experiments:

1. To verify maximum power transfer theorem.
2. To verify superposition theorem.
3. To verify Thevenin's theorem.
4. To draw phasor diagram and impedance triangle of a series RLC circuit.
5. To draw phasor diagram and impedance triangle of a parallel RLC circuit.

6. To measure three phase power by using two wattmeter method.
7. To determine RL and power factor of a choke coil.
8. To determine the turn ration and efficiency of a single-phase transformer.
9. To obtain the open circuit characteristics of a DC Generator
10. To study starting, running & reversal of three phase squirrel cage induction motor.
11. To start, run and reversal of dc shunt motor by field control & armature control method.
12. To measure resistance.
13. To measure inductance.
14. To measure capacitance.

Learning Resources:

Textbooks:

1. Fitzgerald, A. E., Higginbotham, D. E., & Grabel, A. (1981). *Basic Electrical Engineering* (5th ed.). New York: McGraw-Hill. ISBN: 9780070662834.
2. Hambley, A. R. (2017). *Electrical Engineering: Principles & Applications* (7th ed.). Harlow: Pearson Education. ISBN: 9781292223124.
3. Guru, B. S., & Hiziroglu, H. R. (2001). *Electric Machinery and Transformers* (3rd ed.). New York: Oxford University Press. ISBN: 9780195138900.

Reference books:

1. Alexander, C. K., & Sadiku, M. N. O. (2020). *Fundamentals of Electric Circuits* (7th ed.). New York: McGraw-Hill Education. ISBN: 9781260226409.
2. Hayt, W. H., Kemmerly, J. E., & Durbin, S. M. (2019). *Engineering Circuit Analysis* (9th ed.). New York: McGraw-Hill Education. ISBN: 9781259918951.

Online Resources:

1. https://nptel.ac.in/courses/108105053
2. https://nptel.ac.in/courses/108108076

I – Year **I – Semester**

Course code: CEES102	**Engineering Drawing**	**Credits 0–0–4: 2**

Course Outcomes: After completion of the course student will be able to:

CO1	Demonstrate proficiency in creating precise technical drawings using standard line types, clear lettering, and accurate dimensioning techniques and accurately construct and apply various engineering curves
CO2	Utilize projection techniques to represent points, straight lines, and planes in both first and third-angle projections.
CO3	Analyze and illustrate the projection of solid objects, create auxiliary and sectional views.
CO4	Develop surfaces and intersections of solids to produce detailed and accurate technical representations; produce isometric drawings/views.
CO5	Utilize AUTO-CAD to generate precise technical illustrations, integrating digital tools

	into their design processes.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	2	1	1	1	2	1	1	1	2	1	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	2	1
CO3	3	1	1	2	1	1	1	1	1	1	1	2	2	1
CO4	2	1	3	3	1	1	1	1	1	1	1	3	2	1
CO5	2	1	1	3	1	1	1	2	1	1	1	2	2	1

Components for Intensive Practice:

1. Introduction to Engineering Drawing: Lines lettering & dimensioning; Engineering curves: Conic sections, Cycloid, Involute, Spiral, Helix etc.
2. Orthographic Projections: Projection of Points, straight lines, and planes.
3. Projection of regular solids; auxiliary views and sectional views.
4. Development of surfaces, Intersection of solids and Isometric drawings/views.
5. Related drawings using AUTO-CAD.

Learning Resources:

Text Books:

1. Bhatt, N. D., & Panchal, V. M. (2014). *Elementary Engineering Drawing* (53rd ed.). Anand: Charotar Publishing House. ISBN: 9789380358963.
2. Venugopal, K., & Raja, V. P. (2011). *Engineering Drawing + AutoCAD*. New Delhi: New Age International Publishers. ISBN: 9788122431452.
3. Agrawal, B., & Agrawal, C. M. (2019). *Engineering Drawing* (3rd ed.). Singapore: McGraw Hill Education. ISBN: 9789353167448.
4. Gill, P. S. (2013). *Engineering Drawing*. New Delhi: S.K. Kataria & Sons. ISBN: 9789350143155.
5. Jeyapoovan, T. (2010). *Engineering Drawing and Graphics Using AutoCAD* (3rd ed.). New Delhi: S. Chand Publishing. ISBN: 9788125940005.

Reference books:

1. French, T. E., Vierck, C. J., & Foster, R. J. (1993). *Engineering Drawing & Graphic Technology*. Singapore: McGraw-Hill. ISBN: 9780070223471.
2. Jolhe, D. (2017). *Engineering Drawing with an Introduction to AutoCAD*. New Delhi: McGraw-Hill Education. ISBN: 9780070648371.
3. Madsen, D. A., & Madsen, D. P. (2011). *Engineering Drawing and Design* (5th ed.). Clifton Park, NY: Cengage Learning. ISBN: 9781111309572.
4. Giesecke, F. E., Mitchell, A., Spencer, H. C., Hill, I. L., Dygdon, J. T., Novak, J. E., Loving, R. O., Lockhart, S. E., Johnson, C., & Goodman, M. (2016). *Technical Drawing with Engineering Graphics* (15th ed.). Boston: Pearson. ISBN: 9780135090497.

Online Resources:

1. https://archive.nptel.ac.in/courses/112/105/112105294/
2. https://gphisar.ac.in/wp-content/uploads/2021/10/Engineering-Graphics-1.pdf

I – Year **I – Semester**

Course Code: HSSM101	Communication Skills	Credits 2-0-0: 2

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the fundamental principles of communication and overcome common barriers.
CO2	Develop proficiency in academic writing, including research papers and essays.
CO3	Demonstrate effective oral presentation skills using various tools and techniques.
CO4	Master the art of professional electronic correspondence and digital communication.
CO5	Understand prose forms

CO-PO/PSO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1					1	2			2	3	1		3	2
CO2					1	2			2	3	1		3	2
CO3					1	2			2	3	1		3	2
CO4					1	2			2	3	1		3	2
CO5					1	2			2	3	1		3	2

Syllabus:

UNIT	CONTENTS	No. of Lectures
Unit I	Fundamentals of Communication: Introduction to communication process; Verbal and non-verbal communication; Barriers to effective communication. Basic Communication Skills	6 lectures
Unit II	Academic Writing: Essay writing techniques; Research paper structure and formatting; Citation and referencing styles; Functional Grammar.	6 lectures
Unit III	Oral Presentation Skills: Preparing and delivering effective presentations; Using visual aids and multimedia; Handling Q&A sessions.	6 lectures
Unit IV	Electronic Correspondence: Email etiquette and best practices; Writing professional emails; Managing digital communication platforms.	5 lectures
Unit V	Reading and Comprehension Essays: Characteristics and types; Text (General/Personal/Technical essay) for detailed study.	5 lectures

Learning Resources:

Textbooks:

1. Bailey, S. (2018). *Academic Writing: A Handbook for International Students* (5th ed.). London: Routledge. ISBN: 9781138048744.
2. Siddons, S. (2008). *The Complete Presentation Skills Handbook: How to Understand and Reach Your Audience for Maximum Impact and Success*. London: Kogan Page. ISBN: 9780749450373.
3. Rutherfoord, A. J. (2001). *Basic Communication Skills for Technology* (2nd ed.). Upper Saddle River, NJ: Prentice Hall. ISBN: 9780130878229.

4. Jayaprakash, S. (2010). *The Art of Writing Effective E-mails*. Mumbai: Himalaya Publishing House. ISBN: 9788184885019.
5. Vassallo, P. (2007). *The Art of E-mail Writing*. New York: First Books. ISBN: 9780912301792.

Recommended Books:

1. Apps, J. (2019). *The Art of Communication: How to Be Authentic, Lead Others and Create Strong Connections*. Chichester, UK: Capstone. ISBN: 9780857088079.
2. Gallo, C. (2014). *Talk Like TED: The 9 Public Speaking Secrets of the World's Top Minds*. London: Macmillan. ISBN: 9781447261131.
3. Shipley, D., & Schwalbe, W. (2010). *Send: Why People Email So Badly and How to Do It Better*. New York: Knopf. ISBN: 9780307275998.
4. Cottrell, S. (2023). *Critical Thinking Skills: Effective Analysis, Argument and Reflection* (4th ed.). London: Bloomsbury. ISBN: 9781350322585.

Web Resources:

1. https://www.skillsyouneed.com/ips/communication-skills.html
2. https://virtualspeech.com/blog/improve-communication-skills
3. https://www.mindtools.com/cawh8bu/communication-skills
4. https://open.umn.edu/opentextbooks/textbooks/1288
5. https://online.berklee.edu/courses/digital-storytelling

I – Year **I – Semester**

Course Code: HSSM102	**Communication Skills Lab**	**Credits 0-0-2: 1**

Course Outcomes: At the end of the course, the student will be able to

CO1	Demonstrate effective verbal and non-verbal communication skills in various scenarios.
CO2	Produce well-structured academic writings with proper citations and referencing.
CO3	Deliver engaging presentations with appropriate visual aids and handle Q&A sessions effectively.
CO4	Compose professional digital communications and navigate various digital platforms proficiently.
CO5	Apply critical thinking skills to analyse case studies and participate in scientific debates.

CO-PO/PSO mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1					1	2			2	3	1		3	2
CO2					1	2			2	3	1		3	2
CO3					1	2			2	3	1		3	2
CO4					1	2			2	3	1		3	2
CO5					1	2			2	3	1		3	2

Components for Intensive Practice:

Unit – I: Effective Communication Exercises

Role-playing communication scenarios; Non-verbal communication interpretation; Active

listening practice.

Unit - II: Academic Writing Workshop

Peer review sessions for essays; Citation and referencing exercises; Research paper outline development.

Unit - III: Presentation Skills Practice

Impromptu speaking drills; Visual aid creation and usage

Unit - IV: Electronic Communication Practice

Email composition and analysis; Virtual meeting etiquette practice; Digital platform navigation exercises

Unit - V: Critical Thinking Challenges

Group discussions; Group problem-solving activities; Debates and extempore.

Textbooks:

1. Stephen Bailey, *'Academic Writing: A Handbook for International Students,'* (2018), Routledge.
2. Suzy Siddons, '*The Complete Presentation Skills Handbook: How to Understand and Reach Your Audience for Maximum Impact and Success,'* (2008), Kogan Page.
3. Andrea J. Rutherford, '*Basic Communication Skills for Technology,'* (2nd edition), (2001), Pearson Education
4. Sajitha Jayapraksh, '*The Art of Writing Effective Emails,'* (2021), Himalaya Publishing House
5. Philip Vassallo, '*The Art of E-mail Writing,'* (2010), First Books

Recommended Books:

1. Judy Apps, '*Art of Communication: How to be Authentic,'* (2019), Capstone
2. Carmine Gallo, '*Talk Like TED,'* (2014), Macmillan
3. David Shipley and Will Schwalbe, '*SEND: Why People Email so badly and How to Do it Better,'* (2010), Knopf
4. Stella Cottrell, '*Critical Thinking Skills: Effective Analysis, Argument, and Reflection'* (2023), Bloomsbury.
5. Peter Garber, '*50 Communications Activities: Icebreakers and Exercises,'* (2010), HRD

Web Resources:

1. https://www.mindtools.com/pages/main/communication-skills.htm

I – Year **I – Semester**

Course Code: HSAU101	Essence of Indian Knowledge and Tradition	Credits: 2-0-0: 0

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the concept of Bharatvarsha and Indian Knowledge System
CO2	Distinguish between different forms of Indian foundational literatures
CO3	Understand Indian Sciences, Mathematics, and Methodology of IKS
CO4	Familiarize with traditional Indian Agriculture and architectural practices
CO5	Understand traditional Indian Polity, Economy, and its outreach.

CO-PO/PSO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						2	2	3	1					2

CO2						2	2	3	1					2
CO3						2	2	3	1					2
CO4						2	2	3	1					2
CO5						2	2	3	1					2

Syllabus:

Units	Topics	No. of Lectures
Unit I	Basic Structure of Indian Knowledge System; Introducing Bharatvarsha, its geography and culture.	5 lectures
Unit II	Foundational Literatures; Vedangas and other streams of IKS; Classical literature in Sanskrit and other Indian languages; Indian Education	6 lectures
Unit III	Indian Sciences, Mathematics, Health Sciences, and Indian Astronomy; Methodology of Indian Knowledge System	6 lectures
Unit IV	Indian Architecture and Town Planning; Fine Arts; Indian Agriculture; Textiles, and Metallurgy	6 lectures
Unit V	Foundations of Indian Polity, Economy; Outreach of Indian Knowledge Systems	5 lectures

Learning Resources:

Text Books:

1. Baladev Upadhyaya, *Samskrta Śāstrom ka Itihās, Chowkhambha*, Varanasi, 2010.
2. D. M. Bose, S. N. Sen and B. V. Subbarayappa, Eds., *A Concise History of Science in India*, 2nd Ed., Universities Press, Hyderabad, 2010.
3. Astāngahrdaya, Vol. I, *Sūtrasthāna and Śarīrasthāna*, Translated by K. R. Srikantha Murthy, Vol. I, Krishnadas Academy, Varanasi, 1991.
4. Dharampal, Some Aspects of Earlier Indian Society and Polity and Their Relevance Today, New Quest Publications, Pune, 1987.
5. Dharampal, *Indian Science and Technology in the Eighteenth Century: Some Contemporary European Accounts*, Dharampal Classics Series, Rashtrotthana Sahitya, Bengaluru, 2021.
6. Dharampal, *The Beautiful Tree: Indian Indigenous Education in the Eighteenth Century*, Dharampal Classics Series, Rashtrotthana Sahitya, Bengaluru, 2021.
7. J. K. Bajaj and M. D. Srinivas, *Indian Economy and Polity in Eighteenth century Chengalpattu*, in J. K. Bajaj ed., Indian Economy and Polity, Centre for Policy Studies, Chennai, 1995, pp. 63-84.
8. J. K. Bajaj and M. D. Srinivas, Annam Bahu Kurvita, *Recollecting the Indian Discipline of Growing and Sharing Food in Plenty*, Centre for Policy Studies, Chennai, 1996.
9. J. K. Bajaj and M. D. Srinivas, *Timeless India Resurgent India*, Centre for Policy Studies, Chennai, 2001.
10. M. D. Srinivas, *The methodology of Indian sciences as expounded in the disciplines of Nyāya, Vyākarana, Ganita and Jyotisa*, in K. Gopinath and Shailaja D. Sharma (eds.), The Computation Meme: Explorations in Indic Computational Thinking, Indian Institute of Science, Bengaluru, 2022.

I – Year **II –Semester**

Course Code: FEPE201	Thermodynamics in Food Processing	Credits 2-1-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Explain the fundamental concepts, laws, properties, and systems of thermodynamics.
CO2	Apply the first and second laws of thermodynamics to analyze energy, entropy, and irreversibility.
CO3	Analyze properties of pure substances and evaluate thermodynamic cycles used in power and refrigeration.
CO4	Interpret psychrometric properties, phase relations, and humidity for food processing applications.
CO5	Demonstrate understanding of boilers, steam generation, draught systems, and steam properties in food plant operations.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3								3	3	2	
CO2	3	3		2								3		
CO3	3		3	3						2		3	2	3
CO4	3		3		3				2		3	3		3
CO5	3			3								3	2	3

Syllabus:

Unit I	Basic concepts: definitions, approaches, thermodynamic systems, thermodynamic properties and equilibrium, state of a system, state diagram, path and process, different modes of work, Zeroth law of thermodynamics, concept of temperature, heat.	7 lectures
Unit II	First law of thermodynamics: Energy, enthalpy, specific heats, applications of first law, steady and unsteady flow analysis. Second law of thermodynamics: Kelvin-Planck and Clausius statements, reversible and irreversible processes, entropy, availability and irreversibility.	9 lectures
Unit III	Properties of Pure Substances: Thermodynamic properties of pure substances in solid, liquid and vapor phases, P-V-T behaviour of simple compressible substances, phase rule. Thermodynamic cycles: Carnot vapor power cycle, ideal Rankine cycle, air standard Otto cycle, air standard Diesel cycle, vapor-compression refrigeration cycle.	9 lectures
Unit IV	Psychometry: thermodynamic properties of moist air, perfect gas relationship, absolute humidity, relative humidity, percentage humidity, humid volume, total heat, enthalpy, dry bulb temperature, wet bulb temperature, dew point temperature, adiabatic processes, wet bulb depression, humid heat, specific volume, heating, cooling, dehumidifying, sorption isotherms. Three stages of water, phase diagram for water, vapour pressure-temperature curve for water, heat requirement for vaporization, measurement of humidity.	9 lectures
Unit V	Boilers and steam generation: fuels for boilers and steam generation, boiler	8 lectures

	types, boiler mountings and accessories, Introduction to Indian Boiler Regulation Act. Layout of steam pipe-line and expansion joints. Boiler Draught: Definition, importance and classification of draught, Natural and artificial draught, Calculation of Height of chimney, draught analysis; Properties of steam: Wet, dry saturated, superheated steam, use of steam tables.	

Learning Resources:

Text Books:

1. Brooker, D.B., Bakker-Arkema, F.W. and Hall, C.W. 1976. Drying Cereal Grains. The AVI Publishing Company, Inc., Connecticut, MA, USA.
2. Geankoplis, C. J. 2003. Transport Processes and Separation Process Principles (Includes Unit Operations), 4th edn. Prentice-Hall, NY, USA.
3. McCabe, W.L., Julian Smith, Peter Harriott. 2004. Unit Operations of Chemical Engineering, 7th edn. McGraw-Hill, Inc., NY, USA.
4. Nag, P.K. 2005. Engineering Thermodynamics, 3rd edn. Tata-McGraw-Hill Education, New Delhi.
5. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
6. Rajput, R.K. 2007. Engineering Thermodynamics, 3rd edn. Laxmi Publications (P) Ltd., Bangalore.
7. Smith, J.M., Van Ness, H.C. and Abbott, M.M. 2005. Introduction to Chemical Engineering T hermodynamics, 7th edn. McGraw-Hill, Inc., NY, USA.

Reference Books:

1. Nag, P.K. 2005. Engineering Thermodynamics, 3rd edn. Tata-McGraw-Hill Education, New Delhi.
2. Rajput, R.K. 2007. Engineering Thermodynamics, 3rd edn. Laxmi Publications (P) Ltd., Bangalore.

Online Resources:

1. https://nptel.ac.in/courses/126105017
2. https://ocw.mit.edu/

I – Year **II – Semester**

Course Code: FEPC202	**Fluid Mechanics**	**Credits 2-0-0: 2**

Course Outcomes: After completion of the course, student will be able to:

CO1	Explain fundamental fluid properties and principles of pressure measurement.
CO2	Apply fluid statics to analyze hydrostatic forces on submerged surfaces
CO3	Interpret fluid kinematics and dynamics using continuity, Euler's, and Bernoulli's equations.
CO4	Analyze internal flows in pipes, head losses, boundary layer behavior, and energy losses.

CO5	Evaluate flow behavior around submerged bodies and determine drag and lift forces.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	-	1	-	-	1	1	1	3	2	1
CO2	3	3	3	2	1	1	-	-	1	1	1	3	2	1
CO3	3	3	3	2	1	1	-	-	1	1	1	3	2	1
CO4	3	3	3	3	1	1	1	-	1	1	1	3	3	1
CO5	3	3	3	3	1	2	1	-	1	1	1	3	3	2

Syllabus:

Unit I	Properties of fluids: Units and dimensions; properties of fluids—viscosity, thermodynamic properties, compressibility and bulk modulus, surface tension and capillarity, Vapour pressure and cavitation. Pressure and its measurement: pressure at a point, Pascal's law, measurement of pressure, manometers	4 lectures
Unit II	Fluid statics: hydrostatic force on submerged surfaces, total pressure and center of pressure, horizontal and vertical plane surfaces submerged in liquid, inclined and curved surface submerged in liquid.	4 lectures
Unit III	Kinematics of fluids: Types of fluid flow, rate of flow, continuity equation, continuity equation in three dimensions, velocity and acceleration, velocity potential function and stream function, types of motion and vortex flow.	7 lectures
Unit IV	Dynamics of fluid: Equations of motion, Euler's equation of motion, Bernoulli's equation, applications of Bernoulli's equation—venturi-meter, orifice-meter, pitot-tube, positive displacement and centrifugal pumps	8 lectures
Unit V	Internal flow: laminar and turbulent flow in pipes, general equation for head loss, Darcy-Weisbach and Fanning's equations, Moody's diagram, energy losses through pipe fittings, flow through network of pipes. Boundary layer flow-Introduction, Prandtl's boundary layer equation and boundary layer separation. Flow around submerged bodies: drag force, lift and drag coefficient, drag on flat plate circular cylinder and sphere	5 lectures

Learning Resources:

Text Books:

1. Rajput, R. K. (2011). *A text book of fluid mechanics and hydraulic machines in S.I units*. S. Chand and Company.
2. Bansal, R. K. (2019). *A text book of fluid mechanics*. Laxmi Publications.

Reference Books:

1. Ramanuthan, S. (2011). *Hydraulics, fluid mechanics & hydraulic machines*. Dhanpat Rai & Sons.
2. Khurmi, R. S., & Khurmi, N. (1987). *Hydraulics, fluid mechanics and hydraulic machines*. S. Chand & Co. Ltd.

3. Modi, P. N., & Seth, S. M. (2017). *Hydraulics & fluid mechanics including hydraulic machines*. Standard Book House.

Online Resources:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=27
2. https://agrimoon.com/wp-content/uploads/Fluid-Mechanics.pdf

II – Year **III – Semester**

Course code: FEPC203	Fluid Mechanics Lab	Credits 0–0–2: 1

Course Outcomes: After completion of the course student will be able to:

CO1	Verify fundamental fluid mechanics principles through experimental methods.
CO2	Measure flow parameters using devices such as Venturimeter, Rotameter, and Orifice meter
CO3	Analyze energy losses in pipes, fittings, and porous media
CO4	Determine fluid properties such as viscosity, surface tension, and permeability
CO5	Evaluate performance characteristics and efficiency of fluid machinery (pumps and turbines).

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3			1							3	3	
CO2	3	3		2								3		3
CO3	3			3	2							3		3
CO4	3			2	3							3		3
CO5	3	3	2									3		3

List of Experiments:

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

Learning Resources:

Text Books:

1. Rajput, R. K. (2011). *A textbook of fluid mechanics and hydraulic machines in S.I units*. S. Chand and Company.

Reference Books:

1. Departmental Laboratory Manual on Fluid Mechanics

Online Resources:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=27
2. https://archive.nptel.ac.in/courses/112/105/112105269/

I – Year **II – Semester**

Course Code CYBS201	Engineering Chemistry	Credits 3-0-0:3

Course Outcomes: At the end of the course, the student will be able to

CO1	Know about the different treatment methods of water.
CO2	Understand the basic concepts, first, second and phase equilibria of thermodynamics.
CO3	Understand the types of corrosion and controlling of corrosions.
CO4	Know the concept of preparations, properties and applications of polymers
CO5	Apply knowledge to analysis of various compound by spectroscopy.

CO-PO/PSO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1							3		
CO2	3	2	1	1	1							3		
CO3	3	2	1	1	1							3		
CO4	3	2	1	1	1							3		
CO5	3	2	1	1	1							3		

Syllabus:

Unit I	Water Technology: Boiler feed water-hardness, its units and determination; scale and sludge formation, boiler corrosion, caustic embrittlement, priming, foaming and their prevention. Conditioning (internal and external): phosphate, carbonate and Calgon conditioning; sodalime, zeolite and ion-exchange processes. Municipal water, water treatment (purification, coagulation, filtration and disinfection) for municipal supply	09 lectures
Unit II	Chemical Thermodynamics: Basic concepts of thermodynamics-Mathematical form of First law and its limitations-Enthalpy- Applications of first law (relation between C_p and C_v only. Second Law of Thermodynamics – Entropy change accompanying various processes (isothermal expansion, phase transition, heating, entropy of mixing of perfect gases); Absolute entropy and the Third Law of Thermodynamics; Statistical entropy; Spontaneity of a chemical reaction and Gibbs energy; Standard Gibbs energies of formation and reactions; Thermodynamic functions (A, G, U & H) and four fundamental equations, Maxwell relationships; variation of G with T and P, Gibbs-Helmholtz equation, Chemical potential; G versus extent of reaction ( ), Equilibrium constant through chemical potential (gas equilibria), relation between Kp & Kc; Phase equilibria, Gibbs phase rule, phase diagrams of water and carbon	12 lectures

	dioxide (supercritical H_2O & CO_2), Clausius-Clapeyron equation; Liquid-solid phase diagrams – two-component eutectic systems and cooling curves.	
Unit III	Corrosion and its prevention: Definition, theories of corrosion (chemical and electrochemical) and their mechanism. Factors affecting the rate of corrosion. Prevention of corrosion.	04 lectures
Unit IV	Macromolecules: Classification, addition and condensation polymers, molecular weight of polymers (M_n,M_w, M_v), glass transition temperature (T_g), structure- property relationship in polymers (Chemical, electrical, optical and mechanical), examples and uses of inorganic polymers, synthesis of some commercially important polymers and their uses (Nylon 66, Nylon 6, PE, PET, PS)	08 lectures
Unit V	Spectroscopy: UV-Visible spectroscopy: Principle, Types of electrons involved in organic molecules, Important terms used in UV-visible spectroscopy with examples (Chromophores, Auxochrome, Red shift, blue shift, Hyperchromic effects and Hypochromic effects), Instrumentation, working and application. Beer-Lambert law -Problems. Infrared spectroscopy: Principle, Molecular vibration and origin of IR spectrum, Types of stretching and bending vibration-CO_2 and H_2O, Group frequencies, Instrumentation, working and application, Problems. Flame Photometry: Principle, Theory, Instrumentation, working, applications-Estimation of sodium by flame photometry and others applications., Atomic Absorption Spectroscopy (AAS): Principle, Theory, Instrumentation, working, applications-Estimation of nickel by AAS and others applications. NMR spectroscopy: Nuclear spin, gyromagnetic ratio, Larmor Frequency, chemical-shifts, anisotropic effects, spin-spin coupling, coupling constants, structure elucidation using ^{1}H-NMR. EPR spectroscopy: Electron spin, g-factor, hyperfine structure, applications in free radical.	09 lectures

Learning Resources:

Text Books:

1. Jain, P. C., & Jain, M. (2015). *Engineering Chemistry* (16th ed.). Dhanpat Rai Publishing Company. ISBN: 9789352160006.
2. Chawla, S. (2011). *A Textbook of Engineering Chemistry*. Dhanpat Rai & Co. ISBN: 9788177001938.

Recommended Books:

1. Puri, B. R., Sharma, L. R., & Pathania, M. S. (2019). *Principles of physical chemistry* (48th ed.). Jalandhar: Vishal Publishing Co.
2. Atkins, P. W. (2014). *Physical chemistry* (10th ed.). London: Oxford University Press; ELBS Edition.
3. Dara, S. S. (2013). *A textbook of engineering chemistry*. New Delhi: S. Chand & Company Ltd.

4. Sivashankar, B. (2008). *Engineering chemistry*. New Delhi: Tata McGraw-Hill Publishing Company Limited.
5. Gowarikar, V. R., Vishwanathan, N. V., & Sreedhar, J. (1986). *Polymer science* (1st ed.). New Delhi: Wiley-Eastern Ltd.
6. Banwell, C. N., & McCash, E. M. (2017). *Fundamentals of molecular spectroscopy* (4th ed.). New Delhi: Tata McGraw-Hill.
7. Palanisamy, P. N., Manikandan, P., Geetha, A., Manjula Rani, K., & Kowshalya, V. N. (2019). *Environmental science* (Revised ed.). New Delhi: Pearson Education.
8. Cadimartiri, L., & Ozin, G. A. (2009). *Concepts of nanochemistry*. Weinheim: Wiley-VCH.
9. Rao, C. N. R., Müller, A., & Cheetham, A. K. (2004). *The chemistry of nanomaterials*. Weinheim: Wiley-VCH Verlag GmbH & Co.

I – Year **II – Semester**

Course Code: CYBS202	Engineering Chemistry Lab	Credits 0-0-2:1

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the concept of theory based on the experiments.
CO2	Acquire the basic skills required for wet lab chemistry
CO3	Apply or correlate the engineering chemistry concepts with the experiments
CO4	Perform the appropriate experiment for studying kinetics hydrolysis and initial rate methods
CO5	To characterise the functional groups and unsaturation in organic compounds by spectroscopy methods

CO-PO/PSO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2					2	2		3		
CO2	3	2	2	2					2	2		3		
CO3	3	2	2	2					2	2		3		
CO4	3	2	2	2					2	2		3		
CO5	3	2	2	2					2	2		3		

List of Experiments

1. To determine the enthalpy (heat) of neutralisation of hydrochloric acid and sodium hydroxide.
2. To determine the enthalpy (heat) of dilution of sulphuric acid from 18 M to 5 M.
3. To determine the enthalpy (heat) of solution of oxalic acid in water.
4. To determine the temporary and permanent hardness of water in ppm equivalent of calcium carbonate hardness.
5. To determine the chlorine content in the given water sample by Mohr's methods (Argentometric method).
6. To determine the dissolved oxygen in the given water sample.
7. To determine the acid value of an oil.
8. To determine the saponification value of an oil.
9. To determine the partition coefficient of acetic acid between n-butanol and water.

