CURRICULUM

OF

FOOD ENGINEERING

UNDERGRADUATE AND POSTGRADUATE IN FOOD ENGINEERING

(Revised 2018)

HIGHER EDUCATION COMMISSION ISLAMABAD.

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo to achieve some specific objectives. It includes scheme of studies, objectives & learning outcomes, course contents, teaching methodologies and assessment/ evaluation. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled "Supervision of Curricula and Textbooks and Maintenance of Standard of Education". With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

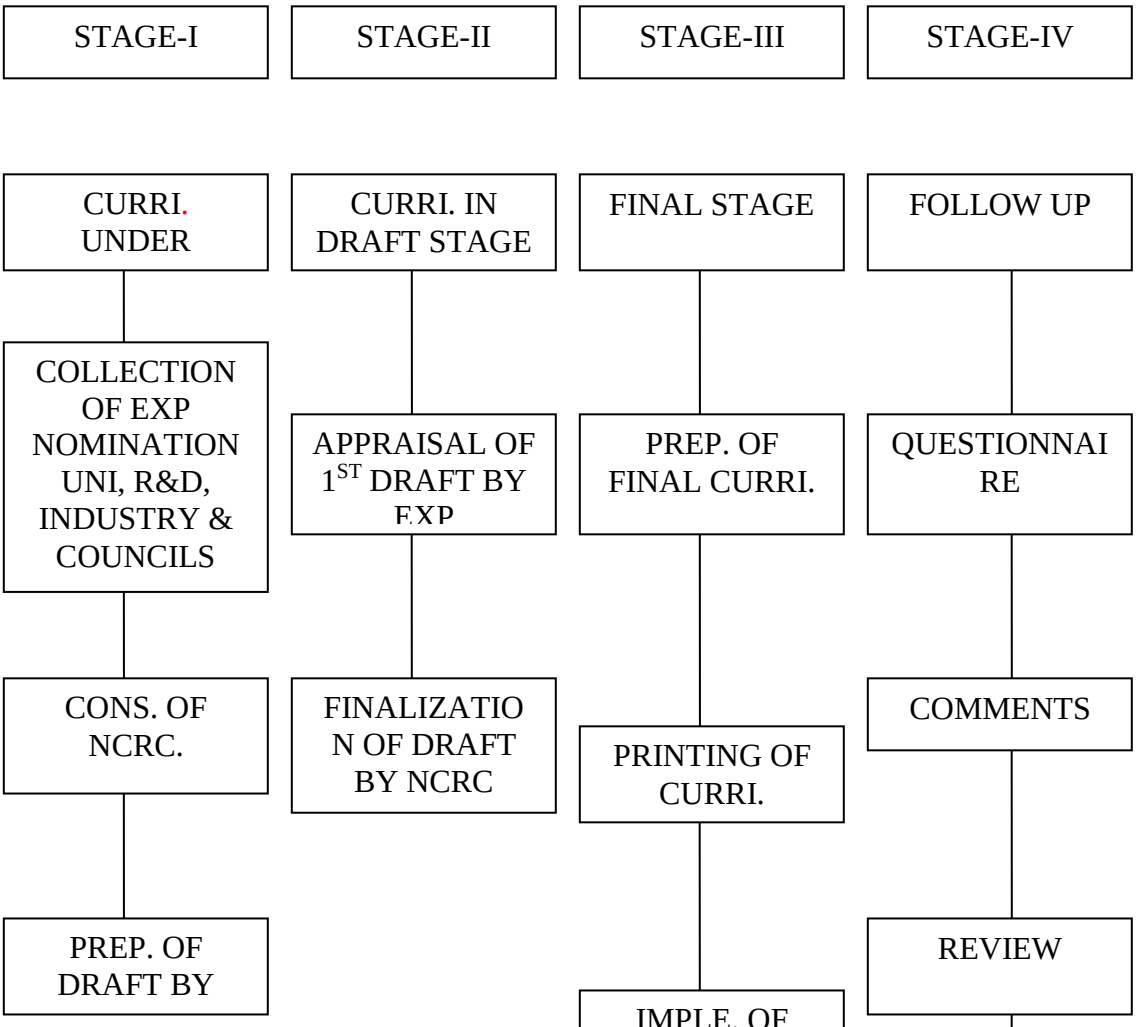
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula regularly through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with indigenous needs and international standards, HEC NCRCs have developed unified framework/ templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC
http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx

(Muhammad Raza Chohan)
Director General (Academics)

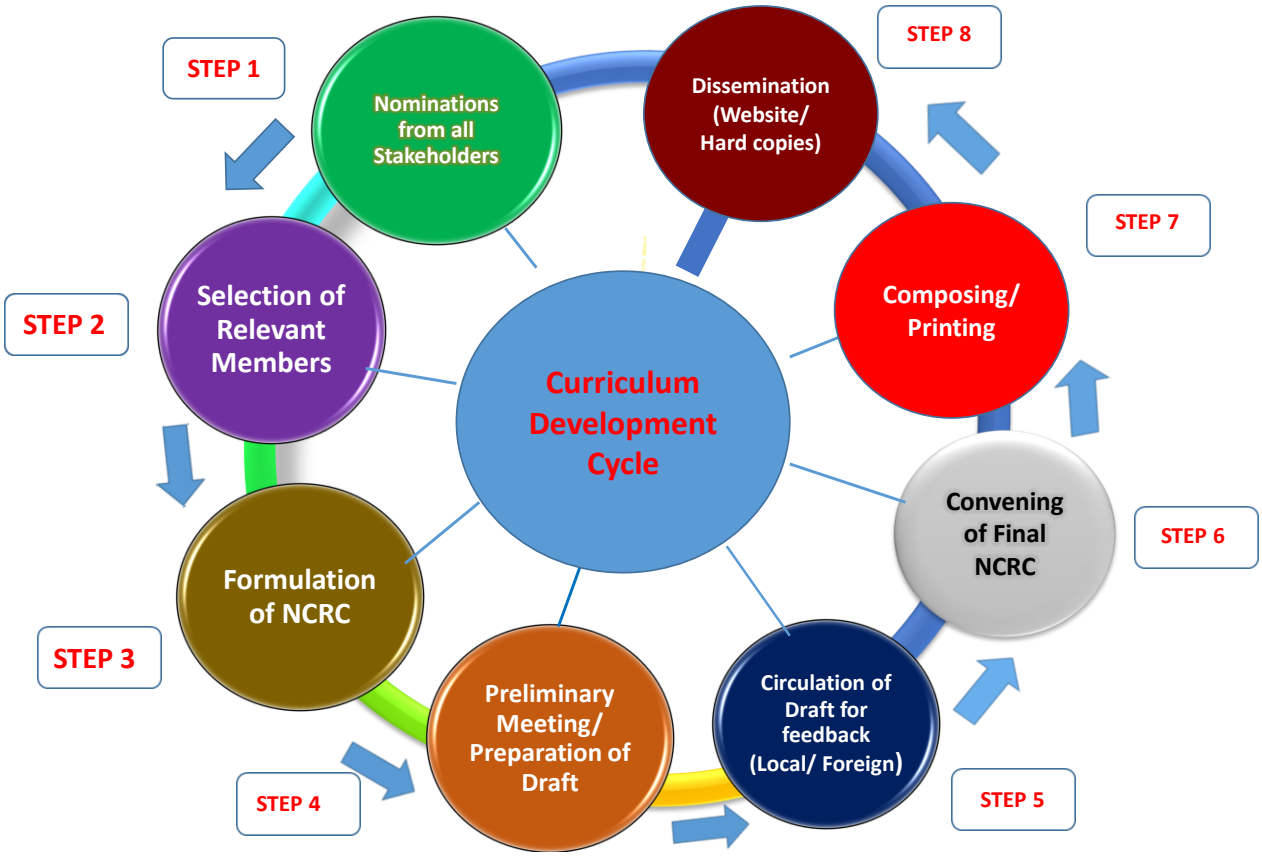
CURRICULUM DEVELOPMENT



Abbreviations Used:

NCRC. National Curriculum Revision Committee
VCC. Vice Chancellor's Committee
EXP. Experts
COL. Colleges
UNI. Universities
PREP. Preparation
REC. Recommendations
LI Learning Innovation
R&D Research & Development Organization
HEC Higher Education Commission
CONS: Constitution

CURRICULUM DEVELOPMENT CYCLE



INTRODUCTION

The preliminary meeting of National Curriculum Revision Committee (NCRC) in the discipline of Food Engineering for Bachelor's and Master's Degree programmes was held from February 07-09, 2017 (03 days) at the Higher Education Commission (HEC), Regional Centre, Lahore. Experts from academia and industry participated in this meeting. Dr. Muhammad Idrees (Director, Academics Division, HEC, Pakistan) coordinated the NCRC meeting. The list of the participants is as below:

S.No.	Name & Institution	Position
1	**Engr. Dr. Kh. Altaf Hussain**, Professor / Subject Expert Food Engineering Programme, Faculty of Agriculture Engineering & Technology, University of Agriculture, Faisalabad.	**Convener**
2	**Mr. Taiq Sarwar Awan** Technical Advisor Pakistan Flour Mills Association, Lahore	**Co-Convener**
3	**Prof. Dr. Farzana Yasmin** Professor/Chairperson Department of Food Engineering, NED University of Engineering & Technology, Karachi.	**Secretary**
	Engr. Dr. Nasir Mahmood Khan (PEC) Nominee) Additional Registrar (Accreditation) Pakistan Engineering Council, Ataturk Avenue G-5/2, Islamabad.	**Member**
4	**Dr. Muhammad Azam Khan** Associate Professor/ Chairman, Department of Food Engineering, University of Agriculture, Faisalabad.	PEC Nominee
5	**Dr. Malik Muhammad Hashim** Chairperson Faculty of Agriculture, Department of Food Science & Technology, Gomal University, Dera Ismail Khan, KPK	Member

6	**Dr. Imtiaz Hussain** HoD Department of Food Science & Technology, The University of Poonch, Old Campus, Hijra Road, Shamssabad, Rawalakot.	Member
7	**Engr. Dr. Asad Ullah Khan** Department of Chemical Engineering, COMSATS Institute of Informational Technology, Lahore Campus, Defence Road, Off Raiwind Road, Lahore.	Member
8	**Dr. Saghir Ahmed Shaikh** Professor, Institute of Food Science & Technology, Sindh Agriculture University, Tandojam.	Member
9	**Engr. Dr. Abdullah Khan Durrani** Professor, Institute of Chemical Engineering & Tech, University of Punjab, Lahore.	Member
10	**Engr. Dr. Muhammad Iqbal** Professor / Subject Expert Food Engineering Programme, Faculty of Agri. Engineering. & Technology, University of Agriculture, Faisalabad	Member
11	**Engr. Dr. Zahoor ul Hussain Awan** Associate Professor Food Engineering Department NED University of Engineering & Technology, Karachi.	Member
12	**Dr. Abdur Rehman** Assistant Professor, Atta-ur-Rehman School of Applied Biosciences (ASAB), Food Engineering, National University of Science & Technology (NUST), Sector H-12, Islamabad.	Member
13	**Dr. Azmat Ullah Khan** Assistant Professor, Department of Food Science and Human Nutrition,	Member