10. Preparation of Novolak resin from phenol and formaldehyde
11. Preparation of polystyrene/Nylon 6,6
12. To characterise the functional groups and unsaturation in organic compounds by IR, UV-VIS spectroscopy and NMR

Learning Resources:

Text Book:

1. J. B. Jadav, 2015. Advanced Practical Physical Chemistry, (Krishna Prakashan).

Reference Books:

1. Viswanathan, B., & Raghavan, P. S. (2015). Practical physical chemistry. Viva Books Pvt. Ltd. ISBN: 9788130929699.
2. Khosla, B. D., Garg, V. C., & Gulati, A. (2011). Senior practical physical chemistry (18th ed.). R. Chand & Co. ISBN: 9788180450792.
3. Athawale, V. D., & Mathur, P. (2005). Experimental physical chemistry. New Age International. ISBN: 9788122413366.
4. Viswanathan, B. (2005). Practical physical chemistry. Viva Books Pvt. Ltd. ISBN: 9788130900616.

I – Year **II – Semester**

Course Code: MABS201	**Mathematics – II**	**Credit: 3-0-0:3**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the concept of Linear differential equation of higher order with constant and variable coefficients.
CO2	Understand the concept of Fourier Series.
CO3	Understand the concept of Laplace, transform in solving differential equations.
CO4	Understand the concept of applications of Fourier transforms in boundary value problems.
CO5	Understand the concept of Introduction to Z-transform and its convergence.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	1							3		
CO2	3	2	1	1	1							3		
CO3	3	2	1	1	1							3		
CO4	3	2	1	1	1							3		
CO5	3	2	1	1	1							3		

Syllabus:

Unit I	Linear differential equation of higher order with constant and variable coefficients, method of variation of parameters, Cauchy Euler's and Legendre's equations, series solution of ordinary differential equations with special emphasis on Legendre's and Bessel's differential equations; application of linear differential equation of second order.	10 lectures
Unit II	Fourier Series: Periodic function, Fourier series of a function with 2π period and arbitrary period, Fourier series of even and odd functions, half	8 lectures

	range Fourier sine and cosine series.	
Unit III	Laplace transform and its properties; existence theorem; Laplace transform of derivatives, inverse Laplace transform; convolution theorem, use of Laplace transform in solving differential equations.	8 lectures
Unit IV	Fourier integral, Fourier transform, Fourier sine and cosine transforms and their elementary properties, applications of Fourier transform in boundary value problems**.**	8 lectures
Unit V	Introduction to Z-transform and its convergence, Properties of Z-transform. Inverse Z-transform by Partial Fraction Method, Power Series Expansion, Convolution theorem.	8 lectures

Learning Resources:

Text Books:

1. Kreyszig, E. (1999). *Advanced engineering mathematics* (8th ed.). John Wiley & Sons.
2. Thomas, G. B., & Finney, R. L. (2019). *Calculus and analytical geometry*. Pearson.
3. Ross, S. L. (1984). *Differential equations* (3rd ed.). John Wiley & Sons.
4. Jain, R. K., & Iyengar, S. R. K. (2016). *Advanced engineering mathematics* (5th ed.). Narosa Publishing House.
5. Grewal, B. S. (1965). *Higher engineering mathematics* (45th ed.). Khanna Publishers.

I – Year **II – Semester**

Course Code: CSES201	**Programming for Problem Solving**	**Credits 2-0-0: 2**

Course Outcomes: After completion of the course student will be able to:

CO1	Develop algorithms and Python programs to solve basic arithmetic and logical problems using appropriate programming constructs.
CO2	Implement decision-making and iterative processes using control structures, functions, and loops in Python to solve various problems.
CO3	Apply object-oriented principles such as classes, objects, and methods to model and solve real-world problems in Python.
CO4	Utilize built-in data structures (lists, tuples, dictionaries, and sets) and file handling techniques to manage and process data efficiently.
CO5	Perform file handling in Python, working with text and binary files, and applying these concepts to real-world scenarios such as data analysis and automation.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1		3							3	2	
CO2	2	2	1		3							3	2	
CO3	2	2	1		3							3	2	
CO4	2	2	1		3							3	2	
CO5	2	2	1		3							3	2	

Syllabus:

Unit I	Introduction to computer systems, programming environments, and programming languages. Basic concepts of algorithms, flowcharts, and	7 lectures

	pseudo-code. Introduction to Python: History, features, structure of Python programs. Installing Python and setting up an IDE. Understanding Python syntax, indentation, variables, data types, and operators. Input and output in Python (input(), print()). Problem-Solving Aspect: Writing basic Python programs for arithmetic operations. Demonstrating simple problems using flowcharts and algorithms.	
Unit II	Operators in Python (arithmetic, relational, logical, assignment, bitwise, and membership operators). Operator precedence and associativity. Decision statements: if, if-else, if-elif-else. Loop control statements: for, while, break, continue, pass. Functions: Defining functions, function parameters (positional, keyword, default, variable-length arguments), return values, recursion. Problem-Solving Aspect: Implementing decision-making and looping programs, such as a simple calculator, grading system, and pattern printing.	7 lectures
Unit III	Built-in Data Structures: Lists: Creation, indexing, slicing, list methods. Tuples: Immutable sequences. Dictionaries: Key-value pairs, dictionary operations. Sets: Unique unordered collections. Introduction to Object-Oriented Programming (OOP): Classes and objects. Constructors (__init__ method). Instance and class variables. Inheritance and polymorphism. Problem-Solving Aspect: Writing programs using lists, dictionaries, and sets. Implementing a simple Student Record System using classes.	8 lectures
Unit IV	Lambda functions and list comprehensions. Exception handling (try, except, finally).n File handling in Python: Working with text and binary files (open(), read(), write()). Handling file operations (append, seek, tell). Exception handling in file operations. Problem-Solving Aspect: Implementing programs for file-based data storage. Writing programs for error handling and automation.	7 lectures
Unit V	Introduction to NumPy and Pandas for data handling. Matplotlib for data visualization. Basics of web scraping using BeautifulSoup. Introduction to APIs and JSON data handling. Automating tasks using Python scripts. Problem-Solving Aspect: Creating simple data analysis projects using Pandas. Visualizing data using Matplotlib. Writing a web scraper to extract data from a website.	7 lectures

Learning Resources:

Textbooks:

1. Sweigart, A. (2019). *Automate the boring stuff with Python* (2nd ed.). No Starch Press.
2. Matthes, E. (2019). *Python crash course* (2nd ed.). No Starch Press.
3. Lutz, M. (2013). *Learning Python* (5th ed.). O'Reilly Media.

Reference Books:

1. Zelle, J. (2016). *Python programming: An introduction to computer science* (3rd ed.). Franklin, Beedle & Associates.
2. McKinney, W. (2017). *Python for data analysis* (2nd ed.). O'Reilly Media.

3. Ramalho, L. (2022). *Fluent Python* (2nd ed.). O'Reilly Media.

Online Resources:

1. Official Python Documentation
2. W3Schools Python Tutorial
3. Coursera: Python for Everybody
4. Udemy: Complete Python Bootcamp

I – Year **II – Semester**

Course code: CSES202	Programming for Problem Solving Lab	Credits 0–0–4: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Develop algorithms and Python programs to solve basic arithmetic and logical problems using appropriate programming constructs.
CO2	Implement decision-making and iterative processes using control structures, functions, and loops in Python to solve various problems.
CO3	Apply object-oriented principles such as classes, objects, and methods to model and solve real-world problems in Python.
CO4	Utilize built-in data structures (lists, tuples, dictionaries, and sets) and file handling techniques to manage and process data efficiently.
CO5	Perform file handling in Python, working with text and binary files, and applying these concepts to real-world scenarios such as data analysis and automation.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1		3							3	2	
CO2	2	2	1		3							3	2	
CO3	2	2	1		3							3	2	
CO4	2	2	1		3							3	2	
CO5	2	2	1		3							3	2	

List of Experiments:

1. Write a Python script that demonstrates the use of variables, keywords, and different data types (numeric, string, list, dictionary, Boolean, tuple, set). Include creation, deletion, and access operations)
2. Write a program (script) for conversion of temperature measured in degree Celsius to Fahrenheit. Use the 4 different ways of printing the results. Create two versions of the program, in which you get the value of the temperature in Celcius: i) manually ii) using command-line parameters.
3. Create a program that asks the user for their age and prints different messages using if, if-else, and nested if-else statements. For example, determine if the user is a minor, adult, or senior.
4. Write a program that prints the first 10 numbers of the Fibonacci sequence using both a for loop and a while loop. Include control statements (break, continue, pass) in different scenarios.
5. Write a script which asks for the details of a student of NERIST such as, name, DoB,

module, year, state, gender, etc. Assign the student to the hostel number calculated as (x%*n +1)*, where x is the sum of date, month and year of the DoB of the student and *n* is the number of hostels. Print the details of the student along with the hostel number using the different ways of printing.

6. Write a program that sums a sequence of integers supplied as command line parameters.[Hint: To get the number of arguments supplied, you can use len(argv).
7. Develop a function that takes variable-length arguments (e.g., using *args or **kwargs) and returns their sum or concatenation. Create test cases to demonstrate its functionality.
8. Define a function called hypotenuse that calculates the length of the hypotenuse of a right triangle when the two sides are given. Use this function in a program to determine the length of the hypotenuse of a triangle. The function should take two arguments and return the hypotenuse.
9. Write a function that takes the time as three integer arguments (for hours, minutes, and seconds), and returns the number of seconds since the last time the clock "struck 12". Use this function to calculate the amount of time in seconds between two times, both of which are within one 12-hour cycle of the clock.
10. Write a recursive function power (base, exponent) that when invoked returns base ^{exponent}
11. Write a Python function swap(i,j,l) which interchanges the ith and jth elements in the list, l.
12. Write a Python program which generates a list of the first n whole numbers with its corresponding factorials. The list will look like [[0,1], [1,1], [2, 2], [3,6], [4, 24]….].
13. A tuple object is immutable. Hence, an item in a tuple cannot be modified. Also, an item cannot be added. However, a workaround is to convert a tuple to a list using the list() function and modify the list and convert back to a tuple using the tuple() function.
14. Write the following Python functions and demonstrate how they can be used in the main module:
    a) appendTuple(T,x) which returns a tuple as a result. The result is tuple, T appended with item x as the last item.
    b) insertTuple(T,i,x) which returns a tuple as a result. The result is tuple, T into which item x is inserted before the ith index.
    c) ModifyTuple(T,i,x) which returns a tuple as a result. The result is tuple, T whose item in the ith index is overwritten by x.
    d) PopTuple(T) which returns a tuple as a result. The first item of the returned tuple is the last item in T and the second item is tuple T from which the last item is remove.
15. Create a vector with values ranging from 10 to 49
16. Use the NumPy module to create a 2D matrix. Perform the following operations: creation, deletion, access, and manipulation (e.g., transpose, reshape). Display the matrix before and after each operation.
17. Write a Python program that calculates the determinant, inverse, rank, and eigenvalues of a given matrix using NumPy. Test the program with a sample 2x2 matrix.
18. Implement a program that uses NumPy to solve a system of linear equations. Provide an example of three equations with three variables and output the solution.
19. Create a Python script that generates a bar graph and a pie chart based on sample data (e.g., sales data). Label the axes and include titles for each plot.
20. Develop a program that generates a histogram of a dataset and a scatter plot showing the relationship between two variables. Use Matplotlib for visualization and provide appropriate titles and labels.
21. Design a program that takes user input for a series of numbers, processes this data to calculate the mean and standard deviation, and then displays the results in a histogram and a line plot. Use NumPy for calculations and Matplotlib for plotting.

22. Create and manipulate DataFrames using Pandas. Perform the following :
    I. Access, filter, and modify data within a DataFrame.
    II. statistical analysis and handle missing data.
    III. Group data and export DataFrames to CSV files.
    IV. Visualize data using Matplotlib.

Learning Resources:

Textbooks:

1. Sweigart, A. (2019). *Automate the boring stuff with Python* (2nd ed.). No Starch Press.
2. Matthes, E. (2019). *Python crash course* (2nd ed.). No Starch Press.
3. Lutz, M. (2013). *Learning Python* (5th ed.). O'Reilly Media.

Reference Books:

1. Zelle, J. (2016). *Python programming: An introduction to computer science* (3rd ed.). Franklin, Beedle & Associates.
2. McKinney, W. (2017). *Python for data analysis* (2nd ed.). O'Reilly Media.
3. Ramalho, L. (2022). *Fluent Python* (2nd ed.). O'Reilly Media.

Online Resources:

1. Official Python Documentation
2. W3Schools Python Tutorial
3. Coursera: Python for Everybody
4. Udemy: Complete Python Bootcamp
5. https://www.udemy.com/course/beginning-c-plus-plus-programming/

I – Year **II – Semester**

Course code: MEES202	Workshop Practice	Credits 0–0–4:2

Course Outcomes: After completion of the course student will be able to:

CO1	Apply safety measures and perform team tasks in workshop activities.
CO2	Use various hand tools and understand their applications.
CO3	Perform various fitting and carpentry operations to produce simple components.
CO4	Perform various welding, casting and machining practice to produce simple components.
CO5	Utilize measuring instruments effectively on the shop floor.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	-	1	-	-	3	2	3	3	1	1	-	1	-
CO2	2	1	2	-	2	1	1	1	2	1	-	2	2	1
CO3	3	2	3	3	2	-	-	-	3	2	-	3	2	1
CO4	3	2	3	3	2	-	2	1	3	2	-	3	2	2
CO5	2	1	2	-	2	1	-	-	1	1	1	2	-	1

List of practices:

Fitting Practice	1. Introduction to safety measures and use of fitting hand tools. 2. Practice on fitting operations like hacksawing, filing, chipping, chiseling, drilling and tapping. 3. Preparation of fitting joints: straight half fitting, Vee joints.	2 Hrs 4 Hrs 8 Hrs
Carpentry Practice	1. Introduction to Carpentry tools and its uses. 2. Carpentry practices on planning, chiseling, marking and sawing. 3. Preparation of carpentry joints such as Butt/ half lap/ rabbet/Mortise and Tenon	2 Hrs 4 Hrs 8 Hrs
Welding and casting practice	1. Introduction to safety measures and use of hand tools in Welding shop. 2. Welding practice in preparation of lap, butt, T joins using arc welding process. 3. Practice of gas welding/ cutting/ casting work. 4. Practice/demonstration on casting of small components.	2 Hrs 6 Hrs 2 Hrs 4 Hrs
Machine shop practice	1. Introduction to various machine tools and accessories. 2. Practice on lathe works: preparation of job works plain turning/ step turning/ chamfering/ knurling/ drilling. 3. Study/demonstration of shaper, milling, grinding etc.	2 Hrs 10 Hrs 2 Hrs

Text Books:

1. Elements of Workshop Technology - Vol. I & II, S.K Hajra Choudhury, A.K.Hajra Choudhury and Nirjhar Roy, Media promoters and Publishers (P) Ltd, 2010.
2. Workshop Technology – Part: 1 & 2, W.A.J. Chapman, CBS Publishers & Distributors Pvt. Ltd.

Reference books:

1. Manufacturing Technology – I, P.Gowri. Hariharan and A. Suresh Babu, Pearson Education, 2008. Mechanical Measurements, T.G.Beckwith and R.D.Marangoni, Education India, 6th Edition, 2007

Online resources:

1. https://www.bspublications.net/downloads/05229cf9b012a3_workshop
2. https://onlinecourses.nptel.ac.in/noc21_me67/
3. http://nptel.ac.in/courses/103103037

I – Year **II – Semester**

Course Code: UHVA201	**Universal Human Values**	**Credits 2-1-0: 3**

Course Outcomes: By the end of the course, students will be able to:

CO1	Develop a deeper awareness of themselves and their environment, including their family, society, and nature.
CO2	Cultivate a greater sense of responsibility in their lives and in addressing problems with sustainable solutions, while keeping human relationships and human nature in mind.

CO3	Strengthen their ability to think critically, analyze situations, and evaluate information more effectively.
CO4	Become more responsive to their role in upholding human values, nurturing healthy relationships, and contributing positively to society.
CO5	Apply the insights and skills they've gained in real-life situations, making a conscious effort to incorporate these learnings into their daily lives and decision-making processes.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						2	3	3	1	1				
CO2						2	3	3	1	1				
CO3						2	3	3	1	1				
CO4						2	3	3	1	1				
CO5						2	3	3	1	1				

Syllabus:

Unit I	Introduction to Value Education: Right understanding, relationship and physical facility (Holistic development and the role of education); Understanding value education; Self-exploration as the process for value education; Continuous happiness and prosperity – the basic human aspirations; Happiness and prosperity – Current scenario; Method to fulfill the basic human aspirations.	6 lectures
Unit II	Harmony in the Human Being: Understanding human being as the co-existence of the self and the body; Distinguishing between the needs of the self and the body; The body as an instrument of the self; Understanding harmony in the self; Harmony of the self with the body; Programme to ensure self-regulation and health.	6 lectures
Unit III	Harmony in the Family and Society: Harmony in the family – the basic unit of human interaction; Trust – the foundational value in relationship; Respect – as the right evaluation; Other feelings, justice in human-to-human relationship; Understanding harmony in the society; Vision for the universal human order.	6 lectures
Unit IV	Harmony in the Nature/Existence: Understanding harmony in the nature; Interconnectedness, self-regulation and mutual fulfilment among the four orders of nature; Realizing existence as co-existence at all levels; The holistic perception of harmony in existence.	4 lectures

Unit V	Implications of the Holistic Understanding – A look at Professional Ethics: Natural acceptance of human values; Definitiveness of (Ethical) human conduct; A basis for humanistic education, humanistic constitution and universal human order; Competence in professional ethics; Holistic technologies, production systems and management models-typical case studies; Strategies for transition towards value-based life and profession.	6 lectures

Learning Resources:

Text Books:

1. Gaur, R. R., Asthana, R., & Bagaria, G. P. (2023). *A foundation course in human values and professional ethics* (3rd ed.). UHV Publications.
2. Naagarazan, R. S. (2006). *A textbook on professional ethics and human values* (1st ed.). New Age International Publishers.
3. Tripathi, A. N. (2009). *Human values*. New Age International Publishers.

Reference Books:

1. Gaur, R. R., Asthana, R., & Bagaria, G. P. (2023). *Teachers' manual for a foundation course in human values and professional ethics* (3rd ed.). UHV Publications.
2. Nagraj, A. (2018). *Jeevan Vidya – Ek Parichaya*. Jeevan Vidya Prakashan.
3. Mazumdar, S. (2013). *Values and ethics in profession* (3rd ed.). Everest Publishing House.

I – Year **II – Semester**

Course Code: CEAU201	**Environmental Science**	**Credits 2–0–0: 0**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the fundamentals of environment and ecology, including ecosystems, their classification, structure, functioning, and balance.
CO2	Analyze natural resources, their classification, utilization, and the principles of sustainable development, including SDGs and associated challenges.
CO3	Identify sources, types, and impacts of environmental pollution on health and ecosystems, including air, water, soil, noise, thermal, and radioactive pollution.
CO4	xamine environmental laws, regulations, management systems, pollution control strategies, and sustainability concepts such as the 3R principle and circular economy.
CO5	Evaluate current environmental issues, their impact, and the role of government, NGOs, and education in environmental protection and awareness

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1	1	3	3	2	1	1	1	3	2	2
CO2	3	2	3	2	2	3	3	2	1	2	2	3	3	2
CO3	3	3	3	2	2	3	3	2	1	2	2	3	3	2
CO4	3	3	3	3	3	3	3	3	2	2	2	3	3	3

CO5	3	2	2	2	2	3	3	2	1	2	2	3	2	2

Syllabus:

Unit I	Environment and Ecology: Introduction, Types of environments, Components of environment, Environmental studies, Need for public awareness, Introduction to ecosystem, Classification of ecosystem, Structure of ecosystems, Functioning of ecosystems, Balance of ecosystems.	5 Lecture
Unit II	Natural Resources and Sustainable Development: Overview of natural resources: Definition of resource; Classification of natural resources- biotic and abiotic, renewable and non-renewable. Water resources: Types of water resources- fresh water and marine resources; Availability and use of water resources; Water scarcity and stress; Conflicts over water. Soil and mineral resources: Important minerals; Mineral exploitation; Environmental problems due to extraction of minerals and use; Soil as a resource and its degradation. Energy resources: Sources of energy and their classification, renewable and non-renewable sources of energy; Conventional energy sources- coal, oil, natural gas, nuclear energy; Non-conventional energy sources- solar, wind, tidal, hydro, wave, ocean thermal, geothermal, biomass, hydrogen and fuel cells. Introduction to sustainable development: Sustainable Development Goals (SDGs)- targets and indicators, challenges and strategies for SDGs.	6 Lecture
Unit III	Environmental Pollution and Health: Definition of pollution; Point sources and non-point sources of pollution. Air pollution: Sources of air pollution; Primary and secondary pollutants; Adverse health impacts of air pollutants; National Ambient Air Quality Standards. Water pollution: Sources of water pollution; River, lake and marine pollution, groundwater pollution; water quality Water quality parameters and standards; adverse health impacts of water pollution on human and aquatic life. Waterborne diseases. Soil pollution and solid waste: Soil pollutants and their sources; Solid and hazardous waste; Impact on human health. Noise pollution: Definition of noise; Unit of measurement of noise pollution; Sources of noise pollution; Noise standards; adverse impacts of noise on human health. Thermal and Radioactive pollution: Sources and impact on human health and ecosystems.	6 Lecture
Unit IV	Environmental Management: Introduction to environmental laws and regulation: Constitutional provisions- Article 48A, Article 51A(g) and other derived environmental rights; Introduction to environmental legislations on the forest, wildlife and pollution control. Environmental management system: ISO 14001. Concept of Circular Economy, Life cycle analysis; Cost-benefit analysis Environmental audit and impact assessment; Environmental risk assessment Pollution control and management; Waste Management- Concept of 3R (Reduce, Recycle and Reuse) and sustainability.	5 Lecture

	One National and one international case study related to the environment and sustainable development.	
Unit V	Current Environmental Issues and Environmental Protection: Population growth, Global warming, Climate change, Urbanization, Acid rain, Ozone layer depletion, Animal husbandry. Impact of industrialization, modern agriculture, housing, mining, and transportation on environment. Environmental Protection: Role of Government, Legal aspects, Initiatives by NGOs, Environmental education, Women's education.	6 Lecture

Text Books:

1. Textbook of Environment & Ecology – D. Dave and S. S. Katewa, Cenage Learning India Pvt. Ltd, Delhi. 2010.
2. Textbook of Environmental Studies – E. Bharucha, Universities Press (India) Pvt. Ltd., Hyderabad. 2010.
3. Textbook of Environmental Studies – R. K. Raghavan Nambiar, Scitech Publication (India) Pvt. Ltd., Chennai. 2015

II – Year **III – Semester**

Course Code: FEPC301	Transport Phenomena in Food Processing	Credits 2-1-0: 3

Course Outcomes: After completion of the course, student will be able to:

CO1	Understand basics of heat and mass transfer in food systems.
CO2	Apply conduction, convection, and radiation principles to food processes.
CO3	Evaluate design and performance of different heat exchangers.
CO4	Analyze fins, unsteady conduction, and use of dimensionless numbers
CO5	Explain mass transfer laws and applications in food and dairy industry.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	2	1	2	1						2	1	
CO2	1	2	3	1	1							2	1	
CO3	3	2	3	1	1						1	2	1	
CO4	3	2	3	1	1						1	2	1	
CO5	2	2	1	1	1					2	1	2	1	

Syllabus:

Unit 1	Overview of transport processes; conservation laws; material and energy balances; industrial relevance.	8 lectures
Unit 2	Fundamentals of conduction, convection, and radiation; Fourier's law and steady-state heat conduction; thermal conductivity of solids, liquids, and gases; convective heat transfer and dimensionless analysis; boiling and condensation heat transfer; radiation heat transfer; heat exchangers and performance analysis; unsteady-state heat conduction; industrial applications in food processing and energy systems; problem-solving and	5 lectures

	case studies.	
Unit 3	Exchangers: General discussion, fouling factors, jacketed kettles, LMTD, parallel and counter flow heat exchangers, shell and tube and plate heat exchangers, heat exchanger design; Efficiency and NTU analysis; Application of different types of heat exchangers in dairy and food industry; Mass transfer	5 lectures
Unit 4	Newton's law of viscosity and fluid properties; velocity profiles in laminar and turbulent flow; flow measurement techniques; Bernoulli's equation and applications; flow past immersed objects; packed and fluidized beds; non-Newtonian fluids; Navier-Stokes equations and applications; momentum transfer in pipes and ducts; industrial applications in food processing and HVAC; problem-solving and case studies	5 lectures
Unit 5	Fick's law of diffusion, steady state diffusion of gases and liquids through solids, equimolal diffusion, isothermal evaporation of water into air, mass transfer coefficient, application in dairy and food industry. application of analogy principles	5 lectures

Learning Resources:

Text Books:

1. Geankoplis, C. J. (2003). Transport Processes and Separation Process Principles. Prentice Hall of India Pvt. Ltd., New Delhi.
2. Heldman, D. R., & Singh, R. P. (2009). Introduction to Food Engineering. Academic Press, USA.
3. Datta, A. K. (2002). Biological and Bioenvironmental Heat and Mass Transfer. CRC Press, Boca Raton.

Reference Books:

1. Welty, J. R., Wicks, C. E., Wilson, R. E., & Rorrer, G. L. (2019). Fundamentals of Momentum, Heat, and Mass Transfer. Wiley, New York.
2. Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2007). Transport Phenomena. John Wiley & Sons.
3. Toledo, R. T. (2007). Fundamentals of Food Process Engineering. Springer, New York.

Online Resources:

1. https://nptel.ac.in/courses/112105125
2. https://ocw.mit.edu/

II – Year **III – Semester**

Course Code: FEPC302	**Food Engineering Operations-I**	**Credits 2-0-0: 2**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand principles and methods of cleaning, sorting, grading and size reduction of food materials.
CO2	Apply theoretical concepts to analyze mixing, sedimentation, centrifugal separation and filtration operations.
CO3	Evaluate process parameters influencing crystallization, distillation, leaching and extraction.
CO4	Develop skills to select suitable equipment for various unit operations in food processing.
CO5	Interpret experimental data to assess efficiency and performance of food engineering operations.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2		2	1		1		2			2	2	2
CO2	2	2		2	1		1		2			2	2	2
CO3	2	2		2	1		1		2			2	2	2
CO4	2	2		2	1		1		2			2	2	2
CO5	2	2		2	3		1		2			2	2	2

Syllabus:

Units	Topics	No. of Lectures
Unit I	Cleaning - Types, aims of cleaning, methods of cleaning- dry, wet and combination methods. Dry cleaning methods: screening, aspiration, magnetic cleaning and abrasive cleaning. Wet cleaning methods: soaking, spray washing, flotation washing and ultrasonic washing. Sorting and Grading - Advantages of sorting and grading, grading factors, methods of sorting and grading.	5 lectures
Unit II	Introduction, Size reduction: Theory of communition, Ritinger's law, Kick's law, Bond's law and their applications in calculation of energy required in grinding, Crushing efficiency, Size reduction equipment used in food industry. Sieving: Separation based on size, Effectiveness of screens, Types of screens, Factors affecting the sieving process, Fineness modules and particle size distribution	5 lectures
Unit III	Mixing: Theoretical aspects of solid mixing. Mixing index, rate of mixing, Theory of liquid mixing, Equipment for liquid and solid mixing. Sedimentation: Theory, Gravitational sedimentation of particles in liquids and gases, Sedimentation equipment.	6 lectures
Unit IV	Centrifugal separation: Basic equation, centrifugal clarification, Equipment. Filtration: Theoretical aspects, Fundamental equation for filtration, Filtration equipment. Crystallization: Rate of crystallization, crystallization equilibrium.	8 lectures
Unit V	Leaching and extraction: Gas – Liquid equilibria, Solid – Liquid equilibria, Extraction-Solid Liquid extraction, Liquid-Liquid extraction, stage equilibrium extraction.	6 lectures

Learning Resources:

Text Books:

1. Ahmed, T. (1997). *Dairy Plant Engineering and Management*. Kitab Mahal.
2. Singh, R. P., & Heldman, D. R. (1993). *Introduction to Food Engineering*. Academic Press.
3. Mangaraj, S., Dash, S. K., Swain, S., & Ali, N. (2016). *Agricultural Process Engineering* (Vol. II). Kalyani Publishers, New Delhi.
4. Sahay, K. M., & Singh, K. K. (1994). *Unit Operations of Agricultural Processing*. Vikas Publishing House Pvt. Ltd., New Delhi.