	University of Veterinary and Animal Sciences, Outfall Road, Civil Lines, Lahore.	
14	**Dr. Rashida Perveen** Assistant Professor, Department of Allied Health Sciences, The Superior College, Superior University Campus, 17KM Raiwind Road, Lahore.	Member
15	**Dr. Sanaullah Iqbal** Assistant Professor, Department of Food Science and Human Nutrition, University of Veterinary and Animal Sciences, Outfall Road, Civil Lines, Lahore.	Member
16	**Dr. Muhammad Liaquat** Assistant Professor, Department of Agriculture & Applied Sciences, University of Haripur, Haripur, KPK.	Member
17	**Dr. Amjad Iqbal** Assistant Professor Department of Agriculture, Adbul Wali Khan University, Garden Campus, Mardan.	Member
18	**Engr. Prof. Dr. Maazullah Khan** Principal Engineer, Food Science Division, Nuclear Institute for Food & Agriculture (NIFA), Tarnab, Peshawar.	Member
19	**Engr. Kiran Khurshid** Lecturer, Department of Food Engineering Faculty of Agricultural Engineering & Technology, University of Agricultural, Faisalabad.	Member
20	**Engr. Amna Amir Rana** Lecturer, Department of Food Engineering Faculty of Agricultural Engineering & Technology, University of Agricultural, Faisalabad.	Member
21	**Prof. Dr. Sarfraz Hussain,** (Fruit & Vegetable Processing Technologist) Institute of Food Science and Technology University of Sargodha, Sargodha.	Member

22	**Dr. Muhammad Idrees** Director Academic, Higher Education Commission, Islamabad	Coordinator
23	**Mr. Rabeel Bhatti** Assistant Director (Curriculum) High Education Commission, Islamabad.	Coordinator

NCRC Agenda

The agenda of NCRC for Food Engineering was as follows:

1. To revise/update the Food Engineering curriculum (2013) for Bachelor Programs according to indigenous needs and to bring it at par with international standards on Outcomes Based Education (OBE) and Develop Postgraduate (Master and Ph.D) Curriculum.
2. To revise/update preface/ preamble and rationale of the subject.
3. To develop & revise program objectives, course learning outcomes (CLOs), teaching methods and assessment criteria (formative & summative).
4. To incorporate/suggest latest reading materials/references (local & international) for every course.
5. To revise/update course contents keeping in view the uniformity across other disciplines and avoiding overlapping.
6. To finalize recommendations for promotion/development of the discipline, keeping in view the futuristic needs of the society and international trends.

The meeting started with recitation from the Holy Quran. Dr. Muhammad Idrees, Director Academics, Higher Education Commission, Pakistan welcomed the participants. All the participants introduced themselves highlighting their qualification, experience and area of expertise within the discipline of Food Engineering. Keeping with the tradition, Dr. Muhammad Idrees, Director Academics Division, HEC, Islamabad offered the house to nominate the Convener, Co-Convener and Secretary of the NCRC for smooth functioning of the activity. **Engr. Dr. Kh. Altaf Hussain**, Food Engineering Programme, Faculty of Agriculture Engineering & Technology, University of Agriculture, Faisalabad, **Mr. Tariq Sarwar Awan,** Technical Advisor, Pakistan Four Mills Association and **Prof. Dr. Farzana Yasmin**, Professor/Chairperson, Department of Food Engineering, NED University of Engineering & Technology, Karachi were unanimously selected as Convener, Co-Convener and Secretary, respectively.

Dr. Idrees presented the agenda and objectives of the NCRC. He highlighted the importance of this meeting and emphasized for adaptation of general rules

of curriculum development and revision like scope of the subject/programme, horizontal & vertical alignment, rule of flexibility and adaptability keeping in view the futuristic approach, market value/job market and societal needs. He also shared a template for revising/updating the curricula. The template was unanimously accepted to be followed. It was also agreed to add vision, mission, learning outcomes, teaching methodology and assessment segments in the curricula.

In the next session, the house openly discussed the nomenclature of the discipline, preface, vision, mission, objectives of the programmes, Programme Learning Outcomes (PLOs), methods of instruction and learning environment, assessment and operational framework as brief by Engr. Dr. Nasir M Khan of PEC. After long deliberation, the committee finalized the above said segments of the curriculum. Similarly, framework/scheme of studies of undergraduate 4-years programme for Food Engineering was discussed keeping in view the duration of the programme, number of semesters, number of weeks per semester, total number of credit hours, number of credit hours per semester, weightage of engineering and non- engineering courses and weightage of theory and practical. Furthermore, list of courses (core & elective) and semester wise breakup of courses were also discussed thoroughly and the same was unanimously finalized.

In the afternoon session, admission criteria/intake criteria were discussed and finalized. After that the list of courses was distributed among the committee members keeping in view the experience and expertise in the field for reviewing course objectives, adding learning outcomes, updating list of contents, adding teaching-learning methods and assessment, and updating bibliography/ references/ suggested books.

On second day, the task assigned to the groups was displayed and the addition/deletion and revision of the courses were discussed. After thorough deliberation, draft curriculum of the Bachelor of Food Engineering was finalized.

On the third day, the courses of Master in Food Engineering was reviewed and after thorough discussion, the courses were finalized. It was decided that the draft curriculum of Food Engineering would be circulated among the experts of field (local & foreign) and the feedback of the experts will be incorporated during the final meeting.

In the end, Mr. Rabeel Bhatti thanked the Convener, Co-Convener, Secretary and all members of the Committee for sparing their time and for their contribution to prepare the revised draft of the curriculum. He further stated that their efforts will go a long way in developing workable, useful and market oriented comprehensive degree programs in Food Engineering. Convener

Engr. Dr. Kh. Altaf Hussain also thanked the Secretary and members of NCRC for their inputs in revising/updating the curriculum to make it more practical, competitive, efficient and realistic. The committee highly appreciated the efforts made by the officials of HEC Regional Centre, Lahore for making arrangements to facilitate the committee and their accommodation. The meeting ended with a vote of thanks to Mr. Rabeel Bhatti and his team from HEC for providing this academic and professional opportunity for national cause.

Recommendations by NCRC

After a comprehensive discussion by all the members of the committee constituted by HEC to adapt the curriculum (devised by HEC) following points were noted:

1. Food Engineering will be a minimum four year degree program inclusive of mandatory engineering courses of foundation, breadth and depth given in the food engineering curriculum.
2. For the final year project (6 credit hours), the budget allocation for each project should be a minimum of PKR 50,000/- to be provided by the university.
3. The food engineering program may be registered as a separate engineering profession with PEC.
4. FSc (Pre-Medical) to be made eligible for admission in Bachelor of Food Engineering. The students with medical background may be offered mathematics courses as minors / deficiencies in order to bring them up to the level of FSc (Pre-Engineering) students if they want to get admission in Bachelor of Food Engineering.
5. Keeping in view the multidisciplinary nature of the food engineering program and a new discipline in Pakistan, it is recommended that non-engineering qualified faculty (PhD only) relevant to the specialized area of food engineering may be hired, but not exceeding 25% of the total strength of the program as per in line with PEC policies.
6. The HEC and PEC need to coordinate in the profession of food engineering degree program for internship and employment generation for the graduates in public and private sector organizations in particular with food industries and chambers of commerce both at federal and provincial levels.
7. The PEC is required to legislate for induction of food engineering graduates in the food industries of Pakistan.
8. The HEC need to facilitate the required necessary funding to the universities offering food engineering program.
9. Industry visits to be made more meaningful and related to Food Engineering domain in the curriculum.
10. The Federal and Provincial Food Control Authorities be approached by HEC and PEC for employment of graduates of food engineering.

11. All the optional courses should be compatible with regard to credit hours approved in the scheme of studies.(within the PEC approved minimum and maximum credit hours limit)
12. Facilities of training abroad to the faculty members in food engineering program be provided by HEC on priority basis.
13. Preference be given by HEC to offer scholarship to the deserving graduates for higher studies abroad.
14. Annual seminars/workshops be organized by the food engineering departments with the financial assistance of HEC for the development and promotion of the discipline of food engineering.
15. Faculty should manage to attend national/international conferences/expo with the financial support from HEC related to the field of food engineering.
16. The launching of “Food Engineering Society of Pakistan (FESP)” may be encouraged by the Higher Education Commission with financial support to start with. Later on, the society may generate its funds through memberships and paid publications in its newly launched journal on sustainable basis.
17. Relevant regulatory bodies should require all food industry to establish a department of Food Engineering and employing qualified registered Food Engineers.
18. Specialized journal in the field of Food Engineering shall be launched under the patronage of HEC, Pakistan.

Mission:

To enhance value engineering, by providing excellence in professional learning, guidance and experience, focusing on capacity building of engineers in the discipline of Food Engineering.

Vision:

To create the competency of graduating engineers for developing linkages between farm, academia, and food industry issues.

Rationale:

The Curriculum of Food Engineering has vertical and horizontal alignments. The vertical alignments include placing/offering of basic and/or prerequisite courses in the initial semesters of a degree and those comprising advanced contents in the senior level semesters. The vertical alignments also address the issues of flow or linear advancement of knowledge from intermediate, undergraduate and graduate level degrees. The horizontal alignments include coherence of Food Engineering with other Engineering disciplines.

Evaluation of students' performance will be based on Bloom's Taxonomy of Learning Domains comprising Cognitive, Affective, and Psychomotor. Evaluation scores of a course are proposed to carry 50% of the total marks in Final exam and the remaining 50% of the marks accordingly distributed for Mid exam and semester work (including quiz, complex engineering problems, assignment, presentation, etc...). The lab part of the course will be evaluated based on RUBRICS for Lab that will include i) Lab Reports, ii) Lab Demonstrating skills of students to perform experiments, iii) introduction of open-ended labs to solve complex engineering problems, and iv) Viva Voce. The lab part of the course may also be assessed, covering the psychomotor (skills) and affective (attitude) domains, as a total of 100 to be converted to the ratio of actual lab score, for the number of specified credit hours. The following table proposes typical calculations for scores/marks for a course.

Activity	**Proportional Score**
Mid	25-30% of the total theory part
Sessional (quiz, complex engineering problems through class projects and assignments, presentations etc...)	20-25% of the total theory part
Lab	100% of the total lab part
Final	50% of the total theory part
Total	100%; 40, 60, and 80 for 2, 3 and 4 credit hours courses, respectively.

Field visits and their reports may be made part of sessional marks wherever it deemed fit.

Mission Statement:

Producing competent Food Engineers to effectively deliver real products and services for benefit to society is a responsibility of Universities/DAIs. The Food Engineering Curriculum is designed to provide necessary knowledge, analytical and leadership abilities, critical thinking, and ethical values to the graduates to cope up with the technological challenges.

Preamble:

Program Educational Objectives (PEOs)

The program offered by the institution should also have well defined program objectives. Program educational objectives (PEO) are broad statements that describe what graduates are expected to achieve a few years after graduation. It should be ensured that the program objectives are aligned with the vision/mission of the institution. Program objectives should be articulated and made known to everyone in the institution through institutional publications and websites.

The successful pursuit and realization of the mission and objectives, and the means adopted to accomplish them bring out the quality of the institution and its programs. Program educational objectives are based on the needs of the program's constituencies and are linked to student learning outcomes and assessment process.

The objectives should be clear, concise, realistic and measurable within the context of the committed resources. A process should be developed to assess the level of attainment of the program objectives to evaluate effectiveness of the academic programs. It should include feedback from faculty, employers, alumni and other stakeholders. The evaluation results should be utilized for redefining/improving the program objectives.

The program must demonstrate that following are in place:

a) Well-defined and published Program Mission
b) Program's educational objectives defined and consistent with the mission
c) Program's educational objectives based on the stakeholder's needs on program
d) A process in place to evaluate the attainment of educational objectives
e) Evaluation results used for continual improvement of the program

The program of Food Engineering will achieve the following PEOs;

PEO-1: Apply Food engineering knowledge to identify and address the technical and societal problems.

PEO-2: Enhance students' intellectual and analytical abilities in taking initiative and/or developing innovative ideas for technological and professional growth in the field of Food Engineering.

PEO-3: Work effectively as a team member or lead multidisciplinary teams while demonstrating the interpersonal and management skills and ethical responsibilities.

Program Learning Outcomes (PLOs)

Program learning outcomes are the narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the knowledge, skills and attitude that the students acquire while progressing through the program.

The program must demonstrate that by the time of graduation the students have attained a certain set of knowledge, skills and behavioral traits, at least to some acceptable minimum level. Specifically, it is to be demonstrated that the students have acquired the following graduate attributes:

The program learning outcomes of Food Engineering will cover **PLO 01-12.**

PLO-01: Engineering Knowledge: Ability to apply knowledge of mathematics, science and engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PLO-02: Problem Analysis: Ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PLO-03: Design/Development of Solutions: Ability to design solutions for complex engineering problems and design systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PLO-04: Investigation: Ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

PLO-05: Modern Tool Usage: Ability to 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.

PLO-06: The Engineer and Society: Ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

PLO-07: Environment and Sustainability: Ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PLO-08: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PLO-09: Individual and Team Work: Ability to work effectively, as an individual or in a team, on multifaceted and/or multidisciplinary settings.

PLO-10: Communication: Ability to communicate effectively, orally as well as in writing on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentations, make effective presentations, and give and receive clear instructions.

PLO-11: Project Management: Ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team to manage projects in a multidisciplinary environment.

PLO-12: Lifelong Learning: Ability to recognize importance of, and pursue lifelong learning in the broader context of innovation and technological developments.

In addition to incorporating the graduate attributes (i) to (xii) listed above as the program learning outcomes, the educational institution may also include any additional outcomes if adopted.

Specific details relating to the processes adopted for assessing, evaluating and reviewing the program outcomes should be provided. The institution can also present the internal quality assessment cycle adopted by its Quality Enhancement Cell (QEC).

In particular, the program must demonstrate the following:

a) Well-defined and published Program Outcomes
b) Program Outcomes linked to the Program Objectives
c) Program Outcomes encompass desired outcomes listed above
d) Mapping of Program Outcomes to Course Learning Outcomes (CLOs)
e) Teaching-learning and assessment methods appropriate and supportive to the attainment of Course Learning Outcomes
f) Quality of assessment mechanism to evaluate achievement levels for all the Program Outcomes by each student
g) Process in place by which assessment results are applied to further refine the assessment mechanism and/or redefine the program / course outcomes, thus leading to continuous improvement of the program

The courses included in Food Engineering programs are based on Course Learning Outcomes (CLOs) that necessitate that upon successful completion of the course, the student will;

a) **Understand** the nature of food and its behavior on food processing equipment and related food engineering systems and **describe** the concept of techniques, accuracy, precision, and errors in all measuring instruments,
b) **Implement** procedures with the instruments used to measure different parameters; e.g., pressure, temperature, force, movement, fluid flow etc.,
c) **Show** the fundamentals of measurement systems by designing the protocol and necessary tools for this task,
d) **Operate** the food processing instruments and able to analyze/ interpret the results of the instrument according to standards,
e) **Demonstrate** the working principles of instruments and techniques for food engineering applications.

In the above statements, the underline verbs may be used in assessment tasks. With the help of this linkage we can find out achievement report of each CLO in final results. The course evaluators may use other key words mentioned in different levels of bloom's taxonomy.

Scope:

The scope of Food Engineering Curriculum is based on existing needs of this discipline and a cushion for accommodation of courses / contents to address emerging / futuristic trends in the discipline of Food Engineering. The role for Industry-Academia linkage to address problems faced by the industry and their indigenous solutions is also in the scope of this curriculum.

Curriculum and Learning Process:

The genesis of any engineering program is the fusion of its stakeholders' perceptions. The academic curriculum of the program is designed to facilitate / ensure the achievement of program outcomes by all students. This is achieved by offering a balanced combination of technical and non-technical contents coupled with appropriate assessment and evaluation methods. This has a well-defined core of essential subjects supported by requisite compulsory as well as elective courses. It also invokes awareness and comprehension of societal problems amongst the students and motivating them to seek solutions for improving the quality of life. The theory content of the curriculum is supplemented with appropriate experimentation / laboratory work.

The program structure is covering the essential fundamental principles at the initial stages, leading to integrated studies in the final year of the program, in consonance with the approach and levels defined in Bloom's taxonomy, particularly in breadth & depth courses.

The hallmark of a curriculum is to infuse original thinking, resourcefulness and entrepreneurial spirits among students. This program is embodying foundation courses as well as the general and specialized professional content of adequate Breadth and Depth, including appropriate Humanities and Science components. The program scheme is designed to ensure acquisition of knowledge and skills, encouraging necessary exposure to inter-disciplinary areas.

The contents of each constituent courses of the curriculum has been updated to absorb recent technological and knowledge developments as per international practices and to meet the national needs. Efforts are also made that there should also be an effective relationship between the curricular content and practice in the field of specialization.

It is expected that the graduates are able to demonstrate professional ethics and competence in oral communication, scientific & quantitative reasoning, critical analysis, system design, logical thinking, creativity and capacity for life-long learning.

The delivery of subject matter and the assessment process employed is expected enabling the students to develop intellectual and practical skills effectively, as deemed essential in program outcomes assessment. Complex engineering problems which are not easily quantifiable, e.g. communication skills (oral / written), critical thinking, ethics, team work, etc. often require rubrics as a tool for their assessment (both in direct or indirect methods).

In addition to regular teaching / learning activities such as classroom interaction, problem based learning (PBL) assignments, lab experimentation and faculty consultation, other aspects of student learning such as tutorial system, research / design projects, seminar / workshops and exposure to industrial practice should form an integral part of curriculum. Internal reviews of quality assurance procedures should be carried out periodically.

ELIGIBILITY CRITERIA:

For undergraduate level

Engineering education regulations of Pakistan Engineering Council should be adhered to for admission criteria and intake policy. Generally, the following eligibility criteria is recommended for approval by the regulatory body (PEC).

- FSc. Pre-Engineering
- FSc. Pre-Medical subject to satisfying the deficiency course of mathematics
- FSc. Pre-Agriculture
- Relevant D.A.E. (as described by PEC)
- O & A levels

Applicants must have secured at least 60% marks and qualifying the entrance examination/test.

Admission criteria for postgraduate in Food Engineering:

- Bachelor in Food engineering or relevant engineering disciplines accredited by the Pakistan Engineering Council.
- Further, relevant HEC/PEC regulations specific to engineering programs be observed/adopted. (www.pec.org.pk)

FRAMEWORK/TEMPLATE FOR BACHELOR IN FOOD ENGINEERING

Duration:	4 years
Number of semesters:	8
Number of weeks per semester:	16-18 (16 for teaching and 2 weeks for examinations)
Total number of credit hours:	**130-141**
Number of credit hours per semester:	15-19
Engineering Courses:	71.3 percent
Non-Engineering Courses:	28.6 percent

Non-EngineeringDomain

Knowledge Area	Sub Area	Name of Course	Lec CH	Lab CH	Credit Hours	Total Courses	Total Credits	% Area	% Overall
Humanities	English	Functional English	3	0	3	2	6	14.286	4.415
		Communication & Presentation Skills / Business Communication & Ethics	2	1	3				
	Culture	Islamic Studies or ethics	2	0	2	2	4	9.523	2.95
		Pakistan Studies	2	0	2				
	Social Sciences	Sociology for Engineers	2	0	2	1	2	4.761	1.47
Management Sciences	Inter-disciplinary	Engineering Economics & Management	3	0	3	2	6	14.286	4.415
		Entrepreneurship	3	0	3				
Natural Sciences	Math	Calculus	3	0	3	4	12	28.572	8.83
		Ordinary Differential Equations & Fourier Series	3	0	3				
		Advance Calculus & Linear Algebra	3	0	3				
		Statistics & Probability	2	1	3				
	Physics	Applied Physics	2	1	3	1	3	7.142	2.205
	Chemistry	Food Chemistry	2	1	3	1	3	7.142	2.205
	Electives	Introduction to Applied Agriculture/Analytical Chemistry	2	1	3	2	6	14.286	4.415
		Postharvest handling of fruits and vegetables / Biochemistry & Enzymology	2	1	3				
Total: 39			33	6	39	15	42	100	30.90

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Math/Physics/Chemistry/Biology/EngineeringEconomicsorrelatedsubjectas appropriatefortheprogramme;
Lec CH: Lecture Credit Hours, Lab CH: Laboratory Credit Hours.