Reference Books:

1. McCabe, W. L., Smith, J. C., & Harriott. (1999). *Unit Operations of Chemical Engineering*. McGraw Hill.
2. Fellows, P. J. (2008). *Food Processing Technology: Principles and Practices*. Woodhead Publishing.

Online Resources:

1. https://elearning.icar.gov.in/eLearning_ContentDisplayUG.aspx?
2. http://ecoursesonline.iasri.res.in/course/view.php?id=47

II – Year **III – Semester**

Course Code: FEPC303	**Food Engineering Operations-I Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Demonstrate the operation of equipment used for cleaning, sorting, grading, and size reduction of food materials.
CO2	Perform experiments on mixing, sedimentation, centrifugal separation, and filtration to understand their working principles.
CO3	Conduct experiments on crystallization, distillation, leaching, and extraction to study process behaviour and efficiency.
CO4	Analyze experimental data to evaluate equipment performance and process parameters in food engineering operations.
CO5	Develop hands-on skills, teamwork, and safety practices while handling food engineering laboratory equipment.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2		2	1		1		2			2	2	2
CO2	2	2		2	1		1		2			2	2	2
CO3	2	2		2	1		1		2			2	2	2
CO4	2	2		2	1		1		2			2	2	2
CO5	2	2		2	3		1		2			2	2	2

List of Experiments:

1. Study of dry cleaning methods: screening and aspiration of grains
2. Study of magnetic and abrasive cleaning of food grains
3. Study of wet cleaning methods: soaking, spray washing, flotation washing, and ultrasonic

cleaning
4. Study of sorting and grading by size and density using sieves and gravity separator
5. Determination of energy requirement in size reduction using Rittinger's, Kick's and Bond's laws
6. Performance evaluation of a laboratory grinder or hammer mill and calculation of crushing efficiency
7. Study of sieving operation: determination of particle size distribution, screen effectiveness and fineness modulus
8. Study of mixing of solids — determination of mixing index and mixing time
9. Study of liquid mixing using different impellers and determination of power consumption
10. Determination of settling velocity of particles in a liquid (sedimentation study)
11. Performance evaluation of centrifugal separator for solid-liquid separation
12. Study of filtration operation using constant pressure filtration and determination of filtration parameters
13. Study of crystallization of sugar from supersaturated solution and determination of crystallization rate
14. Study of simple distillation process using a binary mixture (e.g., ethanol-water)
15. Study of solid-liquid and liquid-liquid extraction: determination of partition coefficient and extraction efficiency

Learning Resources:

Text Books:

1. Sain, E. M. (2023). *Practical Lab Manual: Engineering Properties of Food and Dairy Products*. Prakhar Goonj Publications.
2. Ahmed, T. (1997). *Dairy Plant Engineering and Management*. Kitab Mahal.

Reference Books

1. Tanwar, S., & Mudgal, V. D. (2008). Dairy Process Engineering (Practical Book). Satish Serial Publications.

Online Resources:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=47

II – Year **III – Semester**

Course Code: FEPC304	Food Chemistry	Credits 3-0-0:3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the chemical structure, properties, and interactions of food components.
CO2	Comprehend the chemical changes in food during processing and storage and apply reaction kinetics.
CO3	Perform laboratory analyses related to food chemistry and communicate results effectively.
CO4	Apply food chemistry principles to solve real-world problems in food product design, processing, and safety.
CO5	Understand food structure chemistry and processing effects on quality and safety.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	2							3		
CO2	2	3	3	2	2	2	2	1				3	1	1
CO3	2	2	3	2				1	2	1		3	1	1
CO4	2	2	3	3	2			1	1	1		3		1
CO5	2	2	2	2	3			2	1	1	3	3	1	1

Syllabus:

Unit I	Chemical Composition of Foods – Structures and Functions: Water in Foods: Structure, water activity, sorption isotherms, moisture migration, glass transition; Carbohydrates: definition, Types (Mono, di, oligo and polysaccharides (reducing, non-reducing sugar, starch, cellulose, pectin); gelatinization, retrogradation, dietary fiber chemistry; glycosides in nature; pectins – structure, functional properties (gelling behaviour of HMP vs. LMP); other non- starch polysaccharides and components of dietary fibre: sources, structure, applications; animal polysaccharides; sugar alcohols.	4 lectures
Unit II	Proteins: Types of protein, Amino acids, protein folding, denaturation, hydrolysis, functional properties (foaming, emulsifying, gelation); Lipids: types of lipids, fatty acid profiles, melting points, odor and taste threshold, crystallization, emulsification, rancidity, saponification, quality indicators of oil and fat degradation; Vitamins & Minerals: Sources, classification, solubility, stability, interaction with other food components.	6 lectures
Unit III	Chemical Reactions in Food Maillard Reaction: Mechanism, stages, desirable vs undesirable outcomes, flavor and color development; Caramelization: Reaction conditions, flavor formation; Enzymatic Browning: Role of PPO and POD, prevention methods; Degradation of vitamins (ascorbic acid oxidation and other), pigment.	8 lectures
Unit IV	Food Colors, Flavors, and Functional Ingredients Pigments: Water soluble and fat soluble pigments – structure, color changes, stability under heat/pH/light; Flavor Chemistry: Volatile compounds, flavor precursors, enzymatic formation, retention during processing; Additives: Antioxidants, emulsifiers, thickeners, fermentation-derived ingredients (exopolysaccharide, nisin, biogenic amines); Sensory Chemistry: Structure-activity relationships of taste compounds (e.g., bitter peptides, umami nucleotides).	6 lectures
Unit V	Food Chemistry Applications: Chemistry of Food Structure & Texture: Gels, foams, emulsions, starch-protein-lipid interactions; Modified Starches, Resistant Starch, Chemistry of emulsion (mayonnaise), Food Processing Impacts: Thermal degradation, harmful chemicals generated in food during processing, effect of processing on antinutrients.	4 lectures

Learning Resources:

Text Books:

1. Damodaran, S., Parkin, K. L., & Fennema, O. R. (Eds.). (2007). Fennema's Food Chemistry. CRC press.
2. Belitz, H. D., Grosch, W., Schieberle, P. (2005). Food Chemistry. Springer.
3. Chopra, H. K., & Panesar, P. S., (2018). Food Chemistry. Narosa Publishers.

Reference Books:

1. Chopra, H. K., & Panesar, P. S., (2018). Food Chemistry. Narosa Publishers.

Online Resources:

1. https://nptel.ac.in/courses/126105006

II – Year **III – Semester**

Course code: FEPC305	**Food Chemistry Lab**	**Credits 0–0–2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Estimate proximate components of foods (moisture, ash, protein, fibre, fat).
CO2	Determine water activity, minerals, and oil quality parameters (acid & iodine value).
CO3	Analyze pigments and bioactive compounds (chlorophyll, anthocyanins, phenolics).
CO4	Evaluate antioxidant activity of food materials using standard methods.
CO5	Apply analytical instruments (e.g., AAS, spectrophotometry) for food composition analysis.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	2		1		1		2			2	2	
CO2	2	2	3		1		1		2			2	2	
CO3	2	2	3		1		1		2			2	2	
CO4	2	2	3		1		1		2			2	2	
CO5	2	2	3		1		1		2			2	2	

List of Experiments:

1. Estimation of moisture content in food materials
2. Determination of water activity in food materials
3. Estimation of ash content in food materials
4. Determination content of different minerals in food materials with the help of AAS
5. Estimation of crude protein content in food materials
6. Estimation of crude fibre content in food materials
7. Estimation of chlorophyll content in leaves
8. Estimation of crude fat content in food materials
9. Determination of acid value of oils
10. Determination of iodine value of oils

11. Determination of total phenolic content in fruits by FCR method
12. Determination of antioxidant activity of food materials using different methods
13. Determination of total anthocyanin content in foods

Learning Resources:

Text Books:

1. Damodaran, S., Parkin, K. L., & Fennema, O. R. (2020). Fennema's Food Chemistry (5th Edition). CRC Press.
2. Belitz, H.-D., Grosch, W., & Schieberle, P. (2021). Food Chemistry (4th Edition). Springer.
3. Owens, J., & Stadelman, W. J. (2015). Laboratory Techniques in Food Chemistry. Springer.

Online Resources:

1. https://openwetware.org/wiki/Food_Chemistry

II – Year **III – Semester**

Course Code: FEPC306	Principles of Food Processing and Preservation	Credits 3-0-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the basic principles of food preservation for different food processing applications.
CO2	Understand the effect of preservation methods on food quality attributes
CO3	Identify the processing parameters required for processing different food materials
CO4	Analyze the functions, mechanisms, and regulatory aspects of food additives, and evaluate their impact on food quality, safety, and functionality.
CO5	Evaluate the novel preservation techniques required to improve the shelf life of food

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3		3	3		2	1				3	2	
CO2	3	2	3	3	2							3	3	
CO3	2	3	2	2	2		2		1			3	2	2
CO4	3	3	3	2	2		1					2	2	2
CO5	3	2	2	2		2	1			1	1	3	3	3

Syllabus:

Unit I	Introduction: status of food processing in India, Importance of food processing and its role in prevention of food spoilage; Food spoilage due to microorganisms, enzymes, chemical and physical factors. Principles of food preservation, classification of food based on its shelf life and composition, sustainability in food processing	5 lectures

Unit II	Physical methods of food preservation: preservation by chilling, freezing, blanching, pasteurization, sterilization, high temperature treatments -HTST treatments, retort/canning, extrusion, baking, roasting, frying, drying and dehydration, irradiation	6 lectures
Unit III	Chemical and biochemical methods of food preservation: antioxidants, emulsifiers, thickeners –chemical functions and regulatory status; Clean Label & Natural Alternatives: Plant extracts, fermentation-derived ingredients, fermentation and enzyme technologies, antimicrobial agents, and biological agents	6 lectures
Unit IV	Preservatives, role and mechanisms, types of preservatives (class I, class II etc) food additives, Additives: Intentional and unintentional food additives, their toxicology and safety evaluation; Naturally occurring food additives; Food color and dyes: Regulatory aspects of dyes, food color (natural and artificial), pigments	6 lectures
Unit V	Minimal processing technologies: hurdle technology concepts, non-thermal methods of food preservation, membrane processing, packaging methods	5 lectures

Learning Resources:

Text Books:

1. Fellows, P.J. (2009). Food Processing Technology: Principles and Practices. Woodhead Publishing, Oxford. 3rd edition.
2. Smith, P.G. (2011). Introduction to Food Process Engineering. Springer publication. 2nd edition.
3. Ramaswamy, H.S. & Marcotte, M. (2005). Food Processing: Principles and Applications.Taylor and Francispubl., 1st edition.
4. Mahindru, S.N. 2008. Food Additives: Characteristics, Detection and Estimation. Aph Publishing Corporation, New Delhi.
5. Baker, C.G.J. (1997).Industrial Drying of Foods. Blackie Academic and Professional
6. Srilakshmi, B. (2003). Food science. New Age International.

Reference Books:

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

Online Resources:

1. https://nptel.ac.in/courses/126105006
2. https://vlab.co.in/ba_labs_all.php?id=11

II – Year **III – Semester**

Course Code: MABS 301	**Mathematics – III**	**Credit: 3 3-0-0:3**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the concept of Introduction to limit, continuity and differentiability of complex function.
CO2	Understand the concept of double and triple integrals.
CO3	Understand the concept of Vector Calculus.
CO4	Understand the concept of Introduction to partial differential equations.
CO5	Understand the concept of probability distribution.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1							3		
CO2	3	2	1	1	1							3		
CO3	3	2	1	1	1							3		
CO4	3	2	1	1	1							3		
CO5	3	2	1	1	1							3		

Syllabus:

Unit I	Introduction to limit, continuity and differentiability of complex function; analytic functions, singularity; Cauchy-Riemann equations, complex integration; Cauchy's integral theorem, Calculus of residues.	10 lectures
Unit II	Multiple integral: double and triple integrals, change of order of integration, change of variables, application of double and triple integrals.	7 lectures
Unit III	Vector Calculus: Gradient of a scalar point function, divergence and curl of a vector field, line and surface integrals; Green's theorem, Gauss's theorem; Stoke's theorem.	8 lectures
Unit IV	Introduction to partial differential equations, formation of PDE and solution of first order PDE by Lagrange's method; solution of 2nd order linear partial differential equations by separation of variables, heat, wave and Laplace's equations; application of Fourier transforms in PDE.	9 lectures
Unit V	Random variables; discrete and continuous random variables, probabilitymass function and probability density function; probability distribution Binomial, Poisson and normal distributions.	8 lectures

Learning Resources:

Text Books:

1. Kreyszig, E. (1999). *Advanced engineering mathematics* (8th ed.). John Wiley & Sons.
2. Bali, N. P., & Goyal, M. (2014). *A text book of engineering mathematics*. Laxmi Publications.
3. Raisinghania, M. D. (2005). *Ordinary and partial differential equations*. S. Chand & Company.
4. Grewal, B. S. (2000). *Higher engineering mathematics*. Khanna Publishers.

II – Year **III – Semester**

Course Code: FEBS301	Biology for Engineers	Credits: 2-1-0:3

Course Outcomes: At the end of the course, the student will be able to

CO1	Concepts of biology, classification of organisms, major inventions and discoveries.
CO2	Understand cell division, genetic mapping and recombination processes.
CO3	Concepts of biomolecules, macromolecules, their structures and functions.
CO4	Understand energy principles, thermodynamics, physiological processes and enzyme kinetics.
CO5	Concepts of microorganisms, their identification and classification.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	1	1						2	3	2
CO2	3	3	2	2	1	1						2	3	2
CO3	3	3	2	1	1	2						2	3	2
CO4	2	2	2	2	2	1						2	3	2
CO5	3	2	3	2	1	1						2	3	2

Syllabus:

Unit I	Introduction: Biology is an important scientific discipline as engineering. Fundamental differences between science and engineering by drawing a comparison between eye and camera, bird flying and aircraft. Major inventions and discoveries in biological sciences. Hierarchy of life forms at phenomenological level. Classification of organisms: Concepts of morphological, biochemical or ecological classifications. Classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure- prokaryotes or eucaryotes. (c) energy and Carbon utilization -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion–aminotelic, uricoteliec, ureotelic (e) Habitat- aquatic or terrestrial (e) Molecular taxonomy- three major kingdoms of life. Model organisms for the study of biology come from different groups.	6 lectures
Unit II	Genetics and Cytology: Mendel's laws: Concepts of inheritance, recessive and dominant characters. Concept of allele, Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis. Single gene disorder, concept of complementation and recombination. Information Transfer: Molecular basis of information transfer. DNA as a genetic material. Concept of genetic code and properties. Gene in terms of complementation and recombination.	6 lectures
Unit III	Biomolecules: monomeric units and polymeric structures of biomolecules. Animal physiology: Cell structure and functions, Foodstuffs, Biological oxidations, Enzymes-the biological catalysts, Animal calorimetry, Temperature regulation, Physiological genetics.	6 lectures
Unit IV	Metabolism: The fundamental principles of energy transactions in	5 lectures

	physical and biological world. Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergonic reactions. Concept of Keq and its relation to standard free energy. Spontaneity. ATP as an energy currency. Photosynthesis and cellular respiration. Glycolysis and Krebs cycle, Enzymes: as a biological catalysis, classification and properties. Mechanism of enzyme action with examples. Enzyme kinetics and kinetic parameters. RNA catalysis.	
Unit V	Microbiology: Concept and ecological aspects of single celled organisms. Concept of species and strains. Identification and classification of microorganisms. Microscopes. Sterilization and media compositions. Growth kinetics.	5 lectures

Text Books:

1. Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R. B. (2014). *Campbell biology*. Pearson.
2. Conn, E., & Stumpf, P. (2009). *Outlines of biochemistry*. John Wiley & Sons.
3. Nelson, D.L. and Cox, M (2009). *Lehninger Principles of Biochemistry (VI Edition)*. Macmillan Learning.
4. Stent, G.S. and Calendar, R. (1978). *Molecular Genetics: An Introductory Narrative (Second edition)*. Freeman and company.
5. Prescott, L., Harley, J. and Klein, D. (2004). *Microbiology (VI edition)*. Brown Publishers.

Reference Books:

1. Odaneth, A. (2023) Biology for Engineers. All India Council for Technical Education (AICTE), New Delhi.

Online Resources:

1. https://download.e-bookshelf.de/download/0000/5849/30/L-G-0000584930-0002361074.pdf
2. http://ndl.ethernet.edu.et/bitstream/123456789/79506/16/%5BS.C._Rastogi%5D_Essentials_of_Animal_Physiology%2C_4t%28BookSee.org%29.pdf
3. https://ibe.org/what-is-biological-engineering/.
4. https://dspace.uzhnu.edu.ua/jspui/bitstream/lib/2985/1/Cytology&Genetics.pdf
5. https://ncert.nic.in/textbook/pdf/lech205.pdf
6. http://eagri.org/eagri50/PPHY261/lec13.pdf
7. https://microbenotes.com/

II – Year **III – Semester**

Course Code: ECES301	Basic Electronics Engineering	Credits 3-0-0: 3

Course Outcomes: At the end of the course, the student will be able to

CO1	Demonstrate an Understand the fundamentals of semiconductors.
CO2	Explain the operation and application of diodes.
CO3	Analyze BJT circuits and the concept of biasing
CO4	Analyze small and large signal models of BJTs

CO5	Analyze the single stage amplifiers

CO-PO/PSO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	2	1	3	2	3	1	3	1	3	2
CO2	3	2	1	2	1	1	1	2	2	1	3	1	3	2
CO3	2	1	1	1	1	1	1	2	2	1	3	1	3	2
CO4	3	2	1	1	1	1	2	2	2	1	3	1	3	2
CO5	3	3	1	3	1	1	3	2	2	1	3	1	3	2

Syllabus:

Unit I	Basic Physics of Semiconductor: Semiconductors and diode: Conduction in solids, Energy band diagram, pure and doped semiconductor, charge carriers in solids, Electron and hole mobility, transport of carriers.	8 lectures
Unit II	Diode: p-n junction diode, diode mechanism & I-V characteristics, Equivalent circuits of diodes, Avalanche and Zener effect, Zener diode. Half wave and Full wave rectifier circuits, clipping and clamping circuits, zener voltage regulator circuit.	8 lectures
Unit III	BJT: N-P-N and P-N-P transistors in active, saturation and cut-off modes. CE, CB and CC configuration. Transistor biasing circuits, and stability, ac dc load line concept.	9 lectures
Unit IV	Transistor Analysis: Low frequency and high frequency models for BJT, h parameters /r-parameter model, high frequency π model. Miller's Theorem.	8 lectures
Unit V	Single stage amplifier: Basic structure, Characterization of BJT Amplifier: CE, CB, CC amplifier.	9 lectures

Text Books:

1. Sedra, A., & Smith, K. (2014). *Microelectronic circuits: Theory and applications* (7th ed.). Oxford University Press.
2. Electronic Devices and Circuit Theory, Robert L. Boylestad, Louis Nashelsky, 11th Edition, 2015, Pearson
3. Mircroelectronics Circuits: Theory and Applications, Sedra and Smith, 7th edition, 2015, Oxford University Press.

Reference Books:

1. Sze, S. M., & Ng, K. K. (2007). *Physics of semiconductor devices* (3rd ed.). Wiley-Interscience.
2. Boylestad, R. L., & Nashelsky, L. (2008). *Electronic devices and circuit theory* (10th ed.). Pearson.

Online resource

1. https://onlinecourses.nptel.ac.in

II – Year **III – Semester**

Course Code: ECES302	Basic Electronics Engineering Lab	Credits 0-0-2: 2

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the characteristics of semiconductor diodes.
CO2	Find the output waveforms of various applications of diodes.
CO3	Learn about Transistor operations, various modes of operation and its biasing.
CO4	Study the AC models of bipolar junction transistor.
CO5	Find the gain and frequency response of an amplifier.

CO-PO/PSO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PS03
CO1	2	3	1	1	2	1	0	0	1	2	1	1	0	2
CO2	2	3	3	2	3	1	1	0	2	2	2	1	1	2
CO3	2	3	2	2	3	1	1	1	2	2	2	1	1	2
CO4	2	3	3	3	1	1	0	2	2	2	2	0	1	2
CO5	2	3	3	3	3	1	1	1	2	2	2	1	1	2

List of Experiments:

2. Sketch the V-I characteristics of a P-N junction diode and find its cut-in voltage, static and dynamic resistances.
3. Sketch the V-I characteristics curve of a zener junction diode and find its cut-in voltage, breakdown voltage, static and dynamic resistances.
4. Rig-up a half-wave rectifier circuit, trace its waveform and find the average DC output voltage.
5. Rig-up a full-wave rectifier circuit, (a) using 2-diodes (b) bridge configuration and trace their waveform and find the average DC output voltage.
6. Rig-up the different type of series clipper circuits and plot their input and output waveforms on CRO/DSO.
7. Rig-up the different type of shunt clipper circuits and plot their input and output waveforms on CRO/DSO.
8. Rig-up and plot waveforms of two-level combination (a) two zener diodes (b) two diodes and reference sources of clipper circuits.
9. To plot the input and output characteristics curves of BJT transistor in CE configuration and find its operating point.
10. To plot the input and output characteristics curves of BJT transistor in CB configuration and find its operating point.
11. Rig up a single stage common emitter fixed bias BJT circuit and set its operating point in the middle of the DC load line.
12. Rig up a potential divider biased capacitive coupled common emitter amplifier and find its voltage gain, with and without emitter bypass capacitor (CE).
13. To plot the frequency response curve of a single stage common emitter amplifier and find its lower and upper cut-off frequencies.

Text Books:

1. Mircroelectronics Circuits: Theory and Applications, Sedra and Smith, 7th edition, 2015, Oxford University Press.
2. Electronic Devices and Circuit Theory, Robert L. Boylestad, Louis Nashelsky, 11th Edition, 2015, Pearson

Reference Books:

10. Physics of Semiconductor Devices, S M Sze and Kwok K. Ng, 4th Edition, 2021,
11. Thomas L. Floyd, "Electronic Devices" 10th Edition, 2021 Pearson Education, Inc.

Online Resources:

1. Electronic Devices and Circuits | Udemy
2. https://onlinecourses.nptel.ac.in/noc21_ee80/preview

II – Year **IV – Semester**

Course Code: FEPC401	Food Engineering Operations-II	Credits 2-0-0:2

Course Outcomes: After completion of the course student will be able to:

CO1	Understand pasteurization, sterilization and kinetics.
CO2	Analyze evaporation and concentration processes.
CO3	Explain drying mechanisms and dryer performance.
CO4	Apply psychrometry and air conditioning concepts.
CO5	Understand mass transfer operations in food processing.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3		3	3	1	2	1				3	2	2
CO2	3	3	3	3								3	1	
CO3	3	3	2	2			2					3	2	3
CO4	3	3	3	2	2	1	1					2	2	2
CO5	3	2	3	2		2	1					3	3	3

Syllabus:

Unit I	Pasteurization and Sterilization - Basic concept, Kinetics of Microbial Death. Energy requirement and rate of operations involved in process time evaluation in batch and continuous sterilization. Thermal processes, methods, and equipment- Thermal processing in hermetically closed containers.	5 lectures
Unit II	Concentration and Evaporation: Concentration of liquid foods in batch and continuous type evaporators; heat and energy balance in single and multiple effect evaporators; falling and rising film evaporators; mechanical and thermal vapour recompression systems.	6 lectures
Unit III	Drying of Foods: various mechanisms of moisture removal in solid and liquid foods during drying; Water activity and isotherm, properties of air-water vapour mixture; psychrometry. Types of Dryers and their performance.	8 lectures

	Air properties, dry and wet bulb temperature, Wet and dry bulb hygrometry, Humidity charts, Methods of humidification and dehumidification, Air conditioning.	
Unit IV	Food freezing: Effect of temperature on food spoilage; slow and rapid, Plank's law and estimation of freezing time of foods; equipment used for freezing water in foods, production of crystalline foods, e.g. sucrose and lactose. Freeze drying and freeze concentration: Sublimation of water; Heat and mass transfer in freeze drying; Freeze drying, Freeze concentration: basic principles and equipment.	6 lectures
Unit V	Gas Absorption: Equilibrium relationship, mass transfer theories, concept of driving force, individual and overall mass transfer coefficients. Adsorption: Gas solid isotherms for one and more sorbates, Chemisorption, Liquid and solid isotherm, Adsorption unit - Fixed bed equations, Isothermal operation, Non isothermal operation, pressure swing adsorption, Extraction, supercritical extraction. Leaching, Distillation, steam distillation, batch distillation, vacuum distillation.	3 lectures

Learning Resources:

Text Books:

1. Heldman, D. R., & Singh, R. P. (2019). *Food Process Engineering* (4th Edition). Springer.
2. Rao, M. A., Rizvi, S. S. H., & Datta, A. K. (2017). *Engineering Properties of Foods* (3rd Edition). CRC Press.
3. Perry, R. H., Green, D. W., & Maloney, J. O. (2007). *Perry's Chemical Engineers' Handbook.* McGraw-Hill.

Reference Books:

1. Buhler, A., & Masters, K. (2013). Food Process Engineering and Technology. CRC Press.
2. Heldman, D. R. (2015). Principles of Food Processing. Springer.
3. Singh, R. P., & Heldman, D. R. (2020). Introduction to Food Engineering. Academic Press.

Online Resources:

1. https://elearning.fao.org/
2. https://ocw.mit.edu/

II – Year **IV – Semester**

Course Code: FEPC402	**Food Engineering Operations-II Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Evaluate pasteurization and cream separation processes.
CO2	Analyze evaporation techniques and heat/mass balance.

CO3	Compare drying methods and effects of process parameters.
CO4	Assess extraction and distillation performance.
CO5	Examine blanching for enzyme inactivation and process efficiency.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3									2	3		
CO2	2	3	2								3	3		
CO3	2	3	3								2	3	2	
CO4	2	3	3	3	2					2	3	3		3
CO5	2	3			3						3	3		2

List of Experiment:

1. Performance evaluation of HTST pasteurization of milk.
2. Performance evaluation of evaporation techniques by steam jacketed open and vacuum kettle.
3. Compression of tray dryer and vacuum tray drying of food and vegetable
4. Effect of processing parameter on Spray drying of milk.
5. Effect of processing parameter on Rotary vacuum evaporation.
6. Performance evaluation of cream separator.
7. Study open pan & vacuum evaporator – heat/mass balance.
8. Single-effect evaporator – overall heat transfer & balance.
9. Multiple-effect evaporator – steam economy & balance.
10. Solvent extraction – effect of particle size & time.
11. Simple distillation – distillation rate & VLE.
12. Blanching – enzyme inactivation & process efficacy.

Learning Resources:

Text Books:

1. Rao, M. A., Rizvi, S. S. H., & Datta, A. K. (2017). *Engineering Properties of Foods* (3rd Edition). CRC Press.
2. Perry, R. H., Green, D. W., & Maloney, J. O. (2007). *Perry's Chemical Engineers' Handbook.* McGraw-Hill.

Reference Books:

1. Heldman, D. R. (2015). Principles of Food Processing. Springer.
2. Singh, R. P., & Heldman, D. R. (2020). Introduction to Food Engineering. Academic Press.

Online Resources:

1. https://nptel.ac.in/courses/126105011

II – Year **IV – Semester**

Course Code: FEPC403	Engineering Properties of Food Materials	Credits 2-0-0: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Understand structure, composition, and properties of foods.
CO2	Determine physical properties of foods and powders.
CO3	Analyze moisture relations and food stability.
CO4	Evaluate mechanical, rheological, thermal, and frictional properties.
CO5	Apply experimental methods for characterization in food processing.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1								3	
CO2	3	2	1	1	1								3	
CO3	3	2	1	1	1								3	
CO4	3	2	1	1	1								3	
CO5	3	2	1	1	1								3	

Syllabus:

Unit I	Introduction to engineering properties of food and biomaterials, structure and chemical composition of foods, physical properties (size, shape, surface area, volume, density, sphericity, porosity, specific gravity). Properties of powdery materials.	7 lectures
Unit II	Moisture in food and biological materials, water activity, food stability, sorption and desorption isotherms.	6 lectures
Unit III	Mechanical properties (strain and stress), rheological properties (viscosity, elasticity, visco-elasticity), textural properties.	6 lectures
Unit IV	Thermal properties (specific heat, heat capacity, thermal conductivity, thermal diffusivity, thermal radiation properties)	5 lectures
Unit V	Frictional properties of food materials (angle of repose, coefficient of friction, rolling resistance), aero and hydrodynamic characteristics, optical properties, electrical and dielectric properties	5 lectures

Learning Resources:

Text Books:

1. Sahay, K. M., & Singh, K. K. (2003). *Unit operations of agricultural processing* (3rd ed.). Vikas Publishing House.
2. Chakraborty, A. (2000). *Post-harvest technology of cereals, pulses & oilseeds* (3rd ed.). Oxford & IBH Publishing Co. Pvt. Ltd.
3. Michael, A. M., & Ojha, T. P. (2006). *Principles of agricultural engineering – Vol. I* (3rd ed.). Jain Brothers.

Reference Books:

1. Rao, M. A., Rizvi, S. S. H., Datta, A. K., & Ahmed, J. (2016). *Engineering properties of foods* (4th ed.). CRC Press.
2. Singhal, O. P., & D.V.K. (2003). *Engineering properties of biological material*. Samuel Saroj Prakashan

Online Resources:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=25
2. https://agrimoon.com/wp-content/uploads/Engineering-Properties-of-Biological-Materials-and-Food-Quality.pdf

II – Year **IV – Semester**

Course code: FEPC404	Engineering Properties of Food Materials Lab	Credits 0-0-2: 1

Course Outcomes: After completion of the course student will be able to:

CO1	Understand physical properties of foods.
CO2	Apply methods to measure size, density, moisture, and color.
CO3	Analyze rheological and textural properties.
CO4	Evaluate functional properties of foods.
CO5	Develop practical skills in food engineering experiments.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	2	1	1							2	3	2
CO2	2	1	1	2	2							2	3	2
CO3	2	2	2	1								2	3	
CO4	2	1	1	1										
CO5	3	1	2	1	1							2		2

List of Experiments:

1. Determination of the physical properties size, shape, sphericity of food products.
2. Determination of average particle size and distribution of powdered material.
3. Determination of moisture content and water activity of food products.
4. Determination of bulk density, true density and porosity of food grains.
5. Determination of color of various food grains, fruits, vegetables, spices and processed foods by hunter color lab.
6. Determination of density and specific gravity of various liquid foods.
7. Determination of rheological properties of food material by viscometer.
8. Determination of frictional properties (angle of repose and coefficient of friction) of food grains.
9. Measurement of firmness of fruits and vegetables by penetrometer
10. Determination of electrical properties of food materials.

Learning Resources:

Text Books:

1. Sain, M. (2023). *Practical lab manual: Engineering properties of food and dairy*. Prakhar Goonj Publications.
2. Li, M. (1998). *Engineering properties of foods and other biological materials*. Woodland Publishers

Reference Books:

1. DG Rao. (2012) Fundamentals of Food Engineering

Online Resources:

1. https://rpaulsingh.com/learning/virtual/virtual.html
2. https://elearning.icar.gov.in/DisplayPG_ECoursesContent.aspx?CourseCode=adThnB/feoC!KmGINib!tg==

II – Year **IV – Semester**

Course Code: FEPC405	Instrumentation and process control in food industry	Credits 2-1-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the working principle of sensors for measurement of common food process parameters like pressure, temperature, strain, pH, etc
CO2	Explain types, selection, and applications of sensors/transducers in food processing.
CO3	Quantify the performance characteristics of measuring systems.
CO4	Identify and apply stability analysis of measurement systems.
CO5	Evaluate controllers and their applications in food industry operations.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	2							3		
CO2	2	3	3	2	2	2	2	1				3	1	1
CO3	2	2	3	2				1	2	1		3	1	1
CO4	2	2	3	3	2			1	1	1		3		1
CO5	2	2	2	2	3			2	1	1	3	3	1	1

Syllabus:

Unit I	Concept of instrumentation systems, functional elements, accuracy of Measurements Precision, accuracy, sensitivity, calibration, readability, repeatability, magnification; errors in measurements. Elements of measurement systems, measuring and controlling devices.	6 lectures
Unit II	Transducers: Role of sensors and transducers in food processing, classification of transducers, self-generating transducers, variable parameter type, digital transducers, selection of transducers, actuating and controlling devices.	6 lectures
Unit III	Measurement of pressure, temperature, liquid level, flow, humidity, speed, force and torque. Measurements in food processing: Viscosity, pH, conductivity, spectrophotometry, chromatography -mass spectrometry, texture, particle size, turbidity and colour measurement, thermal properties.	4 lectures
Unit IV	Performance characteristics of instrumentation systems- static and dynamic characteristics, first and second order systems and their responses. Models of physical systems, differential equations, transfer functions in Laplace transform and z transform, block diagrams of open and closed loop systems, stability criterions and stability analysis of systems.	8 lectures
Unit V	Controllers (ON/OFF and PID) and indicators in food industries: temperature control in drying and dehydration, flow ratio controller in food pickling, atmosphere control in food preservation, Food sorting and grading control, discrete controllers, adaptive and intelligent controllers, digital controller and PLC.	4 lectures

Learning Resources:

Textbooks:

1. Schlesser, J. (2007). Measurement and Control in Food Processing, M. Bhuyan. CRC Press, Taylor & Francis Group, Boca Raton, FL, USA (2007). 340pp., Hardback, Price: $159.95, ISBN: 978-0-8493-7244-5.
2. Ogata, K. (2020). Modern control engineering.
3. Kuo B. C. (2002). Automatic Control Systems. Prentice Hall, 7th edition.

Reference Books:

1. Nakra B. C. and Chaudhry K. K. (2016). Instrumentation Measurement and Analysis, Tata McGraw Hill 4th edition 2016.

Online Resources:

1. https://nptel.ac.in/courses/103105134

II – Year **IV – Semester**

Course Code: FEPC406	Food Biochemistry and Nutrition	Credits 2-0-0: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the structure, function, and metabolism of key biomolecules.
CO2	Comprehend the biochemical basis of human nutrition and metabolism.
CO3	Analyze physiological and biochemical changes in plant and animal tissues during storage.
CO4	Describe the functions, metabolism, and health impacts of vitamins, minerals, and bioactive compounds.
CO5	Apply principles of human nutrition to assess dietary needs and address nutrition-related disorders.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1								3	
CO2	3	2	1	1	1								3	
CO3	3	2	1	1	1								3	
CO4	3	2	1	1	1								3	
CO5	3	2	1	1	1								3	

Syllabus:

Unit I	Biomolecules—Structure and Function Water: Structure, pH, buffering systems, Carbohydrates: mono-, di-, and polysaccharides, glycosidic bonds; Proteins: amino acids, primary to quaternary structures, enzymes; Lipids: fatty acids, triglycerides, phospholipids, sterols; Nucleic acids: DNA, RNA, basic role in protein synthesis.	7 lectures

Unit II	Enzymes and Metabolic Pathways Enzymes: cofactors, coenzymes, Michaelis-Menten kinetics, inhibition; Overview of metabolism: catabolism vs. anabolism; Carbohydrate metabolism: glycolysis, gluconeogenesis, TCA cycle; ATP production and energy balance; Lipid metabolism: beta-oxidation, ketogenesis; Protein metabolism: deamination, transamination, urea cycle.	6 lectures
Unit III	Physiological and Biochemical changes in plant and animal tissues during storage.	6 lectures
Unit IV	Vitamins, Minerals, and Bioactive Compounds Fat-soluble vitamins: A, D, E, K – structure, functions, deficiencies; Water-soluble vitamins: B-complex, C – coenzyme functions; Major and trace minerals (e.g., Ca, Fe, Zn, Mg); Nutrient bioavailability, absorption, and transport; Phytochemicals and functional food components.	5 lectures
Unit V	Human Nutrition and Health Applications Digestion and absorption of macronutrients; Protein quality parameters (PER, PDCAAS, BV) etc., Energy balance, BMR, Nutritional assessment and dietary recommendations (RDA); Role of fiber, probiotics, and prebiotics; Nutrition-related disorders: obesity, diabetes, cardiovascular disease; Nutrigenomics.	5 lectures

Learning Resources:

Text Books:

1. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2005). *Lehninger Principles of Biochemistry.* Macmillan.
2. Voet, D., & Voet, J. G. (2010). *Biochemistry.* John Wiley & Sons.
3. Mann, J., Truswell, A. S., & Hodson, L. (Eds.). (2023). *Essentials of Human Nutrition (6e).* Oxford University Press.

Reference Books:

1. Eskin, N. M., & Shahidi, F. (2012). *Biochemistry of Foods.* Academic Press.

Online Resources:

1. https://nptel.ac.in/courses/102105085
2. https://ocw.mit.edu/
3. https://nptel.ac.in/courses/110107164

II – Year **IV – Semester**

Course code: FEPC407	**Food Biochemistry and Nutrition Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Prepare standard solutions and calibrate analytical instruments.
CO2	Determine pH, pKa, pKb, and isoelectric point of biomolecules
CO3	Estimate sugars, starch, proteins, and ascorbic acid in food samples
CO4	Analyze bioactive compounds and absorption maxima using spectrophotometer
CO5	Calculate energy/calorific value of food materials.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	2	1	1							2	3	2
CO2	2	1	1	2	2							2	3	2
CO3	2	2	2	1								2	3	
CO4	2	1	1	1										
CO5	3	1	2	1	1							2		2

List of Experiments:

1. Preparation of different solutions of different concentration.
2. Calibration of pH meter and determination of pH values of various solutions
3. Determination of pKa, pKb and Isoelectric point by titration method
4. Estimation of content of reducing sugars in fruit juices by Lane-Eynon method
5. Estimation of ascorbic acid content in fruits
6. Estimation of protein content by Lowry's method
7. Determination of absorbance maximum values of colored solutions using spectrophotometer
8. Estimation of lycopene content in tomatoes
9. Calculation of calories/energy in food samples
10. Estimation reducing sugars content in food materials by DNS method
11. Estimation starch content in food materials by enthrone method.

Learning Resources:

Text Books:

1. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2005). *Lehninger Principles of Biochemistry.* Macmillan.
2. Voet, D., & Voet, J. G. (2010). *Biochemistry.* John Wiley & Sons.
3. Plummer, D. T. (1998). *An Introduction to Practical Biochemistry.* Tata McGraw Hill.
4. Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology.* Cambridge University Press.

Reference Books:

1. Eskin, N. M., & Shahidi, F. (2012). *Biochemistry of Foods.* Academic Press.
2. Ranganna, S. (2001). *Handbook of Analysis and Quality Control for Fruit and Vegetable Products.* Tata McGraw Hill.
3. Sadasivam, S., & Manickam, A. (2008). *Biochemical Methods.* New Age International Publishers.
4. AOAC (2019). *Official Methods of Analysis of AOAC International.* AOAC International.

Online Resources:

14. https://openwetware.org/wiki/Biochemistry
15. https://elearning.fao.org/
16. https://www.cdc.gov/nutrition/

II – Year **IV – Semester**

Course Code: FEPC408	Processing Technology of Fruits and Vegetables	Credits 2-0-0: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Examine the pre- and post-harvest physiology of fruit and vegetables and assess its quality.
CO2	Identify the post-harvest handling methods for improving the shelf life of fruits and vegetables.
CO3	Understand the effect of storage and processing conditions on the quality of fruit and vegetable products.
CO4	State the standards and specifications related to fruit and vegetable-based products.
CO5	Demonstrate skills for the preparation of fruits and vegetable-based products following industrial practices.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	3	3	1	2	1					3	2	1
CO2	3	3	3	3								3	1	
CO3	3	3	2	2			2					2	2	2
CO4	2	2	3	3	2	1	2					2	2	2
CO5	3	2	3	2			2	1				2	3	

Syllabus:

Unit I	Introduction and Overview: Current Status of production and processing of fruits and Vegetables. Chemical composition; pre-harvest changes, maturity standards.	6 lectures
Unit II	Post-harvest handling of fresh fruits and vegetables: primary processing-selection of fruits and vegetables for processing, sorting, grading, washing, storage. Post-harvest physiology, ripening; physical and chemical treatments for shelf-life enhancement, handling and storage conditions. Factors affecting storage atmosphere on quality, physiological disorders, and technology of cold storage, CA and MA storage.	7 lectures
Unit III	Minimally processing: hurdle technology approach for processing fruits and vegetables, physiology of fresh-cut fruits and vegetables, factors affecting shelf life and the quality of minimally processed fruits and vegetables. Role of enzymes in fruit and vegetable processing, browning reactions in fruits and vegetables, inhibition and control of browning reactions, and blanching.	4 lectures
Unit IV	Processing methods and equipment: fruit juice extraction, clarification, enzymes in fruit juice clarification, chilling, freezing, canning, drying, ionizing radiation, aseptic processing and packaging	7 lectures
Unit V	Fruits and vegetable products: preparation of juice, syrups, squashes, cordials, and nectars; jam, jelly, marmalade, fruit preserves concentrations and drying of juice, packaging, storage, concentrations and powders; fortified soft drinks, tomato products and quality control, fermented fruits and vegetables. Preparation of various types of pickles-theory and practice; preparation of sauces and chutneys; problems relating to the shelf life of pickles and chutneys; quality control. Food	4 lectures

	additives: Sources and uses of food additives. FSSAI standards for fruits and vegetable-based products.	

Learning Resources:

Text Books:

1. Ramaswamy, H. S., Somogyi, L. P., & Hui, Y. H. (Eds.). (1996). Processing Fruits, Science
2. and Technology: Biology, Principles, and Applications. Technomic.
3. Wills, R. B. H., McGlasson, W. B., Graham, D., Lee, T. H., & Hall, E. G. (1989). Postharvest. An Introduction to the Physiology and Handling of Fruit and Vegetables, 3, 174.
4. Manual of Methods of Analysis of Foods – Fruit and Vegetable Products. 2016. FSSAI, New Delhi.

Reference Books:

1. Ranganna, S. (1986). Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill Education.
2. Barrett, D. M., Somogyi, L., & Ramaswamy, H. S. (2004). Processing fruits: science and technology. CRC press.

Online Resources:

1. ICAR e-Courses – Post-harvest Management and Value Addition of Fruits & Vegetables
2. NPTEL Online Course – Food Preservation: Principles and Practices

II – Year **IV – Semester**

Course Code: FEPC409	Processing Technology of Fruits and Vegetables Lab	Credits 0-0-2: 1

Course Outcomes: After completion of the course student will be able to

CO1	Execute fundamental food preservation and processing techniques.
CO2	Formulate standardized food products as per FSSAI specifications.
CO3	Apply analytical methods to assess raw material and final product quality.
CO4	Operate key food processing equipment to control process parameters.
CO5	Analyze the impact of processing methods on final product quality.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2		1		1		2			2	2	
CO2	2	2	3		1		1		2			2	2	
CO3	2	2	3		1		1		2			2	2	
CO4	2	2	3		1		1		2			2	2	
CO5	2	2	3		1		1		2			2	2	

List of Practical:

1. Blanching of vegetable and assessment of its adequacy

2. Osmotic dehydration of fruits and vegetables
3. Preparation of orange squash as per FSSAI specifications
4. Preparation of tomato ketchup as per FSSAI specifications
5. Preparation of fruit jam as per FSSAI specifications
6. Preparation of fruit/vegetable-based pickles
7. Preparation of orange marmalade
8. Testing of preservatives in fruit based products (benzoic acid+sulphur dioxide)
9. Measurement of maturity indices of fruits and vegetables
10. Determination of rehydration ratio of dried fruits and vegetables
11. Determination of vacuum pressure, drained weight of canned product
12. Estimation of pectin quality and pectin content of fruit.

Learning Resources:

Text Books:

1. Ranganna, S. (2019). Handbook of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill.
2. Fellows, P.J. (2022). Food Processing Technology: Principles and Practice. Woodhead Publishing.
3. Potter, N.N. & Hotchkiss, J.H. (2018). Food Science. Springer.
4. Singh, R.P. & Heldman, D.R. (2021). Introduction to Food Engineering. Academic Press.
5. Khurdiya, D.S. & Anuradha, P. (2015). Fruit and Vegetable Preservation: Principles and Practices. ICAR Publication.

Reference Books:

1. Desrosier, N.W. & Desrosier, J.N. (2018). The Technology of Food Preservation. Springer.
2. Wiley, R.C. (2016). Minimally Processed Refrigerated Fruits and Vegetables. Springer.
3. Mizrahi, S. & Saguy, I. (2020). Engineering for Food Safety and Quality. CRC Press.
4. Manay, S. & Shadaksharaswamy, M. (2020). Foods: Facts and Principles. New Age International.

Online Resources:

1. e-Krishi Shiksha (ICAR eLearning Portal)
2. NPTEL online courses on *Food Processing, Food Preservation and Food Engineering* (NPTEL)
3. FAO and WHO video resources on food quality testing.

II – Year **IV – Semester**

Course Code: HSSM401	**Entrepreneurship and Startups**	**Credits 3-0-0:3**

Course Outcomes: At the end of the course, the student will be able to

CO1	Evaluate entrepreneurial values and attitudes and differentiate between entrepreneurial types

CO2	Develop skills for launching new business ventures
CO3	Apply various project appraisal techniques and evaluate viability of entrepreneurial projects
CO4	Conduct comprehensive financial analyses of business ventures
CO5	Analyze the role of startups in Indian economy and assess the socio-economic and political factors affecting different schemes for self-emplpoyment.

CO-PO/PSO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						2	1	1	2	3	3			
CO2						2	1	1	2	3	3			
CO3						2	1	1	2	3	3			
CO4						2	1	1	2	3	3			
CO5						2	1	1	2	3	3			

Syllabus:

UNITS	CONTENTS	No. of Lectures
Unit I	Definition, Importance of entrepreneurship. Entrepreneurial values and attitudes. Innovativeness, risk-taking and analytical ability. Entrepreneurial motivation, Characteristics of entrepreneurs. Types of entrepreneurs. Rural entrepreneurship and women entrepreneurship.	8 Lectures
Unit II	Launching a new Business Venture. Identification of investment opportunities, Project formulation, Project screening, Market analysis and demand forecasting. Technical, Environmental and Managerial analysis of project proposals.	9 Lectures
Unit III	Project Appraisal; Means of financing and working results estimation, Ratio Analysis, Depreciation of Assets, Break-even Analysis, Qualitative Methods for Project Evaluation, Social Cost Benefit Analysis.	8 Lectures
Unit IV	Financial Analysis; Pay-back period, Net Present Value Estimation, IRR calculation, Cost-benefit analysis.	9 Lectures
Unit V	Definition of Start-up; Features of Start-up, Start-up of India Programmes and its importance in the Indian economy, Essentials of start-up schemes. SWOT Analysis, External environment of business venture, Socio-economic, political environment for undertaking to start self-employment schemes, Preservation of environment and improvement in the quality of life in the rural economy.	8 Lectures

Textbooks:

1. Charantimath, P. M. (2021). *Entrepreneurship Development and Small Business Management*. Pearson Education India.
2. Khanka, S. S. (2020). *Entrepreneurship Development in India*. S. Chand Publishing.
3. Jain, P. K. (2018). *Project Appraisal and Financing*. Oxford University Press.

Reference Books:

1. Chandra, P. (1996). *Project Preparation, Evaluation & Implementation*. Tata McGraw-Hill, New Delhi.
2. Rajgopal. (1991). *Agri-Business and Entrepreneurship*. Indian Books & Periodicals, New Delhi.
3. Anderson. (1991). *Entrepreneurship: Starting a New Business*. Allied Publishers Ltd, New Delhi.
4. Colombo Plan Staff College for Technician Education. (1998). *Entrepreneurship Development*. Tata McGraw-Hill, New Delhi.

Web Resources:

1. https://www.ediindia.org/
2. https://niesbud.nic.in/

II – Year **IV – Semester**

Course Code: HSAU 401	Indian Constitution	Credits 2-0-0:0

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the historical context and basic components of the Indian constitution.
CO2	Analyse the structure and functions of the Union government
CO3	Examine and understand the functioning of the state government and its functionaries
CO4	Evaluate the structure and responsibilities of local administrative bodies
CO5	Understand the process of conducting elections in India and the role of the constitutional bodies.

CO-PO/PSO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1						2	1	3					2	1
CO2						2	1	3					2	1
CO3						2	1	3					2	1
CO4						2	1	3					2	1
CO5						2	1	3					2	1

Syllabus:

UNITS	CONTENTS	No. of Lectures
Unit I	The Constitution: Introduction; The History of the Making of the Indian Constitution; Preamble and the Basic Structure, and its interpretation; Fundamental Rights and Duties and their interpretation; State Policy Principles.	5 Lectures
Unit II	Union Government; Structure of the Indian Union; President – Role and Power; Prime Minister and Council of Ministers; Lok Sabha and Rajya Sabha.	6 Lectures
Unit III	State Government; Governor – Role and Power; Chief Minister and Council of Ministers; State Secretariat.	6 Lectures
Unit IV	Local Administration; District Administration; Municipal Corporation; Zila Panchayat.	6 Lectures

Unit V	Election Commission; Role and Functioning; Chief Election Commissioner; State Election Commission.	5 Lectures

Textbooks:

1. Basu, D. D. (2022). *Introduction to Constitution of India*. Lexis Nexis.
2. Laxmikanth, M. (2023). *Indian Polity*. McGraw Hill Education.
3. Jain, M. P. (2022). *Outlines of Indian Legal and Constitutional History*. Lexis Nexis.

Reference Books:

1. Bhargava, R. (2008). *Ethics and Politics of the Indian Constitution*. Oxford University Press, New Delhi.
2. Fadia, B. L. (2017). *The Constitution of India* (New ed.). Sahitya Bhawan.

Online Resources

1. https://www.constitution.org/cons/india/const.html
2. http://www.legislative.gov.in/constitution-of-india
3. https://www.sci.gov.in/constitution
4. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/

III – Year **V – Semester**

Course Code: FEPC501	**Food Packaging and Storage Engineering**	**Credits 2-0-0: 2**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the basic concepts, functions, and current trends in food packaging at national and international levels.
CO2	Explain the properties, applications, and limitations of different packaging materials including metals, glass, paper, plastics, and biodegradable options.
CO3	Analyze various packaging systems and technologies such as MAP, CAP, aseptic, active, intelligent, and antimicrobial packaging.
CO4	Evaluate packaging machinery, material testing methods, shelf-life studies, and safety aspects related to corrosion and toxicity.
CO5	Apply knowledge of packaging laws, regulations, sustainability issues, and product-specific packaging requirements for diverse food categories.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2		2	1		2			1		3	3	
CO2	3	2	1				2		1			3		2
CO3	2	3	3		1					2	2	2	3	
CO4	3	2			1		1				2	3	2	1
CO5	3	1	3									3		3

Syllabus:

Unit I	Introduction: Basic concept of packaging, functions of a food package, package development factors, food package requirement, status and trends	5 lectures

	in food packaging in India and abroad.	
Unit II	Packaging materials: Metal containers made up of tin-plate, tin free steel, aluminium etc., Protective lacquers and coatings for metal containers. Glass containers and closures. Paper and paper-based packaging materials. Plastic polymers and plastic based flexible and rigid packaging materials.	6 lectures
Unit III	Packaging systems: Gas, vacuum and aseptic packaging, MAP, CAP, advances in food packaging: Smart packaging, intelligent packaging, Active Packaging and Antimicrobial packaging, retort pouches, biodegradable and edibles packaging materials and films. Packaging machinery: Machineries for Bottling, canning, capping, labelling, form fill sealing, strapping, cartooning and other advanced machineries. Evaluation of packaging material: Destructive and non-destructive test, testing of rigid, semi rigid and flexible packaging material, shelf-life study. Corrosion and toxicity of packaging material.	6 lectures
Unit IV	Packaging laws and regulations: FSSAI Regulations on packaging, labelling and display. BIS specification on packaging materials. International laws and standards on packaging. Recyclability and sustainability of packaging materials Food product packaging requirements: Application of package for different food products like fruits and vegetables, meat, fish, poultry, dairy products, edible oils and spice products, bakery products, confectioneries, Instant foods, extruded foods, snack foods, alcoholic and non-alcoholic carbonated beverages, compatibility and estimation of shelf life.	5 lectures
Unit V	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.	6 lectures

Learning Resources:

Text Books:

1. Robertson, G. L. (2005). Food packaging: principles and practice. CRC press.

Reference Books:

1. Han, J. H. (Ed.). (2013). Innovations in Food Packaging. Academic Press.
2. Coles, R., McDowell, D., & Kirwan, M. J. (Eds.). (2003). Food packaging technology (Vol. 5).CRC press.
3. Ahvenainen, R. (Ed.). (2003). Novel food packaging techniques. Elsevier.
4. Ranganna, S. (2000). Handbook of canning and aseptic packaging. Tata McGraw-Hill Publishing Company.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc24_ge65/preview

III – Year **V – Semester**

Course Code: FEPC502	Food Packaging and Storage Engineering Lab	Credits 0-0-2: 1

Course Outcomes: After completion of the course student will be able to:

CO1	Determine the physical and mechanical properties of paper, paperboard, plastics, metals, and glass used in food packaging.
CO2	Evaluate the strength, permeability, coating continuity, and resistance characteristics of packaging materials.
CO3	Perform chemical and migration tests to assess the safety and quality of packaging materials.
CO4	Analyze defects, durability, and performance of glass, metal, and edible film packaging systems.
CO5	Demonstrate the operation of modern packaging machinery and advanced systems like MAP and vacuum packaging.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2		2	1		2			1		3	3	
CO2	3	2	1				2		1			3		2
CO3	2	3	3		1					2	2	2	3	
CO4	3	2			1		1				2	3	2	1
CO5	3	1	3									3		3

List of experiments:

1. Determine the Thickness, Grammage, weight, and water absorption capacity of paper and paper board.
2. Estimate the bursting strength, tear strength and crush resistance of paper and paper board.
3. Determination of wax weight, continuity of wax coating and grease resistance of paper.
4. Determination of thickness, density, tensile strength and elongation and dart impact of plastic packaging materials.
5. Estimation of Water Vapor Transmission Rate, Gas Transmission Rate and Migration tests of plastic packaging materials.
6. Determination of tin coating weight and continuity of tin coating.
7. Determinations of headspace analysis of trace elements (Pb, Cr, Fe), lacquer coating and can seaming of metal can.
8. Determine the alkalinity and thermal shock resistance of glass bottles.
9. Study the various defects in glass containers and perform non-destructive tests for glass containers.
10. Development of edible films and coating and their characteristics.
11. Study the operation of different types of packaging machineries ex.MAP, vacuum packaging, filling machines etc.

Learning Resources:

Text Books:

1. Robertson, G. L. (2013). *Food Packaging: Principles and Practice* (3rd Ed.). CRC Press.
2. Kirwan, M. J., & Strawbridge, J. W. (Eds.). (2013). *Packaging Technology* (2nd Ed.). Wiley-Blackwell.