** Electives as approved by the University Department based on their expertise.

Engineering Domain									
Knowledge Area	**Sub Area**	**Name of Course**	**Lec CH**	**Lab CH**	**Credit Hours**	**Total Courses**	**Total Credits**	**% Area**	**% Overall**
Computing	Programming	Computer Programming/ Programming Languages	2	1	3	2	6	6.18	4.41
	Design	Engineering Drawing & Graphics / Computer Aided Engineering Graphics	1	2	3				
Engineering Foundation	--	Fluid Mechanics	3	1	4	9	30	30.9	22.07
		Materials and Metallurgy	2	1	3				
		Engineering Mechanics	3	1	4				
		Manufacturing Engineering	2	1	3				
		Engineering Thermodynamics	2	1	3				
		Heat and Mass Transfer	2	1	3				
		Fluid Flow System/ Process Control in Food Industry.	2	1	3				
		Instrumentations and Measurements	3	1	4				
		Industrial Safety and Maintenance Management	3	0	3				
Major Based Core (Breadth)		Engineering Properties of Foods	2	1	3	11	32	32.98	23.50
		Material and Energy Balance/ Industrial Organization and Management	3	0	3				
		Food Engineering Operations I/Unit Operations in Food Engineering I	2	2	4				
		Introduction to Food Engineering	2	0	2				
		Post-Harvest Engineering	2	1	3				
		Machine Design	3	0	3				
		Mechanics of Materials	2	1	3				
		Food regulations and legislations	2	0	2				
		Food Process Engineering	2	1	3				
		Food Microbiology	2	1	3				
		Engineering Numerical Analysis	2	1	3				
Major Based Core (Depth)		Food Engineering Operations II / Unit Operations in Food Engineering II	1	2	3	7	20	20.61	14.71
		Food Plant Layout and Design	2	1	3				
		Food Storage Engineering	2	1	3				
		Food Packaging	2	1	3				

		Food Quality Control	2	0	2				
		Food Processing and Preservation	2	1	3				
		Food Engineering Design	3	0	3				
Senior Design Project	---	Senior Design Project-I/Food Engineering Project (Phase I)	0	3	3	2	**6**	6.18	4.41
		Senior Design Project-II/Food Engineering Projects(Phase II)	0	3	3				
Industrial Training (Summer Winter)			0	0	0	0	0	0	0
Total Credit: 136			**65**	**33**	**96**	**32**	**136**	**100**	**69.1**

Scheme of Studies
for Bachelor (4 Years) in Food Engineering Programme

First Semester

Course Code	Title of the Course	Credit Hours
	Introduction to Food Engineering	2 (2-0)
	Engineering Drawing and Graphics / Computer Aided Engineering Graphics	3 (1-2)
	Islamic Studies or Ethics (for non-Muslims)	2 (2-0)
	Functional English	3 (3-0)
	Calculus	3 (3-0)
	Applied Physics	3 (2-1)
	Mathematics	4(4-0)*
	Total Credit hours	**16 (13-3)**

* Non Creditable (Intermediate level course for Pre medical students)

Second Semester

Course Code	Title of the Course	Credit Hours
	Manufacturing Engineering	3 (2-1)
	Engineering Properties of Foods	3 (2-1)
	Food Chemistry	3(2-1)
	University Elective-I	3 (2-1)
	Programming Languages	3 (2-1)
	Pakistan Studies	2 (2-0)
	Total Credit hours	**17 (12-5)**

Third Semester

Course Code	Title of the Course	Credit Hours
	Engineering Thermodynamics	3 (2-1)
	Engineering Mechanics	4(3-1)
	Food Process Engineering	3 (2-1)
	Differential Equations& Fourier Series	3 (3-0)
	University Elective-II	3 (2-1)
	Sociology for Engineers	2 (2-0)
	Total Credit hours	**18(14-4)**

Fourth Semester

Course Code	Title of the Course	Credit Hours
	Fluid Mechanics	4(3-1)
	Materials and Metallurgy	3 (2-1)
	Post-Harvest Engineering	3 (2-1)
	Mechanics of Materials	3 (2-1)
	Engineering Economics and Management	3 (3-0)
	Probability and Statistics	3 (2-1)
	Total Credit hours	**19 (14-5)**

Fifth Semester

Course Code	Title of the Course	Credit Hours
	Elective-I (Breadth)	3 (3-0)
	Food Microbiology	3 (2-1)
	Food Engineering Operations- I	4 (2-2)
	Heat and Mass Transfer	3 (2-1)
	Advance Calculus and Linear Algebra	3 (3-0)
	Communication and Presentation Skills	3 (3-0)
	Total Credit Hours	**19 (15-4)**

Sixth Semester

Course Code	Title of the Course	Credit Hours
	Instrumentation & Measurement	4 (3-1)
	Food Engineering Operations- II	3 (1-2)
	Material and Energy Balance	3 (3-0)
	Elective-II (Breadth)	3 (3-0)
	Engineering Numerical Analysis	3 (2-1)
	Total Credit Hours	**16 (11-5)**

Seventh Semester

Course Code	Title of the Course	Credit Hours
	Entrepreneurship	3 (3-0)
	Food Quality Control	2 (2-0)
	Food Storage Engineering	3 (2-1)
	Final Year Design Project-I	3 (0-3)
	Industrial Safety and Maintenance Management	3 (3-0)
	Elective-III (Depth)	3 (2-1)
	Total Credit Hours	**17 (11-6)**

Eighth Semester

Course Code	Title of the Course	Credit Hours
	Food Regulations and Legislations	2 (2-0)
	Food Packaging	3 (2-1)
	Food Plant Layout and Design	3 (2-1)
	Final Year Design Project-II	3 (0-3)
	Elective-IV (Depth)	3 (3-0)
	Total Credit Hours	**14 (9-5)**

Total Credit Hours for Bachelor of Food Engineering = 136

Note:

1. A supervised internship (To be carried out after completion of two years with total duration of 4 to 8 weeks during summer or winter session as part of degree requirements.
2. Final Year Project and Report will be completed in the last two semesters

List of Elective Courses:

The following may be offered as elective specialization courses according to the availability of resources in the respective educational institution.

List of Elective Courses:

The following may be offered as elective specialization courses according to the availability of resources in the respective educational institution.

Electives

A. University Electives

Electronics	3 (2-1)
Food Biochemistry	3 (2-1)
Post Harvest Handling of Fruits and Vegetables	3 (2-1)
Business and communication skills	3(3-0)
Introduction to Applied Agriculture	3(2-1)
Analytical Chemistry	3(2-1)

B. Breadth

Machine Design	3(3-0)
Theory of Machines	3 (3-0)
Food Processing and Preservation	3 (2-1)
Cereal Processing Engineering	3 (2-1)
Beverage Processing Engineering	3 (2-1)
Food Biotechnology	3 (2-1)
Industrial Organization and Management	3(3-0)

C. Depth

Dairy Processing Engineering	3 (2-1)
Meat, Poultry & Egg Processing Engineering	3 (2-1)
Food Product Development	3 (2-1)
Oil & Fats Processing Engineering	3 (2-1)
Process control In Food Industry	3 (3-0)
Sugar & Confectionery	3 (2-1)
Food Engineering Design	3(3-0)

DETAILS OF COURSES
FOR BACHELOR IN FOOD ENGINEERING

Introduction to Food Engineering

Contact Hours:
Theory =32
Practical =0
Total =32

Credit Hours:
Theory =2.0
Practical =0
Total =2.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Identify** the major and minor constituents of food and the chemical reactions in which they participate.	Cognitive	1	1
2.	**Describe** the principals involved in the processing of the major types of food products	Cognitive	1	1
3.	**Define** unit operations and be able to understand their working principles and equipment used in food processing facilities. develop a total process using unit operations	Cognitive	1	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Historical Background and scope of Food Engineering:**
   a. Food engineering and its scope,
   b. Importance of chemistry and biological science in food engineering.

2. **Food Processing**
    a. Dairy products, cereals/baked foods, fruits and vegetable, beverages, snake foods, confectionery and spices, meat poultry and fish fats and oils.
3. **Thermal Techniques in Food Processing**
    a. Heat processing of food,
    b. Freezing and cold storage,
    c. Microwave heating
4. **Food process and plant design**
    a. Personal cleanliness
    b. Buildings and facilities
    c. Plant layout
    d. Food process design
5. **Preservation Techniques in Food Processing**
    a. Food processing from harvest to preservation,
    b. Packaging and distribution

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
    Quiz and Assignment (10%)
    Midterm (30%)
    Final Term (60%)

Suggested Books:

1. Barbosa-Canovas, G.V. and Ibarz, A., 2002. *Unit operations in food engineering*. Crc Press.
2. Gaonkar, A.G. ed., 1995. *Food processing: recent developments*. Elsevier.
3. Lewis, M.J., 1990. *Physical properties of foods and food processing systems*. Elsevier.
   Milton P. E., Ellery H. H. and Stateler, E.S., 1954. *Elements of food engineering*. Reihold Publishing Corporation; New York.
4. Señorans, F.J., Ibáñez, E. and Cifuentes, A., 2003. New trends in food processing. *Critical reviews in food science and nutrition*, *43*(5), pp.507-526.
5. Singh, R.P. and Heldman, D.R., 2001. *Introduction to food engineering*. Gulf Professional Publishing.

Computer Aided Engineering Graphics

Contact Hours:
Theory =16
Practical =48
Total =64

Credit Hours:
Theory =1
Practical =2
Total =3

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of drawing skills and CAD drawings	Cognitive	2	1
2.	**Understand** the concepts of basic drawing techniques and use them efficiently.	Cognitive	2	1
3.	**Demonstrate** individually the drawings of plan, elevation and cross sections of buildings and machine parts	Psychomotor	3	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction to Computer Aided Drafting**
   a. Introduction to the Engineering design Process
   b. Technical Graphics basics
   c. Orthographic projection and Isometric drawings and
   d. Basic concepts of Conventional engineering drawings
   e. Opening a new drawing, paper setting
   f. coordinate systems: User's coordinate system (UCS)
   g. Cartesian coordinates and Polar coordinates
   h. Saving a drawing

2. **Creating Elementary Objects**
    a. Apply the Commands
    b. Grid, Ortho, Escape
    c. Erase, Trim, Undo
    d. Draw Lines
    e. Circles, Ellipse
    f. Rectangle And Arcs
3. **Basic Object Editing**
    a. Apply the following commands
    b. Move, offset, rotate
    c. Fillet
    d. Chamfer
    e. Array and mirror
4. **Dimensioning**
    a. Show the following dimensioning
    b. Linear, aligned
    c. Radial and changing dimensional setting
5. **Solid Modeling**
    a. Apply the following commands to create 3-D models
    b. Region, extrude, revolve
    c. Slice and show plan
    d. Elevation and end view of a 3-D model
6. **Controlling Drawings**
    a. Apply the following commands for a given drawing: Hatching
    b. Coloring and rendering
7. **Text**
    a. Apply the following commands on the given drawing
    b. Creating text
    c. Style of text and changing text properties
8. **Plotting Drawings**
    a. Apply the following commands
    b. Plotting
    c. Print preview and printing

Practical:

1. Introduction to Computer Aided Designing, AutoCAD and its Application.
2. To demonstrate Auto Cad Basics including overview of the AutoCAD screen, Workspaces, Starting Commands and Terminologies.
3. Introduction to AutoCAD Coordinate Systems including Absolute, Relative, Polar, UCS and WCS.
4. Introduction to drawing and modifying that includes Line, Circle, Erase, Print and Undo commands.
5. To demonstrate on modifying commands that includes Rotate, Polygon, Fillet, Chamfer and Array.

6. To demonstrate on modifying commands that includes Trim, Mirror, Offset, Layer with line types.
7. To demonstrate about 3D Graphics and 3D interface using AutoCAD.
8. To study about orbit, Visual Styles, UCS, Extrusion, Union, Subtraction and Intersection.
9. To study about Sweep and Revolve Commands.

Suggested Teaching Methodology

- Lecturing
- Lab tasks
- Exercises

Suggested Assessment

1. Theory (100%)

Quiz and Assignment (10%)
Midterm (30%)
Final Term (60%)

2. Laboratory (100%)

Suggested Reading:

1. French, T.E. and Vierck, C.J., 1960 *Manual of Engineering Drawing: for Students and Draftsmen 9th Edition* McGraw Hill
2. Groover, M. and Zimmers, E.W.J.R., 1983.*CAD/CAM: computer-aided design and manufacturing*. Pearson Education.
3. Parkinson, A.C., 1961. *A First Year Engineering Drawing; Covering the First Year National Certificate Course in Mechanical Engineering*. Pitman
4. Chris, M. and Brown, J., 1998. CAD/CAM Principles, Practice and Manufacturing Management.
5. Jeyapoovan, T., 2005. *Engineering Drawing & Graphics Using AutoCAD 2000*. Vikas Publishing House Pvt Ltd.
6. Madsen, D.A. and Madsen, D.P., 2016. *Engineering drawing and design*. Nelson Education.
7. Munford, P. and Normand, P., 2015. *Mastering Autodesk Inventor 2016 and Autodesk Inventor LT 2016: Autodesk Official Press*. John Wiley & Sons.
8. Pahl, G. and Beitz, W., 2013. *Engineering design: a systematic approach*. Springer Science & Business Media. Giesecke, F.E., 2016. *Technical drawing with engineering graphics*. Prentice Hall.