Reference Books:

1. Ahvenainen, R. (Ed.). (2003). *Novel Food Packaging Techniques*. Elsevier.
2. Coles, R., McDowell, D., & Kirwan, M. J. (Eds.). (2003). *Food Packaging Technology (Vol. 5)*. CRC Press.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc24_ge65/preview

III – Year **V – Semester**

Course Code: FEPC503	Food Refrigeration and Cold Chain Management	Credits 2-1-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Explain the principles of refrigeration and air-conditioning based on thermodynamic laws and evaluate system performance using COP and refrigerating capacity.
CO2	Analyze the working of air refrigeration cycles (Carnot, Bell Coleman) and vapour refrigeration systems (compression and absorption) with p–v, T–s, and p–h diagrams.
CO3	Compare the properties, classifications, and applications of various refrigerants, including eco-friendly alternatives, for food preservation and industrial use.
CO4	Design and evaluate components and systems for ice manufacture, cold storage, refrigerated transport, and cold chain logistics for food handling.
CO5	Apply concepts of load calculation, comfort and industrial air-conditioning, and low-temperature refrigeration (cryogenics) in designing efficient refrigeration and air-conditioning systems.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2										3		
CO2	3	3	2									3		
CO3	3		3	2	2					2		3	2	
CO4	3		3	3	3				2	2	3	3		3
CO5	3			3								3	2	3

Syllabus:

Unit I	Principles of refrigeration: Definition, background with second law of thermodynamics, unit of refrigerating capacity, coefficient of performance; Production of low temperatures: Expansion of a liquid with flashing, reversible/ irreversible adiabatic expansion of a gas/ real gas, thermoelectric cooling, adiabatic demagnetization. Air refrigerators working on reverse Carnot cycle: Carnot cycle, reversed Carnot cycle, selection of operating temperatures; Air refrigerators working on Bell Coleman cycle: Reversed Brayton or Joule or Bell Coleman cycle, analysis of gas cycle, polytropic and multistage compression; plug and chill type refrigeration based on chemicals.	6 lectures
Unit II	Vapour refrigeration: Vapor as a refrigerant in reversed Carnot cycle with p-V and T-s diagrams, limitations of reversed Carnot cycle; Vapour compression system: Modifications in reverse Carnot cycle with vapour as a refrigerant (dry Vs wet compression, throttling Vs isentropic expansion), representation of vapor compression cycle on pressure- enthalpy diagram,	9 lectures

	super heating, sub cooling; effect of suction vapour, super heat and liquid sub cooling on actual vapour compression cycle; Vapour-absorption refrigeration system: Process, calculations, maximum coefficient of performance of a heat operated refrigerating machine; water/lithium bromide and ammonia/water absorption cooling. Common refrigerants and their properties: classification, nomenclature, desirable properties of refrigerants- physical, chemical, safety, thermodynamic and economical; azeotrope refrigerants. Components of vapour compression refrigeration system, evaporator, compressor, condenser and expansion valve	
Unit III	Ice manufacture: principles and systems of ice production, basic types of ice, ice makers, 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.	9 lectures
Unit IV	Refrigerated transport: Handling and distribution, cold chain, refrigerated product handling, order picking, refrigerated vans, refrigerated display. Low temperature Refrigeration: cryogenic fluid and fluid properties; liquefaction; application in food.	9 lectures
Unit V	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/Refrigeration load calculations: Load sources, product cooling, conduction heat load, convection heat load, internal heat sources, heat of respiration, peak load, miscellaneous loads; etc.	9 lectures

Learning Resources:

Text Books:

1. ASHARE Handbook, 2006: Refrigeration.
2. Arora, C.P. 2000. Refrigeration and Air Conditioning, 2nd edn. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
3. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
4. Stoecker, W.F. and Jones, J.W.1982. Refrigeration and Air Conditioning, 2nd edn. McGraw-Hill Book Co., New York, USA.
5. Whitman, W.C., Johnson, W.M., Tomczyk, J.A. and Silberstein, E. 2009. Refrigeration and Air Conditioning Technology, 6th edn. Delmar, Cengage Learning, NY, USA

Reference Books:

1. Arora, R. C. (2012). Refrigeration and air conditioning. PHI Learning Pvt. Ltd.
2. Dellino, C. (Ed.). (1997). Cold and chilled storage technology. Springer Science & Business Media.
3. Gunther, R. C. (1969). Refrigeration, air conditioning, and cold storage: principles and

applications. (No Title).
4. W F, S., & Jones, J. W. (1981). Refrigeration and Air conditioning.
5. Jones, W. P. (2007). Air conditioning engineering. Routledge.

Online Resources:

1. https://www.hvacrschool.com
2. https://www.danfoss.com/en-in/service-and-support/learning/cooling-learning/

III – Year **V – Semester**

Course Code: FEPC504	Biochemical Engineering	Credits 2-0-0:2

Course Outcomes: After completion of the course student will be able to:

CO1	Understand basic concepts of bioprocess technology, enzyme kinetics, and microbial growth models.
CO2	Explain fermentation processes, types, and bioreactor design principles
CO3	Apply knowledge of downstream processing and separation techniques in bioprocessing
CO4	Analyze process control, instrumentation, and modeling of bioreactors.
CO5	Demonstrate applications of bioprocess technology in industrial enzyme and food product production.

Mapping of course outcomes with program outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	1	1	1	1	1	1	1				3	3	2
CO2	3	3	3	2	1		1	1				3	3	2
CO3	2	1	1	1	1		3	1				3	3	2
CO4	1	3	3	1	3		1	1				3	3	2
CO5	2	1	1	1	1		1	1				3	3	2

Syllabus:

Unit I	Basic concepts: Historical development of bioprocess technology, an overview of traditional and modern applications of biotech process, Outline of integrated bioprocess and various (upstream and downstream) unit operations involved in biochemical engineering, generalized process flow sheets. Enzyme technology: Classification of enzymes, mechanism of enzyme action, enzyme kinetics, regulation and inhibition, factors affecting enzyme activity, enzyme immobilization, utilization and regeneration of cofactors. Immobilized enzyme kinetics, application of enzymes in industrial processes	4 lectures
Unit II	Kinetics of microbial growth and product formation. Phases of cell growth in batch cultures, Simple unstructured kinetic models for microbial growth, Monod model, Growth of filamentous organisms. Growth associated (primary) and non-growth associated (secondary) product formation kinetics. Fermentation process: Overview of aerobic and anaerobic fermentation processes and their application in the biotech industry, Solid substrate and submerged fermentation and its application.	6 lectures
Unit III	Bioreactor Design: Basic design and construction of fermenter and ancillaries. Material of construction for fermentation process equipment.	7 lectures

	Main parameters to be monitored and controlled in fermentation processes. Design of spargers, aerators and agitators. Fermenter types. Modelling of batch, fed batch and continuous Fermenters	
Unit IV	Downstream processing operations; Cell disruption, Solid-liquid and liquid-liquid separation processes, Extraction, Microfiltration, membrane filtration and centrifugal separation techniques, Chromatographic techniques for separation, drying of products	6 lectures
Unit V	Biochemical process control and instrumentation. Industrial production of important products: Production of enzymes- sub merged fermentation and semisolid fermentation techniques: Industrial production of fermented food products.	5 lectures

Learning Resources:

Text Books:

1. Bailey, J. E., & Ollis, D. F. (2018). Biochemical engineering fundamentals. McGraw-Hill.
2. DeLisa, M., Kargi, F., Kargı, F., & Shuler, M. (2017). Bioprocess engineering: basic concepts. Pearson.

Reference Books:

1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). Principles of fermentation technology. Elsevier.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_bt21/preview

III – Year **V – Semester**

Course Code: FEPC505	**Biochemical Engineering Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course, students will be able to:

CO1	Estimate protein content and enzyme activity using standard assays.
CO2	Evaluate factors affecting enzyme kinetics and immobilization
CO3	Apply enzymes in food processing and product clarification
CO4	Analyze microbial growth and fermentation processes
CO5	Demonstrate operation of laboratory-scale fermenters and production of fermented products.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	1	1	2	-	-	-	-	-	3	2	1
CO2	3	3	3	2	-	2	-	-	-	-	-	3	2	1
CO3	3	3	3	3	-	2	-	-	-	-	-	3	3	1
CO4	3	2	-	-	-	3	-	-	-	-	-	2	3	2
CO5	3	2	3	2	1	-	1	-	-	-	-	2	3	1

List of experiments:

1. Protein estimation of enzyme solution by Bradford's method
2. Determine alpha- amylase activity
3. Determination of pectinase activity
4. Determine the activity of cellulase in two different substrates
5. Analyze the effect of substrate concentration on enzyme activity
6. Immobilization of cellulase by different methods
7. Determine the effectiveness of immobilized enzyme
8. To find the effect of pH and temperature on enzyme activity
9. Clarification of fruit juice using enzymes
10. To estimate the growth curve of yeast/bacteria by direct and indirect methods
11. Preparation of grapes wine and other fermented products
12. Demonstration of laboratory scale fermenter.

Learning Resources:

Text Books:

1. Bailey, J. E., & Ollis, D. F. (2018). Biochemical engineering fundamentals. McGraw-Hill.
2. DeLisa, M., Kargi, F., Kargı, F., & Shuler, M. (2017). Bioprocess engineering: basic concepts. Pearson.

Reference Books:

1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). Principles of fermentation technology. Elsevier.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_bt21/preview

III – Year **V – Semester**

Course Code: FEPC506	Food Safety and Quality Assurance	Credits 2-1-0: 3

Course Outcomes: After completion of the course student will be able to

CO1	Apply underlying principle of food quality and analysis, techniques to measurement of quality attributes and sensory process food products.
CO2	Use the sampling techniques and quality control tools (statistical, sensory) to assess food quality.
CO3	Utilize instruments and identify food adulteration for ensuring food safety and analyze consumer preferences and acceptance of food products.
CO4	Apply various food safety management systems and Indian food laws and regulations for risk control and management to manufacturing and services processes.
CO5	Design and implement traceability and quality assurance systems in food processing plants.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3

CO1	3	2	2	3	3		1					3	3	3
CO2	3	2	2	3	3					2		3	2	2
CO3	3	3	2	2	3			2				3	3	3
CO4	1	3	2	3	3	1					3	3	3	3
CO5	2	3	1	3	3					3	2	3	3	1

Syllabus:

Unit I	Basics of Food Science and Food Analysis, Concept, objectives and need of food quality. Measurement of colour, flavour, consistency, viscosity, texture and their relationship with food quality and composition.	6 lectures
Unit II	Sampling: purpose, sampling techniques, sampling procedures for liquid, powdered and granular materials, Quality control, Quality control tools, Statistical quality control, Sensory evaluation methods, panel selection methods, Interpretation of sensory results.	7 lectures
Unit III	Instrumental method for testing quality. Food adulteration and food safety. TQM and TQC, consumer preferences and acceptance,	4 lectures
Unit IV	Food Safety Management Systems GAP, GHP, GMP, Hazards and HACCP (Hazard analysis and critical control point), Sanitation in food industry (SSOP), Food Laws and Regulations in India, FSSAI, Food grades and standards BIS, AGMARK, PFA, FPO, ISO 9000, 22000 Series. CAC (Codex Alimentarius commission)	7 lectures
Unit V	Traceability and Quality Assurance system in a process plant, Bio safety and Bioterrorism	4 lectures

Learning Resources:

Text Books:

1. Ranganna, S. (1986). *Handbook of analysis and quality control for fruit and vegetable products*. Tata McGraw-Hill Education.
2. Acharya, K. T. (2017). *Everyday Indian processed foods*. National Book Trust.
3. Jha, S. N. (2015). *Rapid detection of food adulterants and contaminants: Theory and practice*. Elsevier.
4. Negi, H. P. S., Sharma, S., & Sekhon, K. S. (2007). *Handbook of cereal technology*. Kalyani Publishers.
5. Potter, N. N., & Hotchkiss, J. H. (1995). *Food science*. Chapman and Hall.

Reference Books:

1. Sharma, A. (2017). *A textbook of food science and technology*. CBS Publishers & Distributors.
2. Srivastava, R. P., & Kumar, S. (2017). *Fruit and vegetable preservation: Principles and practices*. International Book Distributing Company.
3. Kalia, M. (2002). *Food analysis and quality control* (1st ed.). Kalyani Publishers.
4. Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: Principles and practices* (2nd ed.). Springer.

Online Resources:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=185
2. https://onlinecourses.swayam2.ac.in/cec20_ag06/preview
3. https://egyankosh.ac.in/handle/123456789/657

III – Year **V – Semester**

Course Code: FEPC507	Processing Technology of Milk and Milk Products	Credits 2-0-0: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Interpret the chemistry and physico-chemical changes held in milk and its constituents.
CO2	Understand the principles behind milk product development and emerging dairy technologies.
CO3	Explore the various processing steps involved in the development of milk and dairy products.
CO4	Demonstrate knowledge of processing, preservation, and quality evaluation of major dairy products and by-products.
CO5	Evaluate FSSAI standards, cleaning, sanitation, quality assurance, and waste management practices in dairy plants.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2								3	2	
CO2	2	2	3	2	2							3	2	
CO3	2	3	2	2								3	2	
CO4	2	3	2	2									3	
CO5	2	2	2	2	3	1	2						3	2

Syllabus:

Unit I	Introduction to Dairy Industry: Milk production and consumption trends in India, white revolution, importance of clean milk production.	6 lectures
Unit II	Chemistry of milk: milk composition and structure, physical, chemical and microbiological changes in milk, Milk components: lactose, salts, lipids, proteins, enzymes, other components. Milk properties: solution properties, acidity, redox potential, flavour, density, optical properties, viscosity; Microbiology of milk.	6 lectures
Unit III	Milk processing: General aspects of processing - Bulk cooling of milk, storage and transportation, Standardization; Pasteurization and Sterilization- Process and equipment for milk pasteurization: Batch, flash and continuous pasteurizer, UHT sterilization; Homogenization: Classification of homogenization, single and two stage homogenizer pumps, power requirement; Cream separation- different types of centrifuges, application in dairy industry.	8 lectures
Unit IV	Dairy products and byproducts: milk powders: spray and drum drying, condensed milk; Ice cream and frozen dairy desserts: Ingredients, Ice cream premix formulation and processing, partial and complete freezing, storage and distribution; heat desiccated products: khoa and khoa based products; cultured/Fermented milk products- cheese, dahi, yoghurt:	4 lectures

	srikhand, and lassi; heat-acid coagulated milk products: chhana; fat rich products: cream and butter, butter oil, ghee; dairy by- products: buttermilk, whey and whey based products, ghee residues, lactose, caseinates etc. FSSAI standards for dairy products.	
Unit V	Dairy plant management- cleaning and sanitation in dairy industries, CIP, COP, standards, quality control and assurance, waste management.	4 lectures

Learning Resources:

Text Books:

1. Dairy Technology: Principles of Milk Properties and Processing, P. Walstra, T.J. Geurts, A. Noomen, and J.S. Van Boekel, Marcel Dekker, Illustrated Edition, 1999.
2. De, S. (1981). Outlines of dairy technology.

Reference Books:

1. Tamime, A. Y. (2009). Milk Processing and Quality Management.
2. Chandan, R. C. (2015). Dairy processing and quality assurance: an overview. Dairy processing and quality assurance, 1-40.

Online Resources:

1. https://caas.usu.edu/facilities/dairy-products?utm
2. https://fssai.gov.in/upload/Manual_Dairy_03_10_2022.pdf

III – Year **V – Semester**

Course code: FEPC508	**Processing Technology of Milk and Milk Products Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Perform platform and compositional tests to assess the quality of raw milk and milk products.
CO2	Apply standard methods to determine fat, solids, acidity, density, and adulterants in milk.
CO3	Evaluate efficiency of pasteurization and sterilization processes using phosphatase and turbidity tests.
CO4	Develop and analyze quality of dairy products such as paneer, khoa, yoghurt, ice cream, and cheese.
CO5	Demonstrate practical knowledge of advanced dairy processing techniques like spray drying and frozen milk product preparation.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2								3	2	
CO2	2	2	3	2	2							3	2	
CO3	2	3	2	2								3	2	
CO4	2	3	2	2									3	
CO5	2	2	2	2	3	1	2						3	2

List of Experiments:

1. Platform tests for raw milk
2. Determination of pH and titratable acidity in milk and milk products
3. Determination of density and total solids in milk by lactometer
4. Determination of fat content using Gerber methods
5. To study the pasteurization HTST unit and its performance
6. Determination of phosphatase activity to test milk pasteurization
7. Checking sterilization efficiency by turbidity test
8. Detection of adulterants present in milk
9. Determination of the quality of paneer prepared from buffalo and cow milk
10. Preparation of heat-desiccated product and textural study
11. Preparation of frozen milk and study its characteristics
12. Preparation cheese and its quality analysis
13. Spray drying of milk
14. Preparation of yoghurt

Learning Resources:

Text Books:

1. Dairy Technology: Principles of Milk Properties and Processing, P. Walstra, T.J. Geurts, A. Noomen, and J.S. Van Boekel, Marcel Dekker, Illustrated Edition, 1999.
2. De, S. (1981). Outlines of dairy technology.

Reference Books:

1. Chandan, R. C. (2015). Dairy processing and quality assurance: an overview. Dairy processing and quality assurance, 1-40.

Online Resources:

1. https://caas.usu.edu/facilities/dairy-products?utm
2. https://fssai.gov.in/upload/Manual_Dairy_03_10_2022.pdf
3. https://www.spxflow.com/assets/original/apv-dairy-technology-handbook-9002-gb-0617.pdf

III – Year **V – Semester**

Course Code: FEPC509	Processing Technology of Cereal, Pulses and Oilseeds	Credits 2-0-0:2

Course Outcomes: After completion of the course student will be able to:

CO1	Explain physical and chemical properties of grains, cereals, pulses, oilseed and their products.
CO2	Explain the milling principles and operations of different cereals and pulses.
CO3	Apply various unit operations required for processing different cereals, pulses and oilseeds.
CO4	Demonstrate grain and oilseed processing-based industries.
CO5	Apply principles of oilseed processing, extraction, refining, and value addition to by-products using conventional and modern technologies.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3

CO1	3	3	3	1	2	3	2					3	3	1
CO2	3	2	3	2	1							2	2	2
CO3	2	3	3	2	2	3		1	2			3	2	3
CO4	3	2	3	2	2			2				2	3	3
CO5	3	3	3	1	1	3	2					2	2	2

Syllabus:

Unit I	Introduction: Production of grains, cereals, pulses and oilseeds, Causes of post-harvest losses of grains. Recommended pre-processing practices for handling cereals, pulses and oilseeds for their safe storage. Wheat: Structure, types, composition, quality characteristics and physicochemical properties of wheat; functionality of wheat components; cleaning, tempering and conditioning, and milling processes; milling equipment and milling products (Dalia, Atta, Semolina and flour); By-product utilization.	4 lectures
Unit II	Rice: Structure, composition, quality characteristics and physicochemical properties of rice; milling and parboiling of paddy, curing and ageing of paddy and rice, assessment criteria of milling, cooking, nutritional and storage qualities of raw & parboiled rice; Processed rice products (flaked and expanded rice); by-product (husk and rice bran) utilization.	6 lectures
Unit III	Cereals and millets: Structure, types and composition of corn. Dry and wet milling of corn; Starch and its conversion products; Processed corn products (popped corn, cornflakes etc.); Structure and composition of barley, bajra, jowar and sorghum; Pearling of millets; Parched and snack products. Cereal Malts: basic malting process, malting plant and equipment, malt storage, malt characteristics, malt extract, uses.	7 lectures
Unit IV	Pulses: Structure, types, composition, quality characteristics and physicochemical properties of pulses. Pulses production, types, chemical composition, milling of pulses, milling equipment, factors affecting pulses quality, secondary processing of pulses, processed products, fermented products, traditional products, and by-products utilization; effect of processing on nutritive value.	6 lectures
Unit V	Oilseeds: Classification and types of oilseeds; Processing of oilseeds; oil extraction methods: mechanical (Ghani and expellers) and chemical (solvent extraction); oil refining; the processing of refined oils; New technologies in oilseed processing; Byproduct of oil milling and their value addition. FSSAI standards for cereals, pulses oilseeds based products.	5 lectures

Learning Resources:

Text Books:

1. Chakraverty, A. (1988). Post harvest technology of cereals, pulses and oilseeds.
2. Kulp, K. (Ed.). (2000). Handbook of Cereal Science and Technology, revised and expanded. Crc Press.
3. Owens, G. (Ed.). (2001). Cereals processing technology (Vol. 53). CRC Press.

Reference Books:

1. Shahidi, F. (Ed.). (2005). Bailey's Industrial Oil and Fat Products, Industrial and Nonedible Products from Oils and Fats. John Wiley & Sons.
2. Dendy, D. A., & Dobraszczyk, B. J. (2001). Cereals and cereal products: chemistry and technology.

Online Resources:

1. https://www.canr.msu.edu/fshn/facilities/cereal_milling_product_laboratory
2. https://egyankosh.ac.in/handle/123456789/45380

III – Year **V – Semester**

Course code: FEPC510	Processing Technology of Cereal, Pulses and Oilseeds Lab	Credits 0–0–2: 1

Course Outcomes: After completion of the course student will be able to:

CO1	Evaluate the physicochemical and functional properties of cereals, pulses, and oilseeds using standard laboratory methods.
CO2	Determine quality parameters of wheat flour and dough (gluten content, extensibility, sedimentation value, dough-raising capacity).
CO3	Assess the cooking and milling qualities of rice, including gelatinization, amylose content, alkali score, and milling performance.
CO4	Demonstrate practical knowledge of malting, starch properties, and oilseed/legume processing techniques.
CO5	Detect adulterants and analyze quality indices such as alcoholic acidity and falling number in cereals, pulses, and oils.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	1	1							3	3	1
CO2	3	2	3	2	1							2	3	1
CO3	2	3	3	1	1							3	3	1
CO4	3	2	3	1	1							2	3	1
CO5	3	3	3									3	2	2

List of Experiments:

1. To study the physicochemical properties of food grains and cereals.
2. Determination of the Angle of Repose of grains.
3. Determination of gluten content in wheat flour.
4. To estimate the falling number of wheat flour samples
5. To study the cooking quality of rice.
6. Demonstration of rice milling and calculation of milling performance
7. Determination of Gelatinization Temperature of starch.
8. Determination of amylose content of given rice sample.
9. To study the physical properties and methods of extraction of Legumes and Oil seed.
10. To demonstrate the preparation of malt.
11. Determination of common adulteration of pulses, oils and oilseed.
12. Determination of alkali score of rice and sedimentation value of wheat flour.
13. Determination of alcoholic acidity of given sample.

14. Determination of gluten extensibility.
15. Determination of dough raising capacity.

Learning Resources:

Text Books:

1. Chakraverty, A. and Singh, R.P. 2014. Post Harvest Technology and Food Process Engineering. CRC Press, Boca Raton, FL, USA.
2. Chakraverty, A., Mujumdar, A.S., Vijaya Raghavan G.S. and Ramaswamy, H. S. 2003. Handbook of Post Harvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. Marcel Dekker, Inc., NY, USA.

Reference Books

3. Araullo, E.V., De Padua, D.B. and Graham, M. 1976. Rice Post Harvest Technology. IDRC, Canada.
4. Champagne, E.T. 2004. Rice: Chemistry and Technology, 3rd edn. AACC International, Inc., St. Paul, MN, USA.
5. David, A.V. Dendy and Dobraszczyk, B.J. 2001. Cereal and Cereal Products: Technology and Chemistry. Springer-Verlag, US.

Online Resources:

1. https://course.cutm.ac.in/wp-content/uploads/2020/06/Processing-of-Legumes-and-Oilseeds-Manual.pdf
2. https://dl.ojocv.gov.et/admin_/ttlm_/M13-%20Mechanical%20Extraction.pdf?utm

III – Year **VI – Semester**

Course Code: FEPC601	Marketing Management and International Trade	Credits 2-1-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the fundamental concepts, functions, and scope of marketing and marketing management in the food and dairy sector.
CO2	Analyze market environments, consumer behaviour, and apply segmentation, targeting, and positioning for effective marketing planning.
CO3	Develop appropriate products, branding, packaging, and distribution strategies for efficient marketing channel management.
CO4	Evaluate pricing and promotion strategies, including advertising and sales promotion, for different sectors of the dairy and food industry.
CO5	Examine international marketing practices, trade policies, and institutional support systems related to global food and dairy exports.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	1	1							3	3	2
CO2	3	2	3	2	1							2	3	1

CO3	2	3	3	1	1							3	3	2
CO4	3	2	3	1	1							2	3	1
CO5	2	3	3									3	2	2

Syllabus:

Unit I	Fundamentals of Marketing and Marketing Management: Marketing: Concept, functions, scope, and marketing management, Process: Concepts of marketing-mix, elements of marketing-mix, Market structure and consumer buying behaviour: micro- and macro-environments, and Marketing research and marketing information systems	08
Unit II	Market Analysis and Planning: Market measurement, market forecasting, Market segmentation, targeting, and positioning, Allocation and marketing resources, and Marketing planning process	07
Unit III	Product and Channel Management: Product policy and planning: Product-mix, product line, product life cycle, New product development process, Product brand, packaging, services decisions, Marketing channel decisions, and Retailing, wholesaling, and distribution	06
Unit IV	Pricing and Promotion Decisions: Pricing decisions: Price determination and pricing policy of milk products in organized and unorganized sectors of dairy industry, Promotion mix decisions, Advertising: Objectives, budget and advertising message, media planning, and Personal selling, publicity, and sales promotion	06
Unit V	International Marketing and Trade Environment: World consumption of food: Patterns and types of food consumption across the globe, Salient features of international marketing, Composition and direction of Indian exports, International marketing environment, Deciding which and how to enter international market: Direct exports, indirect exports, licensing, joint ventures, distribution channels, WTO and world trade agreements related to food business, Export trends and prospects of food products in India, Government institutions related to international food trade: APEDA, Tea Board, Spice Board, MOFPI, etc.	07

Learning Resources:

Text Books:

1. Philip Kotler, Kevin Lane Keller, Abraham Koshy, Mithileshwar Jha. (2013). *Marketing Management: A South Asian Perspective* (14th Ed.). Pearson Education, New Delhi.
2. Willium J. Stanton. (1984). *Fundamentals of Marketing.* Tata McGraw-Hill Publication, New Delhi.
3. C.N. Sontakki. *Marketing Management.* Kalyani Publishers, New Delhi.

Reference Books:

1. John Daniels, Lee Radebaugh, Brigham, Daniel Sullivan. *International Business* (15th Ed.). Pearson Education.
2. K. Aswathappa. *International Business.* Tata McGraw-Hill Education, New Delhi.
3. Fransis Cherunilam. (2017). *International Business: Text and Cases* (5th Ed.). PHI

Learning, New Delhi.
4. Ramaswamy, V.S., & Namakumari, S. (2018). *Marketing Management: Global Perspective Indian Context.* McGraw Hill Education, New Delhi.
5. Saxena, Rajan. (2016). *Marketing Management.* McGraw Hill Education, New Delhi.

Online Resources:

https://www.apeda.gov.in

https://mofpi.gov.in

https://www.teaboard.gov.in

III – Year **VI – Semester**

Course Code: FEPC602	**Instrumental Techniques in Food Analysis**	**Credits 2-0-0: 2**

Course Outcomes: After completion of the course student will be able to:

CO1	Apply fundamental concepts, rules, and regulations of food analysis to evaluate the quality, safety, and authenticity of food products.
CO2	Demonstrate proficiency in proximate, rheological, textural, and adulteration analysis of foods using standard methodologies.
CO3	Utilize advanced spectroscopic and chromatographic techniques for qualitative and quantitative food compositional analysis.
CO4	Employ separation and analytical methods, including dialysis, electrophoresis, and ultrafiltration, for characterizing food components.
CO5	Integrate modern sensor technologies and rapid microbiological methods to ensure food safety, quality control, and industrial applications.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2										3		
CO2	3	3										3		
CO3	3		3		2					2		3	2	
CO4	3		3	3	3				2		3	3		3
CO5	3			3								3	2	3

Syllabus:

Unit I	Concepts of food analysis; Rules and regulations of food analysis Principles and methodology involved in analysis of foods: Rheological analysis, textural profile analysis of foods, Methods of analysis: Proximate constituents: Total fat, crude fiber, protein, moisture, minerals analysis; adulterations.	4 lectures
Unit II	Principles and methodology involved in analytical techniques: spectroscopy, ultraviolet visible, infrared spectroscopy, atomic absorption and emission, florescence mass spectroscopy.	6 lectures
Unit III	Food compositional analysis and applications in the food industry.	6 lectures
Unit IV	Chromatography: Principle of chromatography, classifications, Adsorption, column, partition, gel-filtration, affinity, ion-exchange, size-exclusion method) gas-liquid, high performance liquid	6 lectures

	chromatography; Ion chromatography and others.	
Unit V	Separation techniques: Dialysis, electrophoresis, sedimentation, ultra-filtration, ultra centrifugation, iso-electric focusing, Chemically sensitive semiconductor devices: Solid-state sensors for pH, acidity, amperometric, potentiometric and; Acoustic sensors, Rapid microbiological methods: Overview, Conductance/impedance techniques for microbial assay; chemosensors, biosensors, immunosensors.	6 lectures

Learning Resources:

Text Books:

1. Nieisen, S.S. 2010. Food Analysis Laboratory Manual, 2nd edn. Springer, NY, USA.
2. Nieisen, S.S. 2003. Food Analysis, 3rd edn. Kluwer Academic, New York, USA.
3. Ötles, S. 2009. Handbook of Food Analysis Instruments. CRC Press, Boca Raton, FL, USA.
4. Sun, D.W. 2008. Modern Techniques for Food Authentication. Elsevier Inc., Burlington, MA, USA.

Reference Books:

1. Nielsen, S. S. (2017). Food Analysis (5th Edition). Springer, USA.
2. Esteban-Campos, C. et al. (2019). Spectroscopic Methods in Food Analysis. CRC Press (Taylor & Francis).

Online Resources:

1. https://pmc.ncbi.nlm.nih.gov/articles/PMC8152966/?utm

III – Year **VI – Semester**

Course Code: FEPC603	Instrumental Techniques in Food Analysis Lab	Credits 0-0-2: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Understand basic principles and methods of food analysis
CO2	Perform proximate and compositional analysis of foods.
CO3	Apply spectroscopic and chromatographic techniques in food testing.
CO4	Identify food adulterants and assess quality parameters.
CO5	Utilize modern sensors and rapid methods for food safety evaluation.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	1	1							3	3	2
CO2	3	2	3	2	1							2	3	1
CO3	2	3	3	1	1							3	3	2
CO4	3	2	3	1	1							2	3	1
CO5	2	3	3									3	2	2

List of Practicals:

1. Determination of moisture, ash, protein, fat, and fiber content in food.

2. Measurement of food texture and rheological properties.
3. Analysis of food components using UV-Vis and IR spectroscopy.
4. Estimation of minerals by atomic absorption spectroscopy.
5. Separation of food compounds using chromatography techniques.
6. Detection of adulterants in various food samples.
7. Protein estimation by Kjeldahl method and fat by Soxhlet extraction.
8. Separation of biomolecules using electrophoresis and centrifugation.
9. Detection of food contaminants using biosensors and chemosensors.
10. Rapid microbial detection using conductance and impedance methods.

Learning Resources:

Text Books:

5. Nieisen, S.S. 2010. Food Analysis Laboratory Manual, 2nd edn. Springer, NY, USA.
6. Nieisen, S.S. 2003. Food Analysis, 3rd edn. Kluwer Academic, New York, USA.
7. Ötles, S. 2009. Handbook of Food Analysis Instruments. CRC Press, Boca Raton, FL, USA.
8. Sun, D.W. 2008. Modern Techniques for Food Authentication. Elsevier Inc., Burlington, MA, USA.

Reference Books:

3. Nielsen, S. S. (2017). Food Analysis (5th Edition). Springer, USA.
4. Esteban-Campos, C. et al. (2019). Spectroscopic Methods in Food Analysis. CRC Press (Taylor & Francis).

Online Resources:

2. https://pmc.ncbi.nlm.nih.gov/articles/PMC8152966/?utm

III – Year **VI – Semester**

Course Code: FEPC604	Technology for Bakery and Confectionary	Credits 2-0-0: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Know history and scope of bakery & confectionery industry.
CO2	Understand ingredients and their roles in bakery & confectionery.
CO3	Apply processing steps and equipment for bakery products.
CO4	Analyze dough rheology and product quality.
CO5	Explain processing of chocolate, candy, and toffee.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	1	2						2	3	1	1
CO2	3	3	2	1	2	1					2	3	2	1
CO3	3	3	3	2	2						2	3	1	1
CO4	3	3	3	3	2			1			2	3	2	2
CO5	3	2	3	2	3			1			2	3	2	2

Syllabus:

Unit I	Historical development and status of bakery industry in India; Introduction and definition of bakery products as per FSSAI-bread, biscuit, cake, pastries, rusk, crackers, bun and their specifications. Bakery Plant - Layout, setting up of units and hygienic conditions, operation and maintenance.	5 lectures
Unit II	Bread and Biscuit Processing Bread- types; role of major and minor ingredients; processes of bread making; problems associated with bread; equipment for bread manufacturing; Processing steps for biscuit, cookies, cracker, cakes and their major and minor ingredients; equipment for biscuit manufacturing. Rheological testing of dough-Farinograph, mixograph. Extensograph, Amylograph/ Rapid- visco analyzer, Falling number and interpretation of data.	5 lectures
Unit III	Cakes: Flour specifications-, ingredients, manufacturing process and quality evaluation. Preparation of other bakery products - rusks, crackers, buns, muffins, pizza; raw materials, methods of production, quality parameters. Confectionary- historical development; classification of confectionary products; basic technical considerations for confectionary products-TS, TSS, pH, acidity, ERH, RH. Raw materials and their role in confectionary product;	6 lectures
Unit IV	Cocoa, Chocolate Processing Cocoa historical bean- introduction, history and composition; processing of cocoa bean; processed product of cocoa; development in chocolate processing; ingredients and their role in chocolate; processing steps of chocolate processing- mixing, refining, conching, tempering, molding, cooling, coating, enrobing etc.	6 lectures
Unit V	Candy and Toffee Processing High boiled sweets/candy - composition, production and preparation of high boiled sweets- traditional, batch and continuous method; to ffee- composition, types, ingredient and their role, batch and continuous method of toffee manufacturing.	6 lectures

Learning Resources:

Text Books:

1. Y. Pomeranz, Modern Cereal Science and Technology, MVCH Publications, NY
2. Samuel A. Matz, Bakery Technology and Engineering,Chapman and Hall

Reference Books:

1. A Bent, E B Benníon, G ST Bamford, The technology of cake making, Blackie-Academic and Professional, UK.

III – Year **VI – Semester**

Course Code: FEPC605	**Technology for Bakery and Confectionary Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Demonstrate the understanding for the selection and role of ingredients in bakery and confectionary
CO2	Demonstrate the understanding of the various occurrences during preparation of baked products
CO3	Demonstrate the preparation of some of the bakery and confectionary products viz. bread, biscuit, rusk, muffins and cakes.

CO4	Demonstrate the understanding of various types of machinery used in bakery industry
CO5	Demonstrate the understanding of proper layout and various officials requirement in a bakery industry

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	1	2						2	3	1	1
CO2	3	3	2	1	2	1					2	3	2	1
CO3	3	3	3	2	2						2	3	1	1
CO4	3	3	3	3	2			1			2	3	2	2
CO5	3	2	3	2	3			1			2	3	2	2

List of Experiments:

1. Quality assessment: Flour, yeast, water, leavening agents.
2. Production of Sandwich/Milk bread and its quality evaluation.
3. Production of rusk and its quality evaluation.
4. Production of Nankhattai/Cherry Short biscuit and its quality evaluation.
5. Production of Cup cake/ Sponge cake and its quality evaluation.
2. Production of milk chocolate and dark chocolate and its quality evaluation.
3. Preparation of Fudge, Caramel, Fondant Jellies and its sensory evaluation.
4. Visit to bakery plants.

Learning Resources:

Text Books:

1. Y. Pomeranz, Modern Cereal Science and Technology, MVCH Publications, NY
2. Samuel A. Matz, Bakery Technology and Engineering,Chapman and Hall

Reference Books:

1. A Bent, E B Bennion, G ST Bamford, The technology of cake making, Blackie-Academic and Professional, UK.

III – Year **VI – Semester**

Course Code: FEPC606	Food Process Equipment Design	Credits 2-1-0:3

Course Outcomes: After completion of the course, students will be able to:

CO1	Understand the concept of food processes, equipment design, and materials of construction for food processing equipment.
CO2	Understand the process and equipment design and selection of different food processing equipment.
CO3	Analyze the design considerations and applications of transport, handling, heating, cooling, drying, and mass transfer equipment in food processing.
CO4	Apply principles of food plant layout design, utility management, and feasibility analysis for preparing plant design reports.
CO5	Evaluate economic aspects of equipment and plant design, including cost estimation, efficiency, optimization, and profitability analysis.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	1	1							3	3	2
CO2	3	2	3	2	1							2	3	1
CO3	2	3	3	1	1							3	3	2
CO4	3	2	3	1	1							2	3	1
CO5	2	3	3									3	2	2

Syllabus:

Unit 1	Equipment Design Principles: Introduction to design; Fundamental principles of designing food processing equipment including sanitation and Safety aspects; fundamentals of material and energy balance calculations for preliminary estimation of plant capacity and equipment sizes; preparation of flow sheets for material movement and utility consumption in food plants. Materials used in food processing: materials for food processing machinery and other food applications; food-material (Metal) interactions, material properties; mechanical properties, corrosion resistance, etc.	8 lectures
Unit 2	Design Considerations and Selection of Food Processing Equipment Transport and handling equipment for liquid and solid foods: Pumps and pipelines; Conveyors; Fan & Blowers; CIP system; heating and cooling equipment: heat exchangers, pasteurizers, sterilizers, and cooling systems.; drying and dehydration equipment: dryers, dehydrators. Storage structure for solid and liquid food storage;	4 lectures
Unit 3	Mass transfer operation equipment: vapour-liquid; liquid-liquid and solid-liquid equilibria; equilibrium stages; distillation and solvent extraction.	8 lectures
Unit 4	Food Plant Layout Design and Report: Principles of designing efficient and functional food processing plants, including layout, flow, and utilities. Elements of food plant design report; Feasibility analysis and preparation of feasibility report.	4 lectures
Unit 5	Economic Considerations and Design Optimization: Economic aspects of food processing equipment design, including cost of operation, efficiency, break-even analysis, and profitability. Optimization techniques for efficient process and product design	4 lectures

Learning Resources:

Textbooks:

1. Perry, R. H., & Green, D. W. (1997). Perry's Chemical Engineers' Handbook.
2. Khanna, O. P. (1982). Industrial Engineering.

Reference Books:

1. Moore, J. M. (1962). Plant layout and design.
2. Farrall, A. W. (1964). Engineering for Dairy and Food Products.
3. Saravacos, G. D., & Kostaropoulos, A. E. (2002). Handbook of food processing equipment (Vol. 2012, pp. 331-381). Kluwer Academic/Plenum.

Online resources:

1. https://nptel.ac.in/courses/103107207

III – Year **VI – Semester**

Course Code: FEPC607	Food Plant Utilities	Credits 2-0-0: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Ability to employ the selection and operation of boiler in food processing plant as a food process engineer
CO2	Ability to demonstrate the pre-process and post-process handling of water for safe application
CO3	Ability to define the benefits of processed/purified air application in food processing.
CO4	Ability to identify the suitable power supply installations in processing plants
CO5	Explain wastewater treatment and solid waste management methods.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2											3	
CO2	3	3										2	3	
CO3	3		3		2					2			3	2
CO4	3		3	3	3				2		3		3	
CO5	3			3								3	3	2

Syllabus:

Unit I	Process water treatment: Water treatment for prevention against boil corrosion and scale formation on heat exchange equipment. Water treatment against microbial contamination.	6 lectures
Unit II	Steam generation and performance: Boiler types, boiler accessories and auxiliaries, boiler operation and maintenance, forced and induced draught, types of steam and applications. Flue gas composition and performance analysis, water quality and treatment for boiler, regulations for boiler operations.	6 lectures
Unit III	Process air generation and applications: refrigeration systems and cold air and water generations, hot air and compressed air. Air-moving and vacuum equipment, piping systems for fluid flow Power supply system: electrification and power supply systems for food processing plants. Equipment and plant earthing	6 lectures
Unit IV	Process plant sanitation - chemistry and CIP, COP cleaning systems., Cleaning & corrosion: Detergent types, properties and corrosion inhibition	6 lectures
Unit V	Wastewater treatment: Primary , secondary and tertiary treatments and BOD, COD reduction, fundamentals of batch and continuous type effluent treatment system, solid waste handling methods and systems	4 lectures

Learning Resources:

Text Books:

1. Mercer, D. G. (2007). Food plant design, Antonio López-Gómez, Gustavo V. Barbosa Cánovas, in: Food Science and Technology, Vol. 143, CRC Press, Taylor and Francis Group (2005), 416 pages., ISBN: 1-57444-602-9.
2. Cramer, M. M. (2006). Food plant sanitation: design, maintenance, and good manufacturing practices. CRC Press.

Reference Books:

1. Saravacos, G. D., & Kostaropoulos, A. E. (2002). Handbook of food processing equipment (Vol. 2012, pp. 331-381). Kluwer Academic/Plenum.
2. Kessler, H. G. (1981). Food engineering and dairy technology.

Online resources:

1. https://nptel.ac.in/courses/105107207

IV – Year **VII – Semester**

Course Code: FEPC701	AI in Food Processing	Credits 2-1-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Differentiate between AI, machine learning, and deep learning concepts and their scope in the food industry.
CO2	Apply computer vision and AI-sensor systems for automated food quality and safety assessment.
CO3	Implement machine learning models to optimize and control key food processing operations.
CO4	Analyze the role of AI in automation, robotics, and Industry 4.0 for smart food manufacturing.
CO5	Utilize AI tools for product formulation, consumer insight analysis, and personalized nutrition design.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2											3	
CO2	3	3										2	3	
CO3	3		3		2					2			3	2
CO4	3		3	3	3				2		3		3	
CO5	3			3								3	3	2

Unit I	Introduction to Artificial Intelligence in Food Processing: Basics of artificial intelligence, machine learning, and deep learning, types of AI models: supervised, unsupervised, and reinforcement learning, importance and scope of AI in the food industry; digital transformation and ai integration in food value chains.	4 lectures
Unit II	AI in Food Quality Assessment and Safety: Computer vision and image analysis techniques; defect detection in fruits, vegetables, and grains; AI-based sorting and grading systems; integration of AI with sensors and smart devices for quality control.	6 lectures

Unit III	Machine learning for process modeling and optimization: Overview of ML algorithms: regression, classification, clustering; Artificial Neural Networks (ANN), Support Vector Machines (SVM), Random Forest (RF); process parameter optimization in drying, extrusion, and fermentation; predictive analytics and integration with IoT for process control.	6 lectures
Unit IV	Automation and Robotics in Food Processing: Role of AI in automation and robotics; Smart sensors and real-time data monitoring; AI for predictive maintenance and fault detection; Industry 4.0 concepts and digital twins in food industries.	6 lectures
Unit V	AI in New Product Development and Consumer Insights: Role of AI in product formulation and recipe optimization; AI tools for flavor pairing and ingredient selection; Consumer behavior prediction and market trend analysis; Personalized nutrition and smart food design.	6 lectures

Course content:

Learning Resources:

Text Books:

1. Gupta, S., & Garg, M. K. (Eds.). (2023). Artificial intelligence in the food industry: Emerging trends and applications. Springer. https://doi.org/10.1007/978-3-031-...

2. Mittal, G. S. (2022). Intelligent systems in food processing: Engineering and applications (2nd ed.). CRC Press.

3. Sun, D.-W. (Ed.). (2016). Computer vision technology for food quality evaluation (2nd ed.). Academic Press.

Reference Books:

1. Gonzalez, R. C., & Woods, R. E. (2018). Digital image processing (4th ed.). Pearson.
2. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). An introduction to statistical learning with applications in R (2nd ed.). Springer. https://www.statlearning.com/
3. Jeffery, M. (2010). *Data-driven marketing: The 15 metrics everyone in marketing should know*. Wiley.
4. Özdemir, O., & Yücel, İ. (2021). Fundamentals of industry 4.0: Concepts, technologies, and applications. CRC Press.

Online resources:

1. https://onlinecourses.nptel.ac.in/noc21_cs20/preview

IV – Year **VII – Semester**

Course Code: FEPC702	**Statistical Method in Food and Consumer Research**	**Credits 2-1-0: 3**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the fundamentals of descriptive and inferential statistics relevant to food and consumer research.

CO2	Apply appropriate statistical methods for analysing experimental and survey data.
CO3	Interpret and critically analyse statistical findings to draw valid and meaningful conclusions.
CO4	Develop skills to design, conduct, and interpret sensory evaluation tests for food products
CO5	Integrate statistical analysis with consumer research to support evidence-based decision-making.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2											3	
CO2	3	3										2	3	
CO3	3		3		2					2			3	2
CO4	3		3	3	3				2		3		3	
CO5	3			3								3	3	2

Syllabus:

Unit I	Introduction to statistics, data collection in food processing and representation, graphical representation using different tools, Measurement of central tendency- mean, median, mode, measures of dispersion-range, variance, standard deviation, range, quarterly deviation, mean deviation, standard deviation, coefficient of variation.	6 lectures
Unit II	Testing of Hypothesis: null and alternate hypothesis, types of errors: type-1 and type-2, p-values and level of significance, one-sample t-tests, two-sample t-tests, applications in consumer and food product testing, correlation and regression analysis simple linear regression, multiple linear regression	9 lectures
Unit III	Experimental design, types of design, one-way ANOVA, two-way ANOVA and Interaction effects, goodness of fit, post-hoc tests and pairwise comparisons, applications in food quality testing and analysis	9 lectures
Unit IV	Consumer research for product development: sensory evaluation, discrimination tests, descriptive analysis, consumer testing procedures, flavour description terminologies, anatomy and physiology of sensory systems (sight, taste, smell, touch and hearing), correlation of sensory and instrumental measurements, consumer sensory and market research	9 lectures
Unit V	Statistical process control: multivariate analysis, principal component analysis, cluster analysis, factor analysis, case studies in food quality analysis and report writing, data collection for a given problem and statistical analysis and data interpretation.	9 lectures

Learning Resources:

Text Books:

1. Gupta, S. C., & Kapoor, V. K. (2020). Fundamentals of mathematical statistics. Sultan Chand & Sons.
2. Gacula Jr, M. C. (2013). Statistical methods in food and consumer research. Elsevier.
3. Heymann, H., & Lawless, H. T. (2013). Sensory evaluation of food: principles and practices. Springer Science & Business Media.
4. Montgomery, D. C. (2017). Design and analysis of experiments. John wiley & sons.

Reference Books:

1. Heymann, H., & Lawless, H. T. (2013). Sensory evaluation of food: principles and practices. Springer Science & Business Media.
2. Montgomery, D. C. (2017). Design and analysis of experiments. John wiley & sons.

Online Resources:

1. https://nptel.ac.in/courses/111105041

IV – Year **VII – Semester**

Course Code: FEPC703	Processing Technology of Meat, Fish and Poultry	Credits 2-0-0: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Explain the structure, composition, quality attributes, and post-mortem changes in meat, poultry, fish, and eggs.
CO2	Demonstrate knowledge of slaughtering, dressing, deboning, grading, and preservation techniques for meat, poultry, and fish.
CO3	Apply traditional and novel processing methods (curing, smoking, canning, dehydration, irradiation, high pressure, surimi processing) for value-added product development.
CO4	Evaluate meat, fish, poultry, and egg products based on quality parameters, spoilage indices, and safety standards.
CO5	Design layouts, utilize by-products, and ensure compliance with national and international food safety and regulatory systems (FSSAI, HACCP, ISO, Halal, Kosher, EU).

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	1	2	2							3	2	
CO2	1	3	2	2	2							3	2	
CO3	1	3	3	2	2	1	1					3	2	1
CO4	1	3	3	2	2	1	1					3	2	1
CO5	1	3	2	2	2	1	1					3	2	1

Syllabus:

Unit I	Status of meat poultry and fish industry in India; Sources and importance of meat, poultry and fish. Structure and composition of muscle, types, classification and composition of fish, Pre-slaughter operations and slaughtering operations for animals and poultry. Dressing and evaluation of animal carcasses; Factors affecting post-mortem changes, properties and shelf life of meat; Mechanical deboning, grading and aging; Eating and cooking quality of meat.	8 lectures
Unit II	Preservation of meat, poultry and fish by chilling, freezing, pickling, curing, cooking and smoking, canning, dehydration, radiation, chemical and biological preservatives. Novel methods: Low dose irradiation; High pressure treatment, hurdle barrier concept for- meat, poultry and fish, Meat tenderization; Meat emulsions; Fish protein concentrates (FPC), fish protein extracts (FPE), fish protein hydrolysates (FPH); Meat quality	8 lectures

	parameters – color water holding capacity, palatability, marbling quantum of connective tissue, firmness and storage conditions;	
Unit III	Meat cutting and handling; Preparation, preservation and equipment for manufacture of smoked meat and its quality evaluation; Preparation, packaging and equipment for manufacture of dehydrated meat products and their quality evaluation; Preparation, preservation and equipment for manufacture of meat sausages and their quality evaluation;	8 lectures
Unit IV	Surimi process, traditional and modern surimi production lines, quality of surimi products, comparison of surimi and fish mince products; Problems on mass balancing of ingredients in formulation of value-added meat products; Abattoir design and layout; Preservation of fresh fish, characteristic of fresh fish and fermented and value-added products of fish; Spoilage indices of fish and factors affecting the spoilage of fish	9 lectures
Unit V	Eggs: Structure, composition, quality characteristics, defects and grading of egg processing, preservation of eggs; Processing and preservation of poultry meat and chicken patties, Preparation protocols of indigenous products: Fish sauce and paste; By-products of meat, poultry, fish and eggs and their utilization; Safety standards in meat/ fish industry: HACCP/ISO/MFPO/ FSSAI/ Kosher/Halal, EU hygienic regulations and ISO 9000 standards.	9 lectures

Learning Resources:

Text Books:

1. Berkel, B. M.-V., Boogaard, B.V.-D. and Heijnen, C. 2004. Preservation of Fish and Meat. Agromisa Foundation, Wageningen.
2. Borstorm, G. 1961. Fish as Food - Vol. I, II, III and IV. Academic Press, New York.
3. FAO. 2003. Code of Practices of Canned Fishery products. FAO, UN, Rome.
4. Hall, G.M. 1997. Fish Processing Technology, 2nd edn. Chapman and Hall, London, UK.
5. Kerry, J., Kerry, J. and Ledward, D. 2005. Meat Processing-Improving Quality. Woodhead Publishing Ltd., Cambridge, England.
6. Lawrie, R.A. 1985. Meat Science, 4th edn. Pergamon Press, Oxford, UK.
7. Nanda, Vikas 2014. Meat, Egg and Poultry Science and Technology. I.K. International Publishing House Pvt. Ltd., New Delhi.
3. Rautenstrauss, B.W. and Liehr, T. 2002. Fish Technology. Springer-Verlag, US.
4. Sen, D.P. 2005. Advances in Fish Processing Technology. Allied Publishers Pvt. Ltd., Delhi. 10. Sharma, B.D. and Sharma, K. 2011. Outlines of Meat Science and Technology. Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.
5. Swatland, H.J. 2004. Meat Cuts and Muscle Foods, 2nd edn. Nottingham Univ. Press, Nottingham.
6. Toldrá, F., Hui, Y. H., Astiasarán, I., Nip, W.-K., Sebranek, J.G, Silveira, E.-T.F., Stahnke, L.H.,
7. Talon, R. 2007. Handbook of Fermented Meat and Poultry. Blackwell Publishing Professional, Ames, Iowa, USA.
8. Varnam, A.H. and Sutherland, J.P. 1995. Meat and Meat Products: Technology, Chemistry and Microbiology. Chapman and Hall, London.

Reference Books:

1. Sharma, B.D. 2003. Modern Abattoir Practices and Animal Byproducts Technology.

Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.
2. Stadelman, W.J. and Cotterill, O.J. 1995. Egg Science and Technology, 4th edn. Food Products Press, NY, USA.

Online Resources:

1. https://oklahoma.gov/careertech/educators/resource-center/meat-processing-workforce-education.html
2. https://ehaccp.org/haccp-for-meat-and-poultry
3. https://elearning.fao.org/course/view.php?id=579&utm
4. https://seafoodacademy.org/topics/3-topics-seafish-open-learning-programmes.php
5. https://www.uspoultry.org/training/resources

IV – Year **VII – Semester**

Course Code: FEPC704	**Processing Technology of Meat, Fish and Poultry Lab**	**Credits 0-0-2: 1**

Course Outcomes: After completion of the course student will be able to:

CO1	Demonstrate practical knowledge of slaughtering, dressing, and handling of meat, poultry, and fish.
CO2	Apply preservation methods (freezing, curing, dehydration, fermentation, canning) for extending shelf life of animal products.
CO3	Evaluate quality parameters of meat, poultry, fish, and eggs using standard analytical techniques.
CO4	Develop value-added products from meat, fish, poultry, and eggs with appropriate processing methods.
CO5	Interpret industrial practices through field visits to abattoirs and fish/prawn processing plants.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3			1		1		2			2	2	
CO2	2	3			1		1		2			2	2	
CO3	2	3			1		1		2			2	2	
CO4	2	3	1		1		1		2			2	2	
CO5	2	3	3		1		1		2			2	2	

List of Experiments:

1. To study the pre-slaughter operations and slaughtering techniques of meat animals.
2. To study post-mortem changes and rigor mortis in meat.
3. To determine dressing percentage and carcass evaluation of meat animals.
4. To study meat cutting and handling techniques.
5. To preserve meat by freezing and study its quality changes.
6. To preserve meat by curing and pickling.
7. To preserve meat by dehydration and study drying characteristics.
8. To evaluate the quality and grading of eggs.
9. To study preservation methods of shell eggs.
10. To prepare value-added poultry meat products (e.g., nuggets/sausages).
11. To prepare value-added egg products.
12. To study anatomy, dressing and grading of fish.

13. To preserve fish by chilling and freezing.
14. To prepare and evaluate sun-dried or salt-cured fish.
15. To study canning methods for marine fishery products.

Learning Resources:

Text Books:

1. Nanda, Vikas 2014. Meat, Egg and Poultry Science and Technology. I.K. International Publishing House Pvt. Ltd., New Delhi.
2. Rautenstrauss, B.W. and Liehr, T. 2002. Fish Technology. Springer-Verlag, US.
3. Sen, D.P. 2005. Advances in Fish Processing Technology. Allied Publishers Pvt. Ltd., Delhi. 10. Sharma, B.D. and Sharma, K. 2011. Outlines of Meat Science and Technology. Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.
4. Swatland, H.J. 2004. Meat Cuts and Muscle Foods, 2nd edn. Nottingham Univ. Press, Nottingham.

Reference Books:

1. Sharma, B.D. 2003. Modern Abattoir Practices and Animal Byproducts Technology. Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.
2. Stadelman, W.J. and Cotterill, O.J. 1995. Egg Science and Technology, 4th edn. Food Products Press, NY, USA.

Online Resources:

1. https://ehaccp.org/haccp-for-meat-and-poultry
2. https://elearning.fao.org/course/view.php?id=579
3. https://seafoodacademy.org/topics/3-topics-seafish-open-learning-programmes.php
4. https://www.uspoultry.org/training/resources

Professional Elective Courses

III – Year **VI – Semester**

Course Code: FEPE601	Food Process Calculations	Credits 3-0-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand and apply fundamental concepts of process engineering calculations (units, dimensions, mole, temperature, pressure).
CO2	Analyze and solve problems using chemical equations and stoichiometry relevant to food processes.
CO3	Explain unit operations and apply mathematical tools to food processing operations.
CO4	Perform material balance calculations for physical and chemical processes including recycle, purge, and bypass.
CO5	Apply principles of energy balance to food processing operations including enthalpy, solution, and mixing.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3								3	3	2	
CO2	3	3		2								3		
CO3	3		3	3						2		3	2	3
CO4	3		3		3				2		3	3		3
CO5	3			3								3	2	3

Syllabus:

Unit I	**Introduction to process engineering calculations:** Units and dimensions, the mole unit, conventions in methods of analysis and measurement, basis, temperature, pressure, the chemical equation and stoichiometry.	7 lectures
Unit II	**Chemical Equations and Stoichiometry:** The chemical equation, Stoichiometric relations, Applications in food systems	9 lectures
Unit III	**Unit operations in food processes:** Unit operations involved in food processing, mathematical concepts used in food processing operations.	9 lectures
Unit IV	**Material balances:** Material balance of physical processes with and without chemical reactions, including recycle, purge and bypass, material balances for various food processing operations.	9 lectures
Unit V	**Energy balances:** Concept and Units, calculation of enthalpy changes, general balance with reactions, heats of solution and mixing. Energy balances for various food processing operations.	8 lectures

Learning Resources:

Text Books:

1. Yanniotis, S. (2007). Solving problems in food engineering. Springer.
2. Heldman, D. R., & Singh, R. P. (2014). Food Process Engineering. Academic Press.

Reference Books:

1. Himmelblau, D. M., & Riggs, J. B. (2012). Basic principles and calculations in chemical engineering. FT press.
2. Bhatt, B. I., & Vora, S. M. (1976). Stoichiometry. Tata McGraw Hill.

Online Resources:

1. https://www.rpaulsingh.com/course/

III – Year **VI – Semester**

Course Code: FEPE602	Processing of spices and plantation crops	Credits 3-0-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Explain the production, processing scenario, and scope of major and minor spices, flavor, and plantation crops.
CO2	Analyze post-harvest technology, composition, and processed products of major spices and plantation crops.
CO3	Demonstrate knowledge of spice oil, oleoresin extraction, and advanced techniques such as cryogenic grinding and supercritical fluid extraction.
CO4	Evaluate quality standards and specifications (ESA, ASTA, FSSAI) along with sterilization and packaging methods for spices and spice products.
CO5	Utilize by-products and explore functional, nutritional, and flavor aspects of spices and plantation crops for value addition.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3								3	3	2	
CO2	3	3		2								3		
CO3	3		3	3						2		3	2	3
CO4	3		3		3				2		3	3		3
CO5	3			3								3	2	3

Syllabus:

Unit I	Production and processing scenario of spice, flavour and plantation crops and its scope; Major spices: Post harvest technology, composition; Processed products of spices: Ginger, chilli, turmeric, onion and garlic, pepper, cardamom. Equipment for cryogenic grinding.	7 lectures
Unit II	Minor spices: Herbs, leaves and spartan seasonings and their processing and utilization; All spice, Annie seed, sweet basil; Caraway seed, cassia, cinnamon Clove, coriander, cumin, dill seed; Fennel seed, nutmeg, mace, mint marjoram; Rosemary, saffron, sage; Savory, thyme, ajowan; Asafetida, curry leaves	9 lectures
Unit III	Post harvest technology for Tea, coffee, cocoa, Vanilla and annatto processing; Post-harvest technology and processing of areca nut, cashew nut, oil palm, coconut. Flavours of minor spices; Flavour of major spices.	9 lectures
Unit IV	Spice oil and oleoresins: Extraction techniques; Super critical fluid extraction of spices.	9 lectures
Unit V	Standard specification of spices; Standards like ESA, ASTA, FSSAI and maintenance of quality by fumigation, CAS and ETO sterilization. Functional packaging of spices and spice products; By products of	8 lectures

	plantation crops and spices.	