Islamic Studies

Contact Hours:
Theory =32
Practical =0
Total =32

Credit Hours:
Theory =2.0
Practical =0.0
Total =2.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Illustrate Basic information and understanding of Islamic principles	Cognitive	3	12
2	Develop the skill of the students for understanding of issues related to faith and religious life.	Cognitive	5	8
3	**Demonstrate** a better understanding of the Quran & Sunnah.	Cognitive	3	9
4	Have **improved skills** of recitation of the Quran and Hadith in Arabic, and will better **interpret** its meaning and message. (A4)	Affective	4	2
5	**Apply** the basic principles of Islam in their personal and professional domains of life in accordance with the Sunnah. (C3)	Cognitive	3	10

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☐	7 Environment and Sustainability	☐
2 Problem Analysis:	☑	8 Ethics	☑
3 Design/Development of Solutions	☐	9 Individual and Team Work	☑
4 Investigation	☐	10 Communication	☑
5 Modern Tool Usage	☐	11 Project Management	☐
6 The Engineer and Society	☐	12 Lifelong Learning	☑

Course Outline:

1. **Introduction to Quranic Studies**
   a. Basic Concepts of Quran
   b. History of Quran
   c. Uloom-ul-Quran

2. **Study of Selected Text of Holly Quran**
    a. Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)
    b. Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
    c. Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
    d. Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
    e. Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)
3. **Study of Selected Text of Holly Quran**
    a. Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No. 6,21,40,56,57,58.)
    b. Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
    c. Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)
4. **Seerat of Holy Prophet (S.A.W) I**
    a. Life of Muhammad Bin Abdullah (Before Prophet Hood)
    b. Life of Holy Prophet (S.A.W) in Makkah
    c. Important Lessons Derived from the life of Holy Prophet in Makkah
5. **Seerat of Holy Prophet (S.A.W) Ii**
    a. Life of Holy Prophet (S.A.W) in Madina
    b. Important Events of Life Holy Prophet in Madina
    c. Important Lessons Derived from the life of Holy Prophet in Madina
6. **Introduction to Sunnah**
    a. Basic Concepts of Hadith
    b. History of Hadith
    c. Kinds of Hadith
    d. Uloom –ul-Hadith
    e. Sunnah & Hadith
    f. Legal Position of Sunnah
7. **Selected Study from Text of Hadith:**
8. **Islamic Law & Jurisprudence**
    a. Basic Concepts of Islamic Law & Jurisprudence
    b. History & Importance of Islamic Law & Jurisprudence
    c. Sources of Islamic Law & Jurisprudence
    d. Nature of Differences in Islamic Law
    e. Islam and Sectarianism
9. **Islamic Culture & Civilization**
    a. Basic Concepts of Islamic Culture & Civilization
    b. Historical Development of Islamic Culture & Civilization
    c. Characteristics of Islamic Culture & Civilization
    d. Islamic Culture & Civilization and Contemporary Issues
10. **Islam & Science**
    a. Basic Concepts of Islam & Science
    b. Contributions of Muslims in the Development of Science
    c. Quran & Science

11. Islamic Economic System

a. Basic Concepts of Islamic Economic System
b. Means of Distribution of wealth in Islamic Economics
c. Islamic Concept of Riba
d. Islamic Ways of Trade & Commerce

12. Political System of Islam

a. Basic Concepts of Islamic Political System
b. Islamic Concept of Sovereignty
c. Basic Institutions of Govt. in Islam

13. Islamic History

a. Period of Khlaft-e-Rashida
b. Period of Ummayyads
c. Period of Abbasids

14. Social System of Islam

a. Basic concepts of Social System of Islam
b. Elements of Family
c. Ethical values of Islam

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

3. Theory (100%)

Quiz and Assignment (10%)
Midterm (30%)
Final Term (60%)

Text and Reference Books:

1. Hameed ullah Muhammad, “Emergence of Islam” , IRI, Islamabad
2. Hameed ullah Muhammad, “Muslim Conduct of State”
3. Hameed ullah Muhammad, ‘Introduction to Islam
4. Mulana Muhammad Yousaf Islahi,”
5. Hussain Hamid Hassan, “An Introduction to the Study of Islamic Law” leaf Publication, Islamabad, Pakistan.
6. Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research Institute, International Islamic University, Islamabad (1993)
7. Mir Waliullah, “Muslim Jrisprudence and the Quranic Law of Crimes” Islamic Book Service (1982)
8. H.S. Bhatia, “Studies in Islamic Law, Religion and Society” Deep & Deep Publications New Delhi (1989)
9. Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001).

Functional English

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Enhance** language skills and develop critical thinking	Cognitive	1	10
2.	**Enable** the students to meet their real life communication needs	Cognitive	2	10, 12
3.	**Develop** critical thinking and enhance language skills	Cognitive	2	3, 10

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☑
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☑

Course Outline:

1. **Paragraph and essay writing**
   a. Practice in writing a good, unified and coherent paragraph
   b. Practice in writing a good, unified and coherent essay
2. **CV and job application**
   a. Translation skills
   b. Urdu to English
3. **Study skills**
   a. Skimming and scanning
   b. Intensive and extensive
   c. Speed reading
   d. Summary and précis writing and comprehension
4. **Academic skills**
   a. Letter/memo writing,
   b. Minutes of meetings,

c. Use of library and internet
d. How to write a proposal for research paper/term paper

5. **Presentation skills**
   a. Personality development (emphasis on content, style and pronunciation)
6. **Technical Report writing**
   a. Report parts
   b. Progress report writing

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**

  Quiz and Assignments (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Books:

1. White, R., 1987. *Writing: advanced*. Oxford University Press. Jones, P. and Farness, J., 2002. *College writing skills*. Rowman & Littlefield.
2. Kirszner, L.G. and Mandell, S.R., 2011. *Patterns for college writing: A rhetorical reader and guide*. Macmillan..
3. Langan, J. and Langan, J., 2002. *Reading and study skills*. McGraw-Hill.
4. Cottrell, S., 2013. *The study skills handbook*. Palgrave Macmillan.
5. Tonjes, M.J. and Zintz, M.V., 1992. *Teaching reading, thinking, study skills in content classrooms*. WCB/McGraw-Hill.

Calculus

Contact Hours:

Theory	=48
Practical	=0
Total	=48

Credit Hours:

Theory	=3.0
Practical	=0.0
Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Develop understanding of basic calculus used in engineering.	Cognitive	1	2
2	Calculate the limit of a function at a point numerically and algebraically using appropriate techniques	Cognitive	2	2

	including L'Hospital rule. Also to find points of discontinuity for a function and classify them.			
3.	Interpret physical systems and process in term of differential & integral calculus.	Cognitive	2	1
4.	Apply the mathematical tools in relevant engineering problems.	Psychomotor	3	2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Set and Functions**
   a. Define rational, irrational and real numbers;
   b. Rounding off a numerical value to specified value to specified number of decimal places or significant figures; solving quadratic, and
   c. Rational inequalities in involving modulus with graphical representation;
   d. Definition of set, set operations,
   e. Venn diagrams,
   f. DeMorgan's laws,
   g. Cartesian product, Relation,
   h. Function and their types (Absolute value, greatest integer and combining functions). Graph of some well-known functions. Limit of functions and continuous and discontinuous functions with graphical representation.
2. **Propositional Logic**
   a. Definition of Proposition,
   b. Statement and Argument,
   c. Logical Operators,
   d. Simple and Compound proposition,
   e. Various types of connectives,
   f. Truth table,
   g. Tautology,
   h. Contradiction,
   i. Contingency & Logical equivalence.

3. **Boolean Algebra**
    a. Definition, Boolean function,
    b. Duality, some basic theorems & their proofs,
    c. Two valued Boolean algebra,
    d. Truth functions,
    e. Canonical sum of product form,
    f. Digital logic Gates & Switching circuit designs.
4. **Complex Number**
    a. Argand diagram,
    b. De Moivre formula,
    c. Root of polynomial equations,
    d. Curve and regions in the complex plane,
    e. Standard functions and their inverses (exponential, circular and Hyperbolic functions).
5. **Differential Calculus**
    a. Differentiation and Successive differentiation and its application: Leibnitz theorem. Taylor and Maclaurin theorems with remainders in Cauchy and Lagrange form, power series. Taylor and Maclaurin series,
    b. L Hopitals rule,
    c. Extreme values of a function of one variable using first and second derivative test,
    d. Asymptotes of a function,
    e. Curvature and radius of curvature of a curve, partial differentiation,
    f. Exact differential and its application in computing errors, extreme values of a function of two variables with and without constraints. Solution of non-linear equation,
    g. Using Newton Raphson method.
6. **Integral Calculus**
    a. Indefinite integrals and their computational techniques,
    b. Reduction formulae,
    c. Definite integrals and their convergence. Beta and Gamma functions and their identities,
    d. Applications of integration. Centre of pressure and depth of centre of pressure.
7. **Solid Geometry**
    a. Coordinate Systems in three dimensions. Direction cosines and ratios,
    b. Vector equation of a straight line,
    c. Plane and sphere,
    d. Curve tracing of a function of two and three variables,
    e. Surfaces of revolutions,
    f. Transformations (Cartesian to polar & cylindrical).

Suggested Teaching Methodology:

- Lecturing
- Practice problems
- Exercises

Suggested Assessment:

4. **Theory (100%)**
   Quiz and Assignment (10%)
   Midterm (30%)
   Final Term (60%)

Text and Reference Books:

1. Kreyszig, E., 2010. *Advanced engineering mathematics*. John Wiley & Sons.
2. Ayres, F. and Mendelson, E., 1999. *Schaum's outline of calculus*. McGraw-Hill.
3. Thomas, G.B., Finney, R.L., Weir, M.D. and Giordano, F.R., 2003. *Thomas' calculus*. Reading: Addison-Wesley.
4. Stroud, K.A. and Booth, D.J., 2013. *Engineering mathematics*. palgrave Macmillan.
5. Anton, H., Bivens, I. and Davis, S., 2002. *Calculus* (Vol. 2). Hoboken: Wiley.

Applied Physics

Contact Hours:
Theory =32
Practical=48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of common physical phenomenon relevant to biomedical engineering.	Cognitive	1	1
2.	**Explain** the basic laws of properties of matter, electricity and magnetism, optics, fluids, thermodynamics and sound.	Cognitive	2	1
3.	**Discuss** the applications of common physical phenomenon relevant to biomedical engineering.	Cognitive	2	1
4.	**Observe** the laws of heat and optics	Psychomotor	1	1
5.	**Practice** on equipment related to sound, fluid and electromagnetism	Psychomotor	3	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Properties of Matter**
   a. Elasticity and modulus of Elasticity
   b. Experimental determination of young's modulus
   c. Bending of beams
   d. Cantilever.
2. **Fluids**
   a. Steady and turbulent flow
   b. Bernoulli's theorem, Viscosity
   c. determination of Coefficient of viscosity by Poiseuillie's method
   d. Surface tension
   e. Surface energy
   f. Angle of contact
   g. Determination surface tension by rise in a capillary tube.
3. **Heat & Thermodynamics**
   a. Heat, Temperature, and Theories of heat
   b. Adiabatic and isothermal processes
   c. The four laws of thermodynamics
   d. Thermodynamic functions
   e. Efficiency of Heat Engines
   f. Carnot's Cycle
   g. Entropy
   h. Reversible Process and cycles
   i. Thermodynamic equilibrium
   j. Introduction to Heat transfer Mechanisms.
4. **Optics**
   a. Waves and Oscillations
   b. Simple Harmonic Motion
   c. types of wave motion
   d. Optics of light
   e. Interference
   f. Diffraction
   g. Polarization
   h. Double refraction

i. Dispersion
j. Types and uses of Deviation Lasers

5. Electricity and Magnetism

a. Electric charges
b. Electric field
c. Electric potential
d. Coulomb's law
e. Gauss's law
f. Capacitors and dielectrics
g. Electric current
h. Ohm's Law
i. Magnetic properties of matter
j. Magnetic field
k. Magnetic force on current
l. Ampere's law, Faraday's law, and Lenz's law

6. Sound

a. Hearing and Echolocation
b. Ultrasound

Practical:

1. Study of Hook's Law
2. Measuring stress, strain and Young's Modulus of different materials
3. Study of Surface Tension and Viscosity of liquids
4. Study of Boiling points of liquids
5. Study of Gas laws
6. Venturi effect of liquids in motion
7. Heat transfer and entropy
8. Study of light, Color addition, Refection and Prism
9. Measurement of Snell's Law
10. Convex and Concave Lens
11. Study of reversibility and Dispersion of Light
12. Focal point and Magnification of Thin lens
13. Focal point and Magnification of Concave Mirror
14. Telescope and Microscope
15. Calculation of speed of Sound
16. Project : Construction of Telescope./Microscope.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**

  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested readings:

1. Halliday, D., Resnick, R. and Walker, J., 2010. *Fundamentals of Physics, Chapters 33-37*. John Wiley & Sons.
2. Ewen, D., Schurter, N. and Gundersen, E., 2016. *Applied physics*. Pearson.
3. Neeraj, M., 2011. *Applied Physics for Engineers*. PHI Learning Pvt. Ltd.
4. Giancoli, D.C., 2008. *Physics for scientists and engineers*. Pearson Education International.

Manufacturing Engineering

Contact Hours:
Theory =32
Practical =48
Total …...=80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the basics of manufacturing Engineering	Cognitive	1	1
2.	**Explain** the different operations and computerized numerical control system used in manufacturing engineering	Cognitive	2	1
3.	**Discuss** the applications of tooling, milling, drilling operations and also computer Computer-aided manufacturing (CAM	Cognitive	2	1,2
4.	**Practice** on equipment related to manufacturing and tooling	Psychomotor	3	1,5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☑

Course Outline:

1. **Turning and related operations:**
   a. Lathe construction
   b. Types of lathes,
   c. Accessories,
   d. Lathe operations
2. **Chip formation**,
   a. Mechanism of chip formation
   b. Cutting tool materials,
   c. Tool failure and tool life
3. **Shaping and planning**
   a. Shaper classifications and functions
   b. Shaper drive mechanism
   c. Planning construction and types
   d. Planer tools
   e. Metal bending and sheet rolling processes.
4. **Drilling and reaming**:
   a. Drilling types and sizes
   b. Drill chuck
   c. Counter boring and sinking
   d. Reaming
   e. Drilling machine types
5. **Milling**
   a. Operations
   b. Milling machines
   c. Milling types, size and accessories
6. **Gear manufacturing**:
   a. Gear terminology and types
   b. Basic methods for machining gears
7. **Computer-aided manufacturing (CAM) and Computer–integrated manufacturing (CIM) Systems**
   a. Machine tools control,
   b. Numerical control system,
   c. Computerized numerical control system (CNC) programming for numerical control.
   d. Concept of computer-integrated automation system (unmanned factory)

Practical

1. Fabrication of various machine elements using lathe.
2. Making a slot on a shaft for a cotter pin using shaper and milling machines.
3. Cutting threads using milling and lathe machines
4. Making holes in machine parts using drilling machines.
5. Making bends of metal sheet using sheet rolling machines.
6. Fabrication of a given agricultural machinery part.
7. Local visits to agricultural Machinery Manufacturing Industries.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  - Quiz and Assignment (10%)
  - Midterm (30%)
  - Final Term (60%)

- **Laboratory (100%)**

Text and Reference Books:

1. Kalpakjian, S. and Schmid, S.R., 2014. *Manufacturing engineering and technology* (p. 913). Upper Saddle River, NJ, USA: Pearson.
2. Pang, P.N., 2004. *Essentials of manufacturing engineering management*. iUniverse.
3. Qin, Y., 2010. *Micro-manufacturing engineering and technology*. William Andrew.
4. Rao, P.N., 2004.*CAD/CAM: principles and applications*. Tata McGraw-Hill Education.

Engineering Properties of Foods

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2
Practical =1
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of physical properties of food material.	Cognitive	1	1
2.	**Understand** the relationship between food composition and physical properties.	Cognitive	2	1
3.	Measure physical properties of food material.	Psychomotor	1	4
4.	**Apply** knowledge of physical properties of food materials in process calculations.	Psychomotor	3	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction to fundamental**
   a. Physical attributes:
   b. Size and size distribution,
   c. Shape, volume, density, porosity.
2. **Rheological properties:**
   a. Flow of materials; Newton's law of viscosity,
   b. Viscous fluids,
   c. Plastic fluids,
   d. Measurement of viscosity.
3. **Deformation of materials;**
   a. Viscoelastic behavior,
   b. Stress relaxation test,
   c. Creep test,
   d. Dynamic oscillatory test.
4. **Textural properties**:
   a. Texture profile analysis,
   b. Compression, snapping-bending,
   c. Cutting shear, puncture, penetration.
5. **Water activity and sorption properties:**
   a. Prediction and measurement of water activity,
   b. Effect of temperature and pressure on water
   c. Activity, preparation of sorption isotherms.

Practical:

- Determination of particle size and size distribution of particulate foods.
- Measurement of porosity of baked goods.
- Measurement of viscosities: tube viscometer, rotational viscometer.
- Measurement of textural properties: firmness and fracture tests.
- Measurement of optical properties using refract to meter and spectrophotometer.
- Measurement of water activity of foods

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  - Quiz and Assignment (10%)
  - Midterm (30%)
  - Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Rao, M.A., Rizvi, S.S., Datta, A.K. and Ahmed, J., 2014. *Engineering properties of foods*. CRC press.
2. Barbosa-Canovas, G.V., Juliano, P. and Peleg, M., 2009. Engineering properties of foods. In *Food engineering: Encyclopedia of life support systems* (pp. 39-70). EOLSS Oxford.
3. Arana, I., 2012. *Physical properties of foods: novel measurement techniques and applications*. CRC Press.
4. Mohos, F.Á., Engineering Properties of Foods. *Confectionery and Chocolate Engineering: Principles and Applications*, pp.52-96.

Food Chemistry

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** structure and properties of food components, including carbohydrates, proteins, lipids, other nutrients and food additives.	Cognitive	1	4
2.	**Identify** the risk associated with food toxicants and able to take necessary actions in order to avoid them.	Cognitive	2	4
3.	**Discuss** the applications of food chemistry in food industry	Cognitive	2	4
4.	**Apply** the principles of chemistry to food systems	Psychomotor	1	4

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☐	7 Environment and Sustainability	☐
2 Problem Analysis:	☐	8 Ethics	☐
3 Design/Development of Solutions	☐	9 Individual and Team Work	☐
4 Investigation	☑	10 Communication	☐
5 Modern Tool Usage	☐	11 Project Management	☐
6 The Engineer and Society	☐	12 Lifelong Learning	☐

Course Outline:

1. **Carbohydrates, Proteins, Lipid:**
   a. Classification
   b. Properties, Functionality, Reactions
2. **Vitamins, Minerals, Phenolic compounds**
   a. Classification
   b. Properties, Functionality, Reactions
3. **Food Additives:**

3.1 Preservatives:

a. Benzoic acid,
b. Parabens,
c. Sorbic acid,
d. Sulfites,
e. Nitrates,
f. Sodium Chloride

3.2 Colorants

a. Natural pigments,
b. Synthetic dyes

3.3 Antioxidants:

a. Butylated hydroxyanisole (BHA),
b. Butylated hydroxyl toulene (BHT),
c. Tertiary butyl hydroquinone (TBHQ),
d. Ethylene Diamine tetracetic acid (EDTA)

3.4 Sweeteners:

a. Nutritive and Non-nutritive sweeteners,
b. Cyclamate,
c. Saccharin,
d. Aspartame,
e. Acesulfame K

3.5 Emulsifiers:

a. Hydrophile/ lipophile balance (HLB),
b. Lecithin,
c. Di and Triglycerides

4. **Contaminants and evaluation of metals:**
   a. Toxic Trace Elements: Arsenic, Mercury, Lead, Cadmium
5. **Radionuclides**
6. **Toxic Compounds of Microbial Origin**
   a. Food Poisoning by Bacterial Toxins, Mycotoxins
7. **Plant-Protective Agents(PPA):**
   a. Active Agents,
   b. Insecticides,
   c. Fungicides,
   d. Herbicides
8. **Veterinary Medicines and Feed Additives: Antibiotics**
9. **Polycyclic Aromatic Hydrocarbons (PAHs):**
   a. Furan ,
   b. Acrylamide
10. **Nutritional value of food:**
    a. Calorific value and pH of food.

Practical:

1. Determination of iodine content in iodised salt by iodometric titration.
2. Effect of heat on proteins.
3. Effect of different reagents on coagulation of proteins.
4. Spectroscopic analysis of food dyes.
5. Detect the catalase activity in raw potato.
6. Compare titratable acidity of fruit juice samples.
7. Effect of inversion on brix value of sugar solution.
8. Determination of the amount of the acid neutralized by antacid compound using back titration.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**

  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Finley, J.W., Hurst, W.J. and Lee, C.Y., 2018. Principles of Food Chemistry.
2. DeMan, J.M., 1976. *Principles of Food Chemistry*. AVI Publishing Co., Inc..
3. Brody, T., 1998. *Nutritional Biochemistry*. Academic press.
4. Belitz, H.D. and Grosch, W., Food Chemistry/H.-D. Belitz, W. Grosch.