Learning Resources:

Text Books:

1. Peter, K. V. (2001). Handbook of Herbs and Spices (Vols. I-III). CRC Press.
2. Kumar, N., Khader, M. A., Rangaswami, J. B. M., & Irulappan, I. (2000). Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford & IBH Publishing Co. Pvt. Ltd.

Reference Books:

1. Prajapati, N. D., Purohit, S. S., Sharma, A. K., & Kumar, T. (2003). A Handbook of Medicinal Plants: A Complete Source Book. Agrobios.
2. Chadha, K. L., & Gupta, R. (1995). Advances in Horticulture: Vol. II - Medicinal and Aromatic Plants. Malhotra Publishing House.

Online Resources:

1. https://niftem.ac.in/newsite/pmfme/?taining_category=spices-plantation-crops&utm

III – Year **VI – Semester**

Course Code: FEPE603	**Food Regulations & Safety Management System**	**Credits 3-0-0: 3**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the History and implementation of Food Laws in India
CO2	Understand and apply the Licensing and Registration Process in India
CO3	Apply the principles of FSMS in Food Industry
CO4	Demonstrate and understanding the effectiveness of process certification
CO5	Demonstrate and understanding of statutory requirements of labelling of food product

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2										3		
CO2	3	3	2									3		
CO3	3		3		2					2		3	2	
CO4	3		3	2	3				2	2	3	3		3
CO5	3			3								3	2	3

Syllabus:

Unit I	Introduction, concept of food safety, Food Security and Nutrition Security. Indian and Food Regulatory Regime (Existing and old), FSSAI, PFA Act and Rules, Food Licensing and Registration System, Food Import Clearance System. Food hazards and contaminations - biological (bacteria, viruses and parasites), chemical (toxic constituents / hazardous materials) pesticides residues / environmental pollution / chemicals) and physical factors.	8 lectures
Unit II	Food Safety and Standards Act, 2006, Food Safety Standards Regulation, Essential Commodities Act, 1955, Global Scenario, Codex Alimentarius, WHO/FAO Expert Bodies (JECFA/JEMRA/JMPR). Food safety inspection	8 lectures

	services (FSIS) and their utilization. Legal Metro logy act, Weight and Measurement act.	
Unit III	Introduction to OIE and IPPC, Other International Food Standard Bodies (e.g. European Commission, USFDA etc). WTO: Introduction to WTO Agreements: SPS and TBT Agreement, Export and Import Laws and Regulations, Export (Quality Control and Inspection) Act, 1963. Customs Act and Import Control Regulations, Other Voluntary and mandatory product specific regulations, Other Voluntary National Food Standards: BIS, Functions of BIS; AGMARK. Nutritional Labeling, Health claims.	9 lectures
Unit IV	Risk assessment studies: Risk management, risk characterization and communication. Concept and Implementation of HACCP in a food premises.	9 lectures
Unit V	Voluntary Quality Standards and Certification GMP, GHP, GAP, Good Animal Husbandry Practices, ISO 9000, ISO 22000, ISO 14000, ISO 17025, PAS 22000, FSSC 22000, BRC,. Halal & Kosher Standard.	8 lectures

Learning Resources:

Text Books:

1. Singal RS, Handbook of indices of food quality and authenticity; Woodhead Publ. Cambridge, UK.
2. Shapton DA, Principles and practices of safe processing of foods; Butterworth Publication, London.
3. Winton AL, Techniques of food analysis; Allied Science Publications New Delhi.

Reference Books:

5. Pomeranze Y, Food analysis - Theory and Practice; CBS Publications, New Delhi.
6. Jacob MB, The chemical analysis of foods and food products; CBS Publ. New Delhi
7. FSSAI website: www.fssai.gov.in

Online Resources:

1. https://fssai.gov.in/upload/uploadfiles/files/Guidance_Document_Poultry_06_01_2020.pdf
2. https://fssai.gov.in/cms/draft-food-safety-management-system-fsms-guidance-documents.php

IV– Year **VII – Semester**

Course Code: FEPE701	**Functional Foods and Nutraceuticals**	**Credits 3-0-0: 3**

Course Outcomes: After completion of the course student will be able to:

CO1	Define and classify functional foods and nutraceuticals.
CO2	Identify key bioactive compounds and their health implications.
CO3	Evaluate the role of functional foods in disease prevention and health promotion.
CO4	Understand regulatory and safety considerations in the development of functional food products.
CO5	Explore current trends and challenges in the functional food industry

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2											3	
CO2	3	3										2	3	
CO3	3		3		2					2			3	2
CO4	3		3	3	3				2		3		3	
CO5	3			3								3	3	2

Syllabus:

Unit I	**Introduction to Functional Foods** Definitions and distinctions between functional foods, nutraceuticals, and dietary supplements. Historical development and global perspectives. Classification based on source and function. Mechanisms of action and health benefits.	8 lectures
Unit II	**Bioactive Components and Health Implications** Phytochemicals: polyphenols, flavonoids, carotenoids, glucosinolates. Dietary fibers and prebiotics: types, sources, and health benefits. probiotics and synbiotics: mechanisms and applications.	8 lectures
Unit III	Functional lipids: omega-3 fatty acids, conjugated linoleic acid (CLA). Bioactive peptides and proteins. Role in prevention and management of chronic diseases: cardiovascular diseases, diabetes, cancer, etc.	9 lectures
Unit IV	**Development and Processing of Functional Foods** Selection and sourcing of functional ingredients. Processing techniques and their impact on bioactive compounds. Formulation strategies for functional food products. Stability, bioavailability, and sensory evaluation. Quality control and assurance in functional food production. Nutraceuticals: Definition, common products in market, health impact and safety.	9 lectures
Unit V	**Regulatory, Safety, and Market Aspects** Regulatory frameworks: global and national perspectives. Safety assessments and risk analysis. Health claims: types, substantiation, and labeling requirements. Market trends, consumer perceptions, and challenges in commercialization. Future directions and research opportunities in functional foods.	8 lectures

Learning Resources:

Text Books:

1. Vattem, D. A., & Maitin, V. (2016). *Functional foods, nutraceuticals and natural products: Concepts and applications*. DEStech Publications.

Reference Books:

1. Wildman, R. E. (2019). Nutraceuticals and Functional Foods. In Handbook of nutraceuticals and functional foods (pp. 3-22). CRC Press.
2. Gibson, G. R., & Williams, C. M. (2005). Functional foods (Vol. 393). IFIS Publishing.
3. Gupta, R. C. (2016). Nutraceuticals: Efficacy, Safety and Toxicity. Academic Press.

Online Resources:

1. https://www.ifpti.org/resource-catalog/p/sanitation-essentials-in-food-manufacturing-online-program

IV– Year **VII – Semester**

Course Code: FEPE702	Food Plant Sanitation	Credits 3-0-0: 3

Course Outcomes: After completion of the course, student will be able to:

CO1	Understand the principles of sanitation, related laws, regulations, and practices in the food industry.
CO2	Analyse the role of microorganisms, allergens, and foodborne bioterrorism in sanitation and apply suitable control measures.
CO3	Identify sources of food contamination and apply hygienic handling practices to ensure food safety.
CO4	Evaluate cleaning compounds, sanitizers, and integrated pest management techniques for effective sanitation.
CO5	Apply sanitary design principles, waste management techniques, and HACCP-based systems for maintaining food industry hygiene and safety.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2			1					3	2	2
CO2	2	3	2	1	1	1						2	2	2
CO3	1	1	1	3	2	2	1					2	2	3
CO4	3	2	2	2	2	2						3	2	3
CO5	2	2	3	2	2	2	2	1	2		2	3	3	2

Syllabus:

Unit 1	Sanitation and food industry: Sanitation, sanitation laws, regulations, and guidelines, establishment of sanitary Practices. Foodborne bioterrorism: Potential risks and protection measures for bioterrorism.	6 lectures
Unit 2	The Relationship of microorganisms to sanitation: Microbial growth in relation to spoilage and food borne out breaks and its control measures. The Relationship of allergens to sanitation: Food allergens and its control measures.	10 lectures
Unit 3	Food contamination sources: Sources of contamination, contamination of foods, protection against contamination. Personal hygiene and sanitary food handling: Personal hygiene, employee hygiene, sanitary food handling, role of employee supervision, employee responsibility.	6 lectures
Unit 4	Cleaning compounds and sanitizers: Classification, selection of cleaning compounds and sanitizers, CIP and COP, handling and storage, precautions. Pest and Rodent Control: Insect infestation, cockroaches, insect destruction, rodents, birds, use of pesticides, integrated pest management.	8 lectures
Unit 5	Sanitary design and construction for food processing: Site selection, site preparation, building construction considerations, processing and design considerations, pest control design. Waste product handling: solid waste and liquid waste management. Role of HACCP in sanitation: Good manufacturing practices, current good manufacturing practices; Standard	12 lectures

	operating procedures, good laboratory practices.	

Learning Resources:

Text Books:

1. Hui, Y. H., Evranuz, E. Ö., & Özgül Evranuz, E. (2012). Food Plant Sanitation. CRC Press.
2. Cleeland, R., & Gray, M. (2007). Food Sanitation: Principles and Practices. Springer.

Reference Books:

1. Singleton, G. L. (2013). Current Good Manufacturing Practices/Food Plant Sanitation. Elsevier.
2. Stringer, S., & Phillips, J. (2014). Food Plant Sanitation and Hygiene Practices. CRC Press.

Online Resources:

1. https://www.ifpti.org/resource-catalog/p/sanitation-essentials-in-food-manufacturing-online-program
2. https://www.springer.com/gp/book/9780387235039
3. https://aibinternational.com/products/food-safety-and-sanitation-online

IV – Year **VII – Semester**

Course Code: FEPE703	**Principles of Food Product Development**	**Credits 3-0-0: 3**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand nutrients, food groups, nutritive values, and dietary allowances.
CO2	Apply knowledge of nutrition across different age groups and physiological conditions.
CO3	Analyse therapeutic diets and plan diets using exchange lists.
CO4	Evaluate functional foods and nutraceuticals with their design principles.
CO5	Assess and interpret the sensory attributes of food products to ensure quality, acceptability, and consumer satisfaction.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1									3		
CO2	3	1	1									2		
CO3	1	1	3	2								3		
CO4	3		2	2	1							2		
CO5	2	1	1	2	3							1		

Syllabus:

Unit 1	Nutrients and their function, food classification and their nutritive value, anti-nutritional factors present in food; Concept of different food groups,	05 lectures

	recommended dietary allowances (RDA) for Indians; nutrition for infant, pre-school and school children, adult, pregnant and lactating women, old age people.	
Unit 2	Production and formulation of Indian traditional sweet and snack food products, steps for quality improvement and value addition.	10 lectures
Unit 3	Therapeutic diets – Principles and objectives of diet therapy, diet for patient suffering from Diabetes mellitus, osteoporosis, cardiac problem, gastrointestinal disorder, Diet planning and use of exchange list in nutrient calculation.	10 lectures
Unit 4	Functional foods - definition and concepts; design of functional foods; Nutraceuticals food - definition and concepts, design of nutraceutical foods. Recent trends in food formulation; antioxidant rich food products; concepts for formulation of foods for drought and disaster afflicted; defense services, sportsmen, space food.	08 lectures
Unit 5	Definition and importance of sensory evaluation in relation to consumer acceptability and economic aspects, Factors affecting food acceptance; Terminology related to sensory evaluation; Principles of good practice: the sensory testing environment. Interrelationship between sensory properties of food products and various instrumental and physico-chemical tests. Sensory evaluation in quality control, Types of tests, panel selection and testing environment, serving procedures, instruction to judges, difference tests, directional difference tests, classification of difference tests, two-sample tests, three- sample tests, multisampling tests, comparison of procedures, ranking, scoring, hedonic scaling; dilution procedures, descriptive sensory analysis, contour method, other procedures, development of the questionnaire, types of questionnaires, serving procedures.	10 lectures

Learning Resources:

Text Books:

1. Antia, F.P. 1974. Clinical Dietetics and Nutrition, Oxford Medicine Publications.
2. Pokorny, J., Yanishlieva, N. and Gordon, M. 2001. Antioxidants in Food, Woodhead Publishing Limited, Abington Hall, Abington.
3. Potter, N. N. and Hotchkiss, J.H. 1995. Food Science, 5th edn. Chapman and Hall, NY, USA.
4. Mazza, G.1998. Functional Foods. Biochemical and Processing Aspects, Technomic Publ. Co.
5. Robinson, C. 1975. Basic Nutrition and Diet Therapy, Macmillan.
6. Swaminathan, M.1974. Essentials of Nutrition, Ganesh Co.
7. Steinkrauss, K.H. 1995. Handbook of Indigenous Fermented Foods, Marcel Dekker

Reference Books:

1. Davidson, S., Passmore, R. and Eastwood, M.A. 1986. Davidson and Passmore Human Nutrition and Dietetics. Churchill Livingstone.
2. Gopalan, C., Ramshastri, B.V., Balasubramaniam, S.C. 1989. Nutritive Value of Indian Foods National Institute of Nutrition, Hyderabad.

Course Code: FEPE801	Waste and by-product utilization	Credits 3-0-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Identify types and magnitude of food by-products and waste in production and processing
CO2	Use waste characteristics and apply waste management and effluent treatment concepts.
CO3	Analyze biomass combustion processes and assess the benefits of briquettes.
CO4	Explore thermo-chemical and biochemical conversion methods like gasification and biogas production.
CO5	Apply solid waste management techniques and understand key effluent treatment parameters.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	3							1	2	1	
CO2	2	2	3	2								1		
CO3	2	2	2	2	1						1	2	2	
CO4	2	3	1	3	1						2	3	3	3
CO5	3	3	2	3	3		1				1		3	3

Syllabus:

Unit I	Introduction; By-products/waste, types of food by-product and waste, magnitude of by-products and waste in food production, magnitude of by-products and wastes in food processing	6 lectures
Unit II	Waste management concepts; Waste characteristics, waste management and effluent treatment	6 lectures
Unit III	Direct combustion of solid waste; Proximate and ultimate analysis of biomass, theory of combustion, direct combustion of biomass as fuel in furnaces, briquettes, advantages and uses of briquettes.	6 lectures
Unit IV	Thermo-chemical and Bio-chemical conversion of solid waste; Biomass gasification, gasification process mechanism, types of gasifier reactors, utilization of producer gas, Biogas, biogas plants, classification of biogas plants	4 lectures
Unit V	Solid waste management; Methods of disposal solid waste, Vermin composting Effluent treatment and disposal; Parameters of effluent like temperature, pH, Oxygen demands (BOD, COD), fat oil and grease content, metal content, forms of phosphorous and sulphur in effluent	6 lectures

Learning Resources:

Text Books:

1. Bhatia, S. C. (2001). *Environmental Pollution and Control in Chemical Process Industries*. New Delhi: Khanna Publishers.
2. Garg, S. K. (1998). *Environmental Engineering (Vol. II): Sewage Disposal and Air Pollution Engineering*. New Delhi: Khanna Publishers.
3. Joshi, V. K., & Sharma, S. K. (2011). *Food Processing Waste Management: Treatment & Utilization Technology*. New Delhi: New India Publishing Agency.

4. Markel, I. A. (1981). *Managing Livestock Waste*. Westport, CT: AVI Publishing Co.

Reference Books:

1. Prashar, A., & Bansal, P. (2008). *Industrial Safety and Environment*. New Delhi: S.K. Kataria and Sons.
2. Shewfelt, R. L., & Prussi, S. E. (1992). *Post-Harvest Handling: A Systems Approach*. San Diego, CA: Academic Press Inc.
3. USDA. (1992). *Agricultural Waste Management Field Handbook*. Washington, DC: USDA.
4. Vasso, O., & Winfried, R. (Eds.). (2007). *Utilization of By-products and Treatment of Waste in the Food Industry*. New York: Springer Science & Business Media, LLC.

Online Resources:

1. https://agrimoon.com/wp-content/uploads/Waste-and-By-product-Utilization.pdf
2. http://ecoursesonline.iasri.res.in/course/view.php?id=518

Course Code: FEPE802	**Renewable Energy in Food Processing**	**Credits 3-0-0: 3**

Course Outcomes: After completion of the course student will be able to

CO1	Understand renewable energy sources and their applications in food processing.
CO2	Analyse solar energy systems and their utilization in food industry.
CO3	Apply biomass conversion technologies and biodiesel production.
CO4	Evaluate biogas technology, slurry utilization, and food waste-based energy generation.
CO5	Demonstrate awareness of wind, hydro, and ocean energy applications.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2		1						3	2	2
CO2	2	3	1	2		2	1					3	3	3
CO3	3			3		2	2	1				2	1	2
CO4	2	3	2	3			3		2		1	2	1	2
CO5	3	3	2		3	2						3		

Syllabus:

Unit I	Introduction to energy sources; classification of renewable energy sources, utilization of these sources in food processing sector	4 lectures
Unit II	Solar radiation, measurement of solar radiation, types of solar collectors and their uses; familiarization with solar energy gadgets: solar cooker, solar concentrator, solar dryer, solar steam generator; utilization of solar thermal energy in food processing; Solar photovoltaic cells, modules, arrays, conversion process of solar energy into electricity, applications in food industry	6 lectures
Unit III	Biomass and its characterization; briquetting of biomass. Biomass combustion, pyrolysis, gasification and uses of gasifiers in food industry and biodiesel preparation	6 lectures

Unit IV	Importance of biogas technology, production mechanism, types of biogas plants, uses of biogas, handling and utilization of digested slurry. Use of food waste for biogas generation and its applications	8 lectures
Unit V	Brief introduction to wind energy, hydroelectric energy, ocean energy.	4 lectures

Learning Resources:

Text Books:

1. Khandelwal, K.C. and S. S. Mahdi. 1990. Biogas Technology- A Practical Handbook. Rai, G.D. 2013.
2. Non-Conventional Energy Sources, Khanna Publishers, Delhi.
3. Rai, G.D., Solar Energy Utilization, Khanna Publishers, Delhi.
4. Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Non-Conventional Energy Sources, Himanshu Publications.

Reference Books:

1. Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Renewable Energy, Theory and Practice, Himanshu Publications.
2. Tiwari, G.N. and Ghoshal, M.K. 2005. Renewable Energy Resources: Basic Principles and Applications. Narosa Pub. House. Delhi.

Online Resources:

1. https://www.indepthresearch.org/course/integrating-renewable-energy-in-agriculture-training-course?utm_source=chatgpt.com
2. https://www.digicomply.com/blog/sustainable-energy-production-in-the-food-industry-a-glimpse-into-the-future?utm_source=chatgpt.com
3. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Nov/IRENA_FAO_Renewables_Agrifood_2021.pdf

Course Code: FEPC803	**Operations Research and Management**	**Credits 3-0-0: 3**

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the fundamental concepts, scope, and applications of operations research and management in decision-making.
CO2	Formulate and solve linear programming and transportation problems for optimizing resources.
CO3	Apply network analysis, queuing theory, and inventory models to real-life operational situations.
CO4	Analyze project management techniques such as PERT and CPM for effective planning and control.
CO5	Evaluate and apply quantitative techniques for strategic, tactical, and operational decision-making in business and industry.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**

CO1	3	2	1	2							1	2	1	
CO2	2	2	3	2								1		
CO3	2	2	1	2	1						1	2	2	
CO4	2	3	1	3	2						2	3	3	3
CO5	3	3	2	3	3		1				1		3	3

Syllabus:

Unit I	Introduction–Elementary concepts, objectives of operations research, Applications of OR in decision-making; Modelling in Operation Research; Linear Programming: Introduction, mathematical formulation of the problem, Graphical solution, Simplex technique for solving simple LP problems.	6 lectures
Unit II	Inventory Control – Introduction and general notations, Economic lot size models with known demand; Replacement – Introduction, Replacement of items whose efficiency deteriorates with time.	6 lectures
Unit III	Queuing – Introduction and general notions, Classification of queues and their problems, Probability distribution of queues; Various models in the queuing system; Sequencing – Statement of the problem, notations and assumptions, Problems with 'n' jobs and two machines; Generalization to 'm' machines.	6 lectures
Unit IV	Transportation model – Definition and application of transportation model, Formulation of transportation problems and their solutions; Assignment problems and their solutions.	6 lectures
Unit V	Framework of PERT and CPM, Activities, events and network, PERT and activity time estimates, probability of project completion critical path analysis.	4 lectures

Learning Resources:

Text Books:

1. Churchman, C.W., Ackoff R. L. and Arnoff, E.L. 1957. Introduction to Operations Research. John Wiley and Sons, New York.
2. Goel, B.S. and Mittal, S.K. 1974. Operations Research. Pragati Prakashan, Meerut.
3. Kapoor, V.K. and Kapoor, S. 2001. Operations Research Techniques for Management. Sultan Chand and Sons, New Delhi.
4. Sasieni, M.A., Yaspan and Friedman, L. 1959. Operations Research: Methods and Problems. John Wiley and Sons, New York.

Reference Books:

1. Sharma, S.D. 1999. Operations Research. Kedar Nath Ram Nath & Co., Meerut. Swarup, K., Gupta, P.K. and Mohan, M. 1989. Operations Research. Sultan Chand and Sons, New Delhi.
2. Taha, H. A. 2003. Operations Research. 7th edm. Pearson Education, New Delhi. Taha, H.A. 2005. Operations Research: An Introduction. Prentice Hall of India Private Limited, New Delhi.
3. Wagner, H.M. 1982. Principles of Operations Research, with Applications to Management Decisions. Prentice Hall of India, New Delhi.

Online Resources:

https://www.youtube.com/results?search_query=operations+research+tutorial
https://www.sciencedirect.com/journal/european-journal-of-operational-research

Course Code: FEPE804	Food Plant Design and Layout	Credits 3-0-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the fundamental principles of food plant design, layout, and material flow.
CO2	Apply knowledge of sanitary and safety considerations in designing food processing plants.
CO3	Analyse plant location, layout alternatives, utilities, and equipment selection for efficient operations.
CO4	Design functional layouts and process flow diagrams for various food industries.
CO5	Evaluate plant economics, expansion needs, and environmental aspects in food plant design.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3					3	3					3		2
CO2	3	3	2	3								3		
CO3	3		3		3					2	2	3	2	
CO4	3		3	3					2	2	3	3		3
CO5	3			3								3	2	3

Syllabus:

Unit I	Introduction: Classification of food processing plants, food plant design concepts, situations giving rise to plant design problems and general design considerations (technical, economic, legal, safety and hygiene). Feasibility Study Steps involved in feasibility study, collection of the information, information flow diagrams, market analysis, technical analysis and preparation of feasibility report.	7 lectures
Unit II	Plant Location: Factors affecting plant location, their interaction with plant location, location theory models for evaluation of alternate locations. Plant Size Economic plant size, factors affecting the plant size (technical and economical), raw material availability, market demand, competition in the market, return on investment etc. Procedures for estimation of economic plant size (breakeven analysis and optimization), estimation of volume of production for each product.	9 lectures
Unit III	Product and Process Design; Design of product, product specifications, least cost mix of raw materials, process design, process selection considering technical, economic and social aspects. Process planning and scheduling, flow sheeting, flow diagrams and process flow charts including their design and computer aided development of flow charts.	9 lectures
Unit IV	Plant Layout Types of layouts, considerations involved in planning an efficient layout, preparation and development of layout, evaluation of alternate layouts, use of computers in development and evaluation of layouts, equipment symbols, flow sheet symbols, electric symbols, graphic symbols for piping systems, standards for space requirement and dimensions, distances between critical plant areas and for different plant	9 lectures

	facilities. Planning and Design of Service Facilities and Plant Surroundings Requirements of the steam, refrigeration, water, electricity, waste disposal, lighting, ventilation, drainage, CIP system, dust removal, fire protection etc.	
Unit V	Workers Safety and Health Aspects Falling hazards and safeguards, electric hazards, heat exposure, dust protection, noise control, protection against chemicals, fire safety, fumes, moist conditions, personnel hygiene, sanitary requirements and standards, insect, rodent and bird control. Building and Building Materials Requirements in respect of building type, wall, ceiling and floor construction, building height and building materials.	8 lectures

Learning Resources:

Text Books:

1. Chemical Engineering Handbook by Perry R.H. Published by McGraw-Hill.
2. Chemical Engineering Plant Design by Villbrandt F.C. and Dryden C.E. Published by McGraw Hill.
3. Computer Aided Process Plant Design by Leesley M.E. Published by Gulf Publishing Company, Houston.
4. Engineering Economic Analysis by W.T. Morris. Published by Reston Publishing Company, Inc., New York.
5. Food Plant Economics by Z.B. Maroulis and G.D. Sarvacos. Published by CRC press.
6. Project Feasibility Analysis by Clifton D.S. and D.E. Fyfee. Published by John Willey and Sons, New York.

Reference Books:

1. Plant Design and Economics for Chemical Engineers by Peters M.S. and K.D. Timmerhaus. Published by McGraw-Hill.
2. Plant Layout and Design by J.M. Moore Published by The McMillan company.
3. Process Plant Design by Backhusrt J.R. and J.H. Barker. Published by Heimann Educational Books, London.
4. Chemical Engineering Plant Design by Villbrandt F.C. and Dryden C.E. Published by McGraw Hill.

Online Resources:

1. https://uniathena.com/short-courses/mastering-productivity-and-plant-layout
2. https://agrimoon.com/wp-content/uploads/Food-Processing-Plant-Design-layout.pdf
3. https://www.ksrct.ac.in/assets/pdf/foodtech/e_content/food.pdf

Course Code: FEPE805	Process Modeling and Simulation	Credits 2-1-0:3

Course Outcomes: After completion of the course student will be able to

CO1	Ability to prepare a flowsheet of food processing operations.
CO2	Ability to identify the design, operating and performance parameters in food processing operations.
CO3	Ability to develop first principle-based model equations for unit operations in food processing.
CO4	Ability to solve, validate and analyze for sensitivity of model equations.

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

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2		2						3	2	3
CO2	2	3	1	2		2	1					3	3	3
CO3	3	2	1	2		2		1				2	1	2
CO4	2	3	2	2			3		2		1	1	1	2
CO5	3	3	2		3	2						3	2	

Syllabus:

Unit I	Introduction: The role of models in process systems engineering; a systematic approach to model building; conservation principles; constitutive relations; basic mathematic tools for model solution	4 lectures
Unit II	Dynamic Models: Dynamic Models - Lumped Parameter Systems; Solution Strategies for Lumped Parameter Models; Dynamic Models - Distributed Parameter Systems Solution Strategies for Distributed Parameter Systems; Process Model Hierarchies	6 lectures
Unit III	Model Analysis: Basic Tools for Process Model Analysis; Statistical Model Calibration and Validation; Analysis of Dynamic Process Models; Process Modeling for Control and Diagnostic Purposes; Modeling Discrete Event Systems;	6 lectures
Unit IV	Computer Aided Process Modeling: Modeling Hybrid Systems; Modeling Applications in Process Systems; computer Aided Process Modeling; Empirical Model Building.	7 lectures
Unit V	Food Process Modeling: Mathematical modeling of common food processes: heating, thermal processing, drying, evaporation, size reduction.	5 lectures

Learning Resources:

Text Books:

1. Cameron, I. T., & Hangos, K. (2001). Process modelling and model analysis (Vol. 4). Elsevier.
2. Tijskens, L. M. M., Hertog, M. L. A. T. M., & Nicolaï, B. M. (Eds.). (2001). Food process modelling (Vol. 59). Woodhead Publishing.

Reference Books:

1. Özilgen, M. (1998). Food process modeling and control: chemical engineering applications.
2. Bakalis, S., Knoerzer, K., & Fryer, P. J. (Eds.). (2015). Modeling food processing operations. Elsevier.