Programming Languages

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the basic knowledge of computer programming and computer language	Cognitive	1	1
2.	**Explain** general functions, accessories and uses of computer and	Cognitive	2	1 ,3
3.	**Solve** engineering problems using C++ programming	Cognitive	2	1 , 2
4.	**Practice** using computer programming to solve different problems	Psychomotor	3	1 ,5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☑7	Environment and Sustainability	☐
2 Problem Analysis:	☑8	Ethics	☐
3 Design/Development of Solutions	☑9	Individual and Team Work	☐
4 Investigation	☐10	Communication	☐
5 Modern Tool Usage	☑11	Project Management	☐
6 The Engineer and Society	☐12	Lifelong Learning	☐

Course Outline:

1. **The Turbo C programming environment**
   Setting up the integrated development environment, file used in C program development, use of integrated development environment, the basic structure of C program, explaining the printf( ) function.
2. **C Building blocks**
   Variables, input/output, operators, comments
3. **Loops**
   The for loop, the while loop, the do while loop
4. **Decisions**
   The if statement, the if-else statement; the else-if construct, the switch statement, the conditional operator

5. **Functions**
   Simple functions, functions that return a value, using arguments to pass data to a function, using more than one functions, external variables, prototype versus classical K and R, preprocessor directives
6. **Arrays and strings**
   Arrays; referring to individual elements of the array; string; string functions; multidimensional arrays
7. **Pointers**
   Pointer overview, returning data from functions, pointers and arrays, pointers and strings, double indirection, pointers to pointers, Structures, unions and ROM BIOS
8. **Turbo C graphics functions**
   Text-mode functions graphics - mode functions, text with graphics.
9. **Files**
   Types of disk I/O, standard, input/output binary mode and text mode, record, input/output, random access, error conditions, system level input/output, redirection
10. **Advanced variables**
    Storage classes, enumerated data type, renaming data type with typedef, identifiers and naming classes, type conversion and casting, labels and goto statement
11. **c++ and object oriented programming**
    Object oriented programming, some useful c++ features, classes and objects, constructors and memory allocations, inheritance, function overloading, operator overloading

Practical:

1. Introduction to Turbo C IDE and Programming Environment
2. C Building Blocks
3. Operators and Expressions
4. Using Standard Libraries in C Language
5. Looping construct in C Language
6. Nested Looping
7. Decision control structure
8. The switch case and conditional operator
9. Debugging and Single Stepping of C programs
10. Functions in C Language
11. Preprocessor Directives
12. Arrays in C (single dimensional)
13. Arrays in C (Multidimensional)
14. Text and Graphics modes of display in C
15. Structures
16. Pointers in C-Language
17. Pointers with arrays and function
18. Filing in C-Language

Suggested Teaching Methodology:

- Lectures
- Practical exercises

Suggested Assessment

- **Theory (100%)**
  - Quiz and Assignment (10%)
  - Midterm (30%)
  - Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Kanetkar, Y. P., 2006. *Let Us C*. BPB Publications.
2. Goel, A., 2010. *Computer fundamentals*. Pearson Education India.
3. Courter, G., Browning, K. and Marquis, A., 2001. *Mastering Microsoft Office XP Premium Edition*. SYBEX Inc..
4. Lafore, R., 2001. *Object-oriented programming in Turbo C++*. Galgotia publications
5. Samek, M., 2008. *Practical UML statecharts in C/C++: event-driven programming for embedded systems*. CRC Press.
6. Peter, N., 2014. *Introduction to Computers*. McGraw-Hill, New York, USA.

Pakistan Studies

Contact Hours:
Theory =32
Practical =0
Total =32

Credit Hours:
Theory =2.0
Practical =0
Total =2.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.	Cognitive	1	8, 12
2.	**Acquire** the knowledge of the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.	Cognitive	2	1, 3
3.	**Compare** different cycles of thermodynamics	Cognitive	3	1, 2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☑
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☑

Course Outline:

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.
2. **Government and Politics in Pakistan**
   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward
3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm(30%)
  Final Term (60%)

Suggested Books:

1. Rizvi, H., 2000. *Military, state and society in Pakistan*. Springer
2. Zaidi, S.A., 2005. *Issues in Pakistan's economy*. OUP Catalogue
3. Mehmood, S., 1994. Pakistan Political Roots & Development
4. Wilcox, W.A., 1973. *The Emergence of Bangladesh*. American Enterprise Inst. for Public Policy Research
5. Amin, T., 1988. *Ethno-national movements of Pakistan: domestic and international factors*. Insitute of Policy Studies
6. Ziring, L., 1980. *Pakistan: The Enigma of Political Development*. Folkestone, Kent: Dawson; Boulder, Colo.: Westview

Engineering Thermodynamics

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the basic knowledge of thermodynamics	Cognitive	1	1
2.	**Explain** the different cycles of energy used for engines and their applications in food industry	Cognitive	2	1, 3
3	**Compare** different cycles of thermodynamics	Cognitive	3	1, 2
4	**Observe** the laws of thermodynamics	Psychomotor	2	1
5	**Practice** on available equipment to check the efficiency of thermodynamics cycles used in engines	Psychomotor	3	1, 5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Basic of thermodynamics**
   a. Definition of thermodynamics and energy;
   b. Dimensions and units;
   c. Systems and control volume; properties
2. **Energy and Energy Transfer:**
   a. Forms of energy
   b. Energy transfer by heat and work
   c. Mechanical work
   d. First law of thermodynamics.
   e. Pure substances
   f. Phases of pure substance
   g. Property diagrams and tables
   h. Ideal gas equations
   i. Compressibility factor
   j. Mass and energy analysis for closed systems and control volumes; examples.
3. **Second Law of Thermodynamics & Entropy:**
   a. Second law concepts
   b. Carnot cycle
   c. Entropy
   d. Isentropic processes
   e. Increase of entropy principle
   f. Power and Refrigeration cycles
   g. Essential equipment
4. **Thermodynamics Properties for Mixture:**
   a. Maxwell relations;
   b. Clapeyron equation
   c. Joule Thomson Coefficient;
   d. Gibbs free energy and fugacity for pure substance;
   e. Criteria for phase equilibria in multi-component system; vapor-liquid equilibrium.
5. **Chemical & Phase Equilibria:**
   a. Chemical equilibrium in single phase system;
   b. Chemical reactions; combined chemical and phase equilibrium.
   c. pH as criteria for ionization of biochemicals;

Practical:

1. Introduction to thermodynamic terms and properties.
2. Introduction to thermodynamic processes.
3. Measurement of temperature of solid, liquid and gas using different temperature measuring devices.
4. To observe the variation of pressure with depth.
5. To determine the specific gravity of an unknown liquid.
6. To measure the applied and differential pressures using different pressure measuring devices.

7. To observe the behaviour of liquid following the Pascal's and Steven's Laws.
8. To study the Boyle's Law as applied to air at moderate pressure.
9. To identify the main components and study the working of a two stroke compression ignition engine.
10. To identify the main components and study the working of a four stroke spark ignition engine.
11. To study the steam power plant cycle and the steam plant in the laboratory.
12. To study the vapour compression refrigeration cycle.
13. To study gas turbine cycle and identify various gas turbine components in the laboratory.

Suggested Teaching Methodology

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**

  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Chattopadhyay, P., 2011. *Engineering thermodynamics*. Oxford University Press.
2. Schwartzberg, H.G. and Hartel, R.W. eds., 1992. *Physical chemistry of foods*. CRC Press.
3. Levenspiel, O., 1996. *Understanding engineering thermo*. Prentice Hall PTR.
4. Lewis, M.J., 1990. *Physical properties of foods and food processing systems*. Elsevier.
5. Bejan, A., 2016. *Advanced engineering thermodynamics*. John Wiley & Sons.
6. Moran, M.J., Shapiro, H.N., Boettner, D.D. and Bailey, M.B., 2010. *Fundamentals of engineering thermodynamics*. John Wiley & Sons.
7. Klotz, I.M. and Rosenberg, R.M., 2008. *Chemical thermodynamics: basic concepts and methods*. John Wiley & Sons.
8. Moran, M.J., Shapiro, H.N., Boettner, D.D. and Bailey, M.B., 2010. *Fundamentals of engineering thermodynamics*. John Wiley & Sons.

Engineering Mechanics

Contact Hours:
Theory =48
Practical =48
Total =96

Credit Hours:
Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the basic knowledge of mechanics with the concepts of free body diagram and the concepts of vectors.	Cognitive	1	1
2.	**APPLY** the principles of mechanics by employing the equations of static equilibrium for different systems.	Cognitive	2	1
3.	**IDENTIFY** and model various types of loading and support conditions that act on structural systems.	Cognitive	2	1
4.	**Observe** , the law of parallelogram of forces	Psychomotor	1	1
5.	**Practice on** modulus of rigidity of metal bar by static and dynamic methods	Psychomotor	3	1 ,5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction:**
   a. General principles of statics,
   b. Forces in a plane,
   c. Newton's First law of motion,
   d. Scalars & Vectors,

e. Vector addition & subtraction,
f. Parallelogram law, Triangle law,
g. Momentum, Co-planar force system,
h. Forces in a space (rectangular components),
i. Equilibrium of a particle,
j. Force vectors,
k. Cartesian vectors,
l. Position vectors,
m. Dot product,
n. Three dimension force system, Free body diagram.

2. Rigid Bodies:

a. Equivalent system of forces,
b. Principle of vectors,
c. Moment of forces,
d. Couple, Cross product,
e. Center of gravity of a three dimensional body and a centroid of a volume.

3. Equilibrium of Rigid bodies:

a. Equilibrium in 2D and 3D
b. Constrains for a rigid body
c. Redundant and improper constraints,

4. Friction:

a. Types of friction;
b. Angle of repose;
c. Application of friction.

5. Kinematics of a Particle:

a. Rectilinear motion;
b. Curvilinear motion;
c. Motion of projectile;
d. Absolute dependent motion of two particles.

6. Kinetics of a Particle:

a. Equation of motion for a system of particle;
b. Equation of motion in rectangular,
c. Cylindrical, normal and tangential coordinates;
d. Principles of work and energy for a system of particles;
e. Linear momentum;
f. Conservation of momentum;
g. Impact; angular momentum;
h. Kinematics of a rigid body;
i. Translation;
j. Rotation.

Practical:

1. To study vernier calipers, take different types of measurement and study different types of errors.

2. To study screw gauge, take measurements and study different types of errors.
3. To determine Young's Modulus of a given steel bar by flexure or deflection method.
4. To determine the modulus of rigidity steel rod.
5. To determine the reaction forces for supported beam, which is arbitrarily loaded.
6. To measure the coefficient of restitution different inetallic and non-metallic balls hardened steel block.
7. To investigate the effect lipan the time period of a vibrating system caused by varying it mass and to determine the value of unknown mass by dynamical method.
8. To study the law of conservation of momentum for the case of two colliding objects, which strikes together after the impact and to measure the loss of the K.E. at the impact.
9. To determine the velocity of an arrow in flight by plastic collision.
10. To determine the moment of inertia of a body about an axis and to compare this with the theoretical value computed from the masses and dimension of the body.
11. To verify the velocity of the end ball after impact in a multi-impact system.
12. To observe the effect on the precession axis of gyroscope when the spin axis speed is changed.
13. Compare the range of follower on an eccentric circular cam.
14. To study the effects of projected object moving on a rotating surface.
15. To balance a given shaft through static and dynamic balancing apparatus.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Bedford, A., Fowler, W.L. and Fowler, W.T., 2003. *Engineering Mechanics: Statics & Dynamics Principles*. Pearson Education.
2. Rajasekaran, S., 2009. *Engineering Mechanics: Statics and Dynamics*. Vikas Publishing House.
3. Bedford, A., Fowler, W.L. and Fowler, W.T., 2003. *Engineering Mechanics: Statics & Dynamics Principles*. Pearson Education.