Online Resources:

1. https://alison.com/course/engineering-system-design-modeling-techniques-and-simulations

2. https://onlinecourses.nptel.ac.in/noc22_ch58/preview
3. https://www.anylogic.com/resources/books/free-simulation-book-and-modeling-tutorials/

Course Code: FEPE806	Food Business Management and Entrepreneurship Development	Credits 2-1-0:3

Course Outcomes: After completion of the course student will be able to

CO1	Apply project management and entrepreneurship concepts.
CO2	Perform project formulation, scheduling, and resource allocation.
CO3	Estimate project costs and calculate break-even analysis.
CO4	Identify business opportunities and apply SWOT analysis in food processing
CO5	Analyse financial institutions' roles and evaluate supply chain management in food businesses.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2		2						3	2	3
CO2	2	3	1	2		2	1					3	3	3
CO3	3	2	1	2		2		1				2	1	2
CO4	2	3	2	2			3		2		1	1	1	2
CO5	3	3	2		3	2						3	2	

Syllabus:

Unit I	Introduction and definitions related with project management and entrepreneurship; Fundamentals of project management and entrepreneurship development.	4 lectures
Unit II	Project formulation: market survey techniques, project identification, project selection, project proposal, work breakdown structure; Network scheduling: activity, networks, use of CPM, PERT in project scheduling. Resource planning, resource allocation, project scheduling with limited resources	6 lectures
Unit III	Estimation of project costs, earned value analysis, project techno-economic viability, break-even analysis.	7 lectures
Unit IV	Identification of business opportunity in food processing sector; Government policies for promotion of entrepreneurship in food processing; Launching and organizing an enterprise, enterprise selection, market assessment, feasibility study, SWOT analysis; Resource mobilization	7 lectures
Unit V	Financial institution in promoting entrepreneurship; Supply chain management; Case study of a food business.	4 lectures

Learning Resources:

Text Books:

1. Awasthi, D., & Jaggi, R. (2005). *Entrepreneurship and management inputs for entrepreneurs in food processing sector*. EDII.

2. Bell, G. F., & Balkwill, J. (2003). *Management and engineering*. Prentice Hall International.

Reference Books:

1. Bharatia, C. R. (2007). *Food technology and entrepreneurship management*. Surendra Publications.
2. Jordan, L. (2015). *Food industry: Food processing and management* (2nd ed.). Callisto.

Online Resources:

1. http://ecoursesonline.iasri.res.in/mod/resource/view.php?id=5961
2. https://elearning.icar.gov.in/DisplayUG_ECoursesContent.aspx?CourseCode=RHobmwnQyE7yP2N/Dy7jlA

Course Code: FEPE807	Emerging Technologies in Food Processing	Credits 2-1-0:3

Course Outcomes: After completion of the course student will be able to

CO1	Enumerate emerging technologies and evaluate their scope and applications in food processing.
CO2	Analyse principles and applications of advanced heating systems and perform equipment selection for hybrid drying technologies.
CO3	Evaluate vacuum, high pressure, pulsed electric field, ultrasonication, and radiation-based processing methods and equipment.
CO4	Test and apply advanced processing techniques like pulsed X-ray, cold plasma, ozone treatment, and dense phase carbon dioxide systems.
CO5	Analyse the manufacture and applications of nanomaterials in food processing

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2		2						3	2	3
CO2	2	3	1	2		2	1					3	3	3
CO3	3	2	1	2		2		1				2	1	2
CO4	2	3	2	2			3		2		1	1	1	2
CO5	3	3	2		3	2						3	2	

Syllabus:

Unit I	Introduction, different emerging technologies and their scope and applications.	4 lectures
Unit II	Principle, equipment and applications of ohmic heating, infrared heating, dielectric heating, microwave heating systems, radio frequency heating equipment, combined microwave vacuum drying new hybrid drying technologies	6 lectures
Unit III	Principles and equipment for Vacuum processing, High pressure processing, Pulsed electric field processing, Ultrasonication, Gamma irradiation/ ionising radiation, Ultraviolet radiationprocessing.	6 lectures

Unit IV	Pulsed X-ray processing, Pulsed light processing, Cold plasma Processing, Ozone treatment,Electron beam processing, Static and oscillating magnetic fields, Dense phase carbon dioxide, High voltage arc discharge.	7 lectures
Unit V	Nanomaterial utilisation in food processing, manufacture of nanomaterials, applications	5 lectures

Learning Resources:

Text Books:

1. Dash, S. K., Chandra, P., & Kar, A. (2016). *Food engineering principles and practices*. CRC Press.
2. Passos, M. L., & Ribeiro, J. A. (2011). *Innovation in food engineering: New techniques and products*. CRC Press.
3. Sun, D.-W. (2006). *Thermal food processing: New technologies and quality issues*. CRC Press.

Reference Books:

1. Sun, D.W. (2004). *Emerging technologies in food processing*. Elsevier.
2. Tewari, G., & Juneja, V. K. (2012). *Advances in thermal and non-thermal food preservation*. Blackwell.

Online Resources:

1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=5138
2. https://onlinecourses.nptel.ac.in/noc20_ag02/preview

Exit Courses

At the end of I – Year: II – Semester

Course Code: FEEX201	Food Supply Chain Management	Credits 3-0-0: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Analyze the requirements for effective food supply chain management.
CO2	Identify the effect of food production, manufacturing, retailing and logistics on food
CO3	Apply effective sourcing and purchasing models to improve supply chain operations.
CO4	Analyze and manage the risk in the supply chain and apply aneffective traceability system.
CO5	Apply food laws and regulation for food safety and fulfill the sustainability challenges in food industry

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2		2						3	2	3
CO2	2	3	1	2		2	1					3	3	3
CO3	3	2	1	2		2		1				2	1	2
CO4	2	3	2	2			3		2		1	1	1	2
CO5	3	3	2		3	2						3	2	

Syllabus:

Unit I	Introduction to supply chains in India, types of food chains, factors influencing food supply chains, and case studies in food supply chains. Bullwhip Effect. Food retailing: The retail environment, online retailing of food, future challenges in food retailing Food logistics & distribution management: Logistics and supply chain structure. Integrated logistics and the supply chain, channels of distribution. Logistics processes, supply chain segmentation, logistic network planning, management and organization.	5 lectures
Unit II	Food Sourcing and Procurement: sourcing, sourcing models, purchasing models, supplier segmentation, supplier development, strategic sourcing, sustainable procurement, case example Risk Management: Risk management and uncertainty, Risks in the supply chain, Risks in the food supply chain, managing supply chain risks, managing risks in food supply chains, PARETO, Case examples Challenges in International food supply chains: International food supply chains, Factor affecting international food supply, International politics and food, case studies	5 lectures
Unit III	ERP in Supply Chain Management: Introduction to ERP and LC technologies, and their integration. Cloud ERP, software, benefits and challenges, un-premises ERP. Modules of ERPproduction, planning, sourcing, inventory anil warehouse management, and under processing, SAP main concepts, navigation, functionality, customization and documentation, demand forecasting. Demonstration of SAP	6 lectures
Unit IV	Trends in Food Supply Chains: Traceability and use of technology, food production, food processing in a technological context, food packaging in a technological context, food logistics Cold Chain technology and Management Food regulation, safety and quality: Attributes to consider when designing	6 lectures

	food supply chains, food regulation and its effect on safety, food laws and regulation, reference standards, compatibility standards, private food standards, other initiatives within the food supply chains, case examples.	
Unit V	Sustainability challenges in food supply chain: Introduction to sustainability, sustainable supply chains, sustainable food supply chains, measuring sustainability, developing sustainability within food supply chains, case studies.	6 lectures

Learning Resources:

Text Books:

1. Accorsi, R., and Manzim, R. (2016) Sustainable food supply chains-Planning, design, and control through interdisciplinary methodologies, Elsevier, Academic Press, ISBN: 978-0-12- 813411-5
2. Food Supply Chain Management and Logistics from Farm to fork. Samir Dani, Kogan Page

Reference Books:

1. Food Supply Chain Management. Michael A. Bourlakis (Editor), Paul W. H. Weightman (Editor), Wiley-Blackwell.
2. Food Safety Regulatory Compliance: Catalyst for a Lean and Sustainable Food Supply Chain, by Preston W. Blevins

Online Resources:

1. https://www.scribd.com/document/74654728/Food-Supply-Chain-Textbook

Course Code: FEEX202	**Operation and Maintenance of Food Processing Equipment**	**Credits 3-0-0: 3**

Course Outcomes: After completion of the course, student will be able to:

CO1	Understand the role of mechanization in food processing
CO2	Identify, select, and maintain food processing equipment.
CO3	Operate and repair primary processing equipment.
CO4	Apply maintenance practices for preservation and packaging equipment.
CO5	Ensure safe handling, storage, and by-product utilization in food industries.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1		1			1	1				3		
CO2	2	2	2	3			2	1	2	2	2	3	3	2
CO3	2	2	2	3			2	1	2	2	2	3	3	2
CO4	2	2	2	3			2	1	2	2	2	3	3	2
CO5	1	2	1	1			1		2			2	1	

Syllabus:

Unit I	Scope and benefits of mechanization in food processing industries, role in improving productivity, efficiency, quality, and hygiene. Limitations including high cost, energy consumption, environmental impact, and requirement of skilled manpower.	4 lectures
Unit II	Overview of various food processing equipment (cleaning, grading, drying, milling, storage, refrigeration). Criteria for selection based on capacity, raw material, and process requirements. Preventive and routine maintenance practices	7 lectures
Unit III	Operation, repair, and maintenance of equipment for cleaning, grading, sorting, and drying of grains, fruits, and vegetables. Maintenance of dryers and separators to ensure process efficiency	7 lectures
Unit IV	Operation and upkeep of equipment for milling, oil extraction, pasteurization, sterilization, blanching, refrigeration, freezing, and packaging. Maintenance practices to ensure safety and quality of processed foods.	7 lectures
Unit V	Operation and maintenance of conveyors, elevators, pumps, and storage structures. Equipment for waste management and by-product utilization. Safety measures to minimize equipment breakdowns and hazards in food industries	3 lectures

Learning Resources:

Text Books:

1. Sahay, K.M. and Singh, K.K. *Unit Operations of Agricultural Processing*. Vikas Publishing.
2. Heldman, D.R. and Singh, R.P. *Food Process Engineering*. Springer.
3. Toledo, R.T. *Fundamentals of Food Process Engineering*. Springer.

Reference Book:

1. Fellows, P.J. *Food Processing Technology: Principles and Practice*. Woodhead Publishing.
2. Charm, S.E. *The Fundamentals of Food Engineering*. AVI Publishing
3. Saravacos, G.D. and Kostaropoulos, A.E. *Handbook of Food Processing Equipment*. Springer.
4. Pandey, P.H. *Principles and Practices of Post-Harvest Technology*.

Course Code: FEEX203	**Unit Operations in Food Processing**	**Credits 3-0-0: 3**

Course Outcomes: After completion of the course, student will be able to:

CO1	Understand the geometrical, physical, and mechanical properties of food materials and their relevance in post-harvest and processing operations.
CO2	Apply principles of mechanical separation and size reduction, and analyze energy requirements using Rittinger's, Kick's, and Bond's laws.
CO3	Explain the principles of mixing and filtration processes and evaluate the performance of various equipment used in food processing.

CO4	Analyze the principles of drying and dehydration, including heat and mass transfer, drying kinetics, and their effects on product quality.
CO5	Evaluate evaporation and concentration operations, perform mass and energy balances, and assess process economy in multiple-effect systems.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1		1			1	1				3		
CO2	2	2	2	3			2	1	2	2	2	3	3	2
CO3	2	2	2	3			2	1	2	2	2	3	3	2
CO4	2	2	2	3			2	1	2	2	2	3	3	2
CO5	1	2	1	1			1		2			2	1	

Syllabus:

Unit I	Introduction: Geometrical, physical, functional and growth property of foods, post-harvest operations, concept of force and deformation in food materials. Mechanical separation processes: Sieving: screening efficiency and effectiveness	7 lectures
Unit II	Size reduction: Benefits, classification, determination and designation of the fineness of ground material, 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, crushers (jaw crushers, gyratory, smooth roll), hammer mills and impactors, attrition mills, buhr mill.	7 lectures
Unit III	Mixing: theory of solids mixing, criteria of mixer effectiveness and mixing indices, rate of mixing, theory of liquid mixing. Filtration: filter medium and cake resistances in pressure, vacuum and centrifugal filtration, filtration equipment; Types of centrifuges and their selection criteria	7 lectures
Unit IV	Drying & dehydration: Water activity and isotherm, Thermodynamics of moist air; Convective drying; drying curve, drying rates; heat & mass transfer during drying; Dryers in the food processing industry. Pre-drying treatments, Effect of drying conditions on quality, Energy consumption in drying, Other drying techniques: Foam-Mat drying, conductive drying, spray drying, refractance window Drying, Osmotic dehydration, heat pump drying.	8 lectures
Unit V	Evaporation and Concentration: Concentration of liquid foods in batch and continuous type evaporators; boiling point elevation, mass and energy balance during evaporation; Type of evaporators for food applications; Improving process economy: multiple-effect evaporator and recompression systems.	8 lectures

Learning Resources:

Text Books:

4. Sahay, K.M. and Singh, K.K. *Unit Operations of Agricultural Processing*. Vikas Publishing.
5. Heldman, D.R. and Singh, R.P. *Food Process Engineering*. Springer.

6. Toledo, R.T. *Fundamentals of Food Process Engineering*. Springer.

Reference Book:

5. Fellows, P.J. *Food Processing Technology: Principles and Practice*. Woodhead Publishing.
6. Charm, S.E. *The Fundamentals of Food Engineering*. AVI Publishing
7. Saravacos, G.D. and Kostaropoulos, A.E. *Handbook of Food Processing Equipment*. Springer.
8. Pandey, P.H. *Principles and Practices of Post-Harvest Technology*.

At the end of II – Year: IV– Semester

Course Code: FEPC604	**Bakery and Confectionary Products**	**Credits 3-0-0: 3**

Course Outcomes: After completion of the course student will be able to:

CO1	Know history and scope of bakery & confectionery industry.
CO2	Understand ingredients and their roles in bakery & confectionery.
CO3	Apply processing steps and equipment for bakery products.
CO4	Analyze dough rheology and product quality.
CO5	Explain processing of chocolate, candy, and toffee.

Mapping of course outcomes with program outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	1	2						2	3	1	1
CO2	3	3	2	1	2	1					2	3	2	1
CO3	3	3	3	2	2						2	3	1	1
CO4	3	3	3	3	2			1			2	3	2	2
CO5	3	2	3	2	3			1			2	3	2	2

Syllabus:

Unit I	Historical development and status of bakery industry in India; Introduction and definition of bakery products as per FSSAI-bread, biscuit, cake, pastries, rusk, crackers, bun and their specifications. Bakery Plant - Layout, setting up of units and hygienic conditions, operation and maintenance.	5 lectures
Unit II	Bread and Biscuit Processing Bread- types; role of major and minor ingredients; processes of bread making; problems associated with bread; equipment for bread manufacturing; Processing steps for biscuit, cookies, cracker, cakes and their major and minor ingredients; equipment for biscuit manufacturing. Rheological testing of dough-Farinograph, mixograph. Extensograph, Amylograph/ Rapid- visco analyzer, Falling number and interpretation of data.	5 lectures
Unit III	Cakes: Flour specifications-, ingredients, manufacturing process and quality evaluation. Preparation of other bakery products - rusks, crackers, buns, muffins, pizza; raw materials, methods of production, quality parameters. Confectionary- historical development; classification of confectionary products; basic technical considerations for confectionary products-TS, TSS, pH, acidity, ERH, RH. Raw materials and their role in	6 lectures

	confectionary product;	
Unit IV	Cocoa, Chocolate Processing Cocoa historical bean- introduction, history and composition; processing of cocoa bean; processed product of cocoa; development in chocolate processing; ingredients and their role in chocolate; processing steps of chocolate processing- mixing, refining, conching, tempering, molding, cooling, coating, enrobing etc.	6 lectures
Unit V	Candy and Toffee Processing High boiled sweets/candy - composition, production and preparation of high boiled sweets- traditional, batch and continuous method; to ffee- composition, types, ingredient and their role, batch and continuous method of toffee manufacturing.	6 lectures

Learning Resources:

Text Books:

2. Y. Pomeranz, Modern Cereal Science and Technology, MVCH Publications, NY
3. Samuel A. Matz, Bakery Technology and Engineering,Chapman and Hall

Reference Books:

1. A Bent, E B Bennion, G ST Bamford, The technology of cake making, Blackie-Academic and Professional, UK.

Course Code: FEEX402	Food Enterprise Development	Credits 3-0-0: 3

Course Outcomes: After completion of the course, student will be able to:

CO1	Understand the process of innovation and product development.
CO2	Apply market research, idea screening, and evaluation techniques.
CO3	Explain stage-gate, open innovation, and Industry 4.0 concepts.
CO4	Analyze case studies in dairy, bakery, and brewing industries.
CO5	Understand financial aspects, DPR preparation, and stability testing.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	1	-	-	1	-	-	-	2	-
CO2	1	2	1	1	-	1	-	-	3	-	-	3	3	2
CO3	1	2	1	1	-	1	1	-	2	-	-	3	3	3
CO4	1	2	2	1	-	1	1	-	3	-	-	3	3	2
CO5	1	2	2	1	-	1	1	-	3	-	-	3	3	2

Syllabus:

Unit I	Innovation and product development process, generation of ideas, market research, Screening/appraisal of initial ideas. Evaluation of test results. Open Innovation, Stage Gates Processes, introduction to Industry 4.0 revolution	5 lectures
Unit II	Product Development, Marketing and Market Segments, Outsourcing, Consultants, Stability Testing of Foods, Case studies: Innovations in Dairy industry, Bakery industry, brewing industry.	5 lectures

UNIT III	Product Development, Marketing and Market Segments, Outsourcing, Consultants, Stability Testing of Foods	5 lectures
UNIT IV	Case studies: Innovations in Dairy industry, Bakery industry, brewing industry.	5 lectures
Unit V	Financial aspects, financial sources, DPR fundamentals, Case study on DPR preparation	8 lectures

Learning Resources:

Text Books:

1. Hu, R. (2017). Food product design: a computer-aided statistical approach. Routledge.
2. Moskowitz, H. R., Saguy, I. S., & Straus, T. (2009). An integrated approach to new food product development. CRC Press.

Reference Books:

1. Moskowitz, H. R., Porretta, S., & Silcher, M. (2008). Concept research in food product design and development. John Wiley & Sons.

At the end of III – Year **VI– Semester**

Course Code: FEEX601	Primary Processing, Value Addition and Cold Chain Logistics	Credits 3-0-0:3

Course Outcomes: After completion of the course student will be able to

CO1	Determine the causes of post-harvest losses and strategies for mitigation while exploring the post-harvest value chain.
CO2	Apply knowledge of food chain systems, packaging, and inventory management to enhance food safety and market competitiveness.
CO3	Analyze food supply chains, traceability, ICT integration, and risk management strategies.
CO4	Use food logistics, including packaging, temperature-controlled systems, and international supply chain challenges.
CO5	Explore digital innovations, cold chain integration, and automation for efficient post-harvest management.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	1	1	1				2	3	2
CO2	3	2	3	2	2		1	1				3	2	2
CO3	2	1	1	1	1		3	1				3	3	2
CO4	1	3	3	1	3		1	1				2	3	2
CO5	2	1	1	1	1		1	1				3	1	2

Syllabus:

Unit I	Post-harvest losses: causes, assessment, and mitigation strategies. Role of processing in reducing post-harvest losses and enhancing value. Components	5 lectures

	of the post-harvest value chain: harvesting, transportation, storage, and marketing.	
Unit II	Food Manufacturing: Importance of food processing, market conditions, food processing and packaging, Inventory management, food safety, procurement,	6 lectures
Unit III	Introduction to supply chains in India, types of food chain, factors influencing food supply chains. Traceability and use of technology, risk management: risk management and uncertainty, risks in the food supply chain, managing supply chain risks, managing risks in food supply chains.	6 lectures
Unit IV	Food Logistics: movement of food, trends in food logistics, packaging in logistics, temperature controlled in supply chains, Case studies. Challenges in International food supply chains: International food supply chains, Factor affecting international food supply, international politics and foods.	6 lectures
Unit V	Digital innovations in post-harvest management, real-time monitoring using sensors of storage conditions (temperature, humidity, and gas levels), cold chain innovations: integration of cold chain with digital platforms for monitoring. Automation handling systems for loading, unloading, and quality evaluation.	5 lectures

Learning Resources:

Text Books:

1. Chakraverty, A., Mujumdar, A. S., & Raghavan, G. S. V. (Eds.). (2008). *Handbook of postharvest technology*. Woodland Publishers.
2. Fellows, P. J. (2008). *Food processing technology: Principles and practice*. Elsevier.
3. Food and Agriculture Organization (FAO). (2000). *Post-harvest management of fruits and vegetables in Asia-Pacific region*.
4. Parfitt, J., Barthel, M., & Macnaughton, S. (2001). *Food waste within food supply chains*. CRC Press.

Reference Books:

1. Garg, D. (2020). *Supply chain and logistics management* (1st ed.). New Age International Ltd Publishers.

Online Resources:

1. https://iimm.org/wp-content/uploads/2019/12/Logistics-and-Warehousing-Management.pdf

Course Code: FEEX602	Processing Technology of Beverages	Credits 3-0-0:3

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the history, importance, and current status of the beverage industry, including regulatory specifications (FSSAI).
CO2	Explain the processing principles, ingredients, and packaging of various beverages such as fruit-based, dairy-based, alcoholic, synthetic, and specialty drinks.
CO3	Evaluate the role of water treatment, carbonation, sweeteners, colorants, acidulants, and flavoring agents in beverage formulation and quality.

CO4	Analyze quality control tests, safety parameters, and technological aspects of beverage manufacturing.
CO5	Apply knowledge of processing and equipment for miscellaneous beverages like coconut water, sugarcane juice, cocoa, coffee, and plant extract-based drinks.

Mapping of course outcomes with program outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3
CO1	3	1	1	1	1	1	1	1				3	3	2
CO2	3	3	3	2	1		1	1				3	3	2
CO3	2	1	1	1	1		3	1				3	3	2
CO4	1	3	3	1	3		1	1				3	3	2
CO5	2	1	1	1	1		1	1				3	3	2

Syllabus:

Unit I	History and importance of beverages and status of beverage industry	4 lectures
Unit II	Processing of beverages: Packaged drinking water, juice-based beverages, synthetic beverages, still, carbonated; Low-calorie and dry beverages, isotonic and sports drinks.	6 lectures
Unit III	Dairy based beverages, Alcoholic beverages, fruit beverages, specialty beverages, Tea, coffee, cocoa, spices, plant extracts, etc.	7 lectures
Unit IV	FSSAI specifications for beverages. Ingredients, manufacturing and packaging processes and equipment for different beverages; Water treatment and quality of process water; Sweeteners, colorants, acidulants, Clouding and clarifying and flavouring agents for beverages, Carbon dioxide and carbonation.	6 lectures
Unit V	Quality tests and control in beverages, Miscellaneous beverages: Coconut water, sweet toddy, Sugar cane juice, coconut milk, flavoured syrups.	5 lectures

Learning Resources:

Text Books:

1. Ashurst, P.R. 2005. Chemistry and Technology of Soft Drinks and Fruit Juices, 2nd edn. Blackwell Publishing Ltd., Oxford, UK.
2. Hui, Y.H. 2007. Handbook of Food Products Manufacturing: Principles, Bakery, Beverages, Cereals, Cheese, Confectionary, Fats, Fruits, and Functional Foods. John Wiley and Sons, Inc., Hoboken, New Jersey, USA.

Reference Books:

1. Chakraverty, A., Mujumdar, A.S., Vijaya Raghavan G.S. and Ramaswamy, H. S. 2003. Handbook of Post Harvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. Marcel Dekker, Inc., NY, USA.
2. Eblinger, H.M. 2009. Handbook of Brewing: Processes, Technology, Markets. Wiley-VCH Verlag GmbH and Co. KGaA, Weinheim. Germany.

3. Joshi, V.K. and Pandey, A. 1999. Biotechnology: Food Fermentation – Microbiology, Biochemistry and Technology, Vol. II. Educational Publishers and Distributors, New Delhi.
4. Varnam, A.H. and Sutherland, J.P. 1994. Beverages: Technology, Chemistry and Microbiology. Chapman, London, UK.

Open Elective Courses (For students of other Departments)

Course Code: FEOE701	Development of Processed Food Products Lab	Credits 0–0–6: 3

Course Outcomes: After completion of the course student will be able to:

CO1	Design process flow charts for various food processing operations.
CO2	Prepare value-added products from raw agricultural materials.
CO3	Evaluate the operations and machinery used in food and agro-processing industries
CO4	Analyse the processing methods and machinery in flour, rice, and oil mills.
CO5	Perform field studies of fruit, vegetable, and sugar processing plants to understand industrial workflows

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		3	3	2	2					1	2	3	1
CO2	3	3	3	3	2		1					2	3	3	2
CO3	2	2	2	2	2	2	1			1		2	2	1	2
CO4	3	3	3	2	1	1	2					2	3	2	3
CO5	1	3	2	2		2	2			1	1		3	3	1

List of Experiments:

1. Process design and preparation of process flow chart.
2. Preparation of different value-added products.
3. Visit to roller flour mill, rice mill, spice grinding mill, milk plant, dal and oil mill.
4. Visit to fruit/ vegetable processing plant, sugar mill and other food processing industries.
5. Study of operations and machinery.

Learning Resources:

Text Books:

1. Acharya, K. T. (2017). *Everyday Indian processed foods*. New Delhi: National Book Trust.
2. Mudambi, S. R., Rao, S. M., & Rajgopal, M. V. (2006). *Food science*. New Delhi: New Age International Publishers.

Reference Books:

1. Negi, H. P. S., Sharma, S., & Sekhon, K. S. (2007). *Handbook of cereal technology*. Kalyani Publishers.

2. Srivastava, R. P., & Kumar, S. (2019). *Fruit and vegetable preservation: Principles and practices*. International Book Distributing Company.

Online Resources:

1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=4822

Course Code: FEOE801	Food Packaging Technology	Credits 2-1-0: 3

Course Outcomes: After completion of the course student will be able to

CO1	Identify factors affecting food spoilage and the purpose of food packaging.
CO2	Analyse technical properties and manufacturing techniques of packaging materials.
CO3	Select suitable packaging materials for various food products.
CO4	Evaluate nutritional labeling, CAS, MAP, and advanced packaging methods
CO5	Perform testing and selection of packaging materials based on characteristics.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	3	2	1	1						3	2	
CO2	3	3	1	3	3	3	2	1				1	3	3	3
CO3	3	3	1	3	2	1							3	3	3
CO4	3	3	3	3	2	1	3					1	3	2	
CO5	3	2	3	3	3	2	1			2	2	1	2	2	2

Syllabus:

Unit I	Factors affecting shelf life of food material during storage, Interactions of spoilage agents with environmental factors as water, oxygen, light, pH, etc. and general principles of control of the spoilage agents; Difference between food infection, food intoxication and allergy. Packaging of foods, requirement, importance and scope, framework of packaging strategy, environmental considerations,	6 lectures
Unit II	Packaging systems, types: flexible and rigid; retail and bulk; levels of packaging; special solutions and packaging machines, technical packaging systems and data management packaging systems, Different types of packaging materials, their key properties and applications, Metal cans, manufacture of two piece and three-piece cans, Plastic packaging, different types of polymers used in food packaging and their barrier properties. manufacture of plastic packaging materials, profile extrusion, blown film/ sheet extrusion, blow molding, extrusion blow molding, injection blow molding, stretch blow molding, injection molding.	7 lectures
Unit III	Glass containers, types of glass used in food packaging, manufacture of glass and glass containers, closures for glass containers. Paper and paper board packaging, paper and paper board manufacture process, modification of barrier properties and characteristics of paper/boards. Relative advantages and disadvantages of different packaging materials; effect of these materials on packed commodities.	4 lectures
Unit IV	Nutritional labelling on packages, CAS and MAP, shrink and cling packaging, vacuum and gas packaging; Active packaging, Smart packaging, Packaging requirement for raw and processed foods, and their	7 lectures

	selection of packaging materials, Factors affecting the choice of packaging materials, Disposal and recycle of packaging waste	
Unit V	Package testing: Testing methods for flexible materials, rigid materials and semi rigid materials; Tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.), plastic film and laminates (thickness, tensile strength, gloss, haze, burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.), glass containers (visual defects, colour, dimensions, impact strength, etc.), metal containers (pressure test, product compatibility, etc.).	4 lectures

Learning Resources:

Text Books:

1. Coles, R., McDowell, D., & Kirwan, M. J. (2003). *Food packaging technology*. Blackwell Publishing Co.
2. Gosby, N. T. (2001). *Food packaging materials*. Applied Science Publication.
3. Mahadevia, M., & Gowramma, R. V. (2007). *Food packaging materials*. Tata McGraw Hill.
4. Robertson, G. L. (2001). *Food packaging and shelf life: A practical guide*. Narendra Publishing House.

Reference Books:

1. Robertson, G. L. (2001). *Food packaging and shelf life: A practical guide*. Narendra Publishing House.
2. Robertson, G. L. (2005). *Food packaging: Principles and practice* (2nd ed.). Taylor and Francis.

Online Resources:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=28
2. https://onlinecourses.nptel.ac.in/noc23_ge32/preview