4. Beer, F.P., Johnston Jr, E.R., Mazurek, D.F., Cornwell, P.J., Eisenberg, E.R. and Sanghi, S., 1972. *Vector mechanics for engineers* (Vol. 1). Tata McGraw-Hill Education.

Food Process Engineering

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of food processing	Cognitive	1	1
2.	**Explain** the working principal and mechanism of different machines involve in food processing	Cognitive	2	1
3.	**Discuss** the applications of food processing in industries.	Cognitive	2	1
4.	**Observe** the laws of evaporators and dryers	Psychomotor	1	1
5.	**Practice** on equipment related to evaporators and dryers.	Psychomotor	3	1,2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Overview**
   a. Unit conversion
   b. Material and energy balance
   c. Fluid flow properties
   d. Engineering properties of food

2. **Food processing**;
    a. Thermal processing
    b. Non-thermal processing
3. **Drying and dehydration process**
    a. Solar drying
    b. Oven drying
    c. Forced convection drying
    d. Microwave drying,
    e. Ohmic heating,
4. **Low temperature processing**
    a. Air circulation freezing
    b. Immersion freezing
    c. Cryogenic freezing
5. **Evaporator**
    a. Introduction
    b. Types of evaporator
6. **Membrane separation**
    a. Emulsification process
    b. Filtration
7. **Minimal processing**
    a. Electrostatic coating,
    b. Design of coatings

Practical

1. Demonstration of an Auto Clave
2. Sterilization of Glassware
3. Determination of PH and Specific Gravity of Milk
4. Sample of Milk for Analysis
5. Determination of Fat, SNF, Density and Water Contents of Milk
6. Difference between Pasteurization and Sterilization
7. Clot on boiling test
8. Alcohol precipitation Test
9. Carbonate and Bicarbonate Test
10. Cost Analysis of Food Processing Machinery
11. To study the working principal of evaporator
12. To Study the working principle of drum dryer

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Quiz and Assignment (10%)
  - Midterm (30%)
  - Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Brennan, J.G. and Grandison, A.S. eds., 2012. *Food processing handbook*. John Wiley & Sons.
2. Dunne, C.P., 2008. *High pressure processing of foods* (Vol. 12). John Wiley & Sons.
3. Gaonkar, A.G. ed., 1995. *Food processing: recent developments*. Elsevier. Science
4. Smith, J.S. and Hui, Y.H. eds., 2008. *Food processing: principles and applications*. John Wiley & Sons.

Differential Equations and Fourier Series

Contact Hours:
Theory = 48
Practical = 0
Total = 48

Credit Hours:
Theory = 3.0
Practical = 0.0
Total = 3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the different methods of solving differential equations	Cognitive	2	1
2.	**Apply** laplace transformation to solve differential equations	Cognitive	2	1, 2
3.	**Evaluate** Fourier series of periodic function	Cognitive	4	2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **1st Order Differential Equations**
   a. Basic concept
   b. Formation of differential equations and solution of differential equations by direct integration and by separating the variables,
   c. Homogeneous equations and equations reducible to homogeneous from
   d. Linear differential equations of the order and equations reducible to the linear form
   e. Bernoulli's equations and orthogonal trajectories,
   f. Application in relevant Engineering
2. **2nd and Higher Orders Equations**
   a. Special types of IInd order differential equations with constant coefficients and their solutions
   b. The operator D
   c. Inverse operator l/D
   d. Solution of differential by operator D methods; Special cases
   e. Cauchy's differential equations
   f. Simultaneous differential equations
   g. simple application of differential equations in relevant Engineering
3. **Partial Differential Equation**
   a. Basic concepts and formation of partial differential equations
   b. Linear homogeneous partial differential equations and relations to ordinary differential equations
   c. Solution of first order linear and special types of second and higher order differential equations
   d. D' Alembert's solution of the wave equation and two dimensional wave equations
   e. Lagrange's solution: Various standard forms
4. **Lap lace Integral & Transformation**
   a. Definition
   b. Laplace transforms of some elementary functions
   c. first translation or shifting theorem
   d. second translation or shifting theorem
   e. change of scale property
   f. Laplace transform of the nth order derivative
   g. initial and final value theorem Laplace transform of integrals Laplace transform of functions tn F(t) and F(t)/ t,
   h. Laplace transform of periodic function, evaluation of integrals
   i. definition of inverse Laplace transform and inverse transforms
   j. convolution theorem
   k. solutions of ordinary differential using Laplace transform
5. **Fourier series**
   a. Periodic functions and expansion of periodic functions in Fourier series and Fourier coefficients

b. Expansion of function with arbitrary periods. Odd and even functions and their Fourier series
c. Half range expansions of Fourier series
d. “DFT and FFT, Fourier Spectrum"

Suggested Teaching Methodology

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Farlow, S.J., 2006. *An introduction to differential equations and their applications*. Courier Corporation.
2. Zill, D.G., 2012. *A first course in differential equations with modeling applications*. Cengage Learning.
3. Kreyszig, E., 2010. *Advanced engineering mathematics*. John Wiley & Sons.
4. Anton, H., 2010. *Elementary linear algebra*. John Wiley & Sons.
5. Strang, G., 1993. *Introduction to linear algebra* (Vol. 3). Wellesley, MA: Wellesley-Cambridge Press.
6. Axler, S., 1997. *Linear algebra done right* (Vol. 2). New York: Springer.
7. Kolman, B. and Hill, D.R., 2004. *Elementary linear algebra*. Pearson Education.
8. Kreyszig, E., 2010. *Advanced engineering mathematics*. John Wiley & Sons.

Sociology for Engineers

Contact Hours:
Theory =32
Practical =0
Total =32

Credit Hours:
Theory =2
Practical =0
Total =2.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of social interaction and interpersonal behavior	Cognitive	1	8
2.	**Understand** the human ecology and social satisfaction with change in population dynamics	Psychomotor	2	6
3.	**Discuss** the community development and crime.	Cognitive	2	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☑
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☑	12	Lifelong Learning	☐

Course Outline:

1. **Introduction to Sociology**
   a. Nature, Scope, and Importance of Sociology
   b. Social Interactions, Social Groups, Social Institutions Culture and Related Concepts
2. **Definition of Culture**
   a. Types of Culture
   b. Elements of Culture
   c. Role of Culture in Organization
   d. Socialization and Personality
3. **Interpersonal Relations**
   a. Interpersonal Behavior
   b. FormationofPersonalAttitudes,LanguageandCommunication,Motivation sandEmotions,PublicOpinion
4. **Social Stratification**
   a. Factors of Social Stratification
   b. Caste and class, Power, Prestige, and Authority
   c. Social Mobility and Migration
5. **Human Ecology**
   a. Ecological Processes
   b. Ecosystem and energy, Ecosystem and Physical Environment
   c. Solid Waste Disposal, Pollution

6. **Population Dynamics**
   a. World Population Growth and Distribution
   b. Population Dynamics in Pakistan
   c. Causes and Consequences of Urbanization
   d. Population Policyin Pakistan
   e. Population and Development
7. **Community Development**
   a. Meaning, Scope, and Subject Matter of Community Development
   b. Processes of Community Development, Community Development Programs in Pakistan
   c. Community Organization and Related Services
   d. Cooperation and Conflict in Community Development
8. **Deviance and Crime**
   a. Crimeasa Social and Cultural
   b. Phenomenon, Crime and Social Organization
   c. Organized Crime, Culture Based Crime, Economics of Crime
9. **Sociology of Change and Development**
   a. What is Social Change and Development
   b. Dynamics of Social Change, Role of NGO sin Development
   c. World System and Development, Gender and Development

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Van Krieken, R., Habibis, D., Smith, P., Hutchins, B., Martin, G. and Maton, K., 2013. *Sociology* 5th Edition.
2. Bassis, M.S., Gelles, R.J., Levine, A. and Calhoun, C., 1988. *Sociology: an introduction* (No. 3rd). Random house.
3. Ritzer, G., 2017. *Introduction to sociology*. SAGE publications.
4. McIntyre, L.J., 2011. *The practical skeptic: Core concepts in sociology* (p. 304). McGraw-Hill.
5. Urry, J., 2012. *Sociology beyond societies: Mobilities for the twenty-first century*. Routledge.

Fluid Mechanics

Contact Hours:		**Credit Hours:**
Theory	=48	Theory =3.0
Practical	=48	Practical =1.0
Total	=96	Total =4.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of fluid properties	Cognitive	1	1
2.	**Understand** the basic laws fluid kinematics and fluid statics.	Psychomotor	2	1
3.	**Discuss** the applications of energy consideration in steady flow as well as momentum and forces in fluid flow	Cognitive	2	2
4.	**Observe** the Similitude and dimensional analysis	Psychomotor	1	1
5.	**Practice** the steady in compressible flow in pressure conduits and turbine	Psychomotor	3	4

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☑	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline

1. **Introduction**
   a. Concept of fluids
   b. Fluid continuum
   c. The no-slip condition
   d. Density
   e. Specific gravity
   f. Vapor pressure & cavitation
   g. Surface tension & capillary effects
2. **Fluid Statics**
   a. Pressure at a point
   b. Pressure measurement
   c. Manometry; hydrostatic force on a submerged place & curved surface
   d. Buoyancy and stability
3. **Fluid Kinematics**
   a. Flow kinematics

b. Stress & strain rate
c. Viscosity
d. Newtonian fluids
e. Conservation laws
f. Continuity& momentum equation

4. Viscous Flow

a. Laminar internal flow
b. Poiseuille and Couette flow
c. Turbulent internal flow
d. Friction factor
e. Boundary layer thickness
f. Skin friction& drag
g. Internal flow in pipes
h. External flow past immersed bodies

5. Dimensional Analysis

a. Dimensional analysis
b. Nature of dimensional analysis
c. Buckingham's Π theorem
d. Arrangement of dimensionless group

Practical:

Section – I Fluid Statics Practical

- Measurement of Viscosity
- Hare's Apparatus
- Pascal's Law Application: The Hydraulic Press
- Demonstration of Pascal's Law: press
- Measurement of Surface Tension
- Capillary Effects
- Demonstration of Archimedes' Principle

SECTION – II Fluid Dynamics Practical

- Study of Pressure auto Flow Measurement Devices
- Study of Venturimeter
- Study of Orifice Plate
- Study of Turbulent Flow
- Study of Laminar Flow
- Study of V-notch
- Study of Flow Nozzle

Suggested Teaching Methodology

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**

  Quiz and Assignment (10%)
  Midterm (30%)

Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Munson, B.R., Okiishi, T.H., Rothmayer, A.P. and Huebsch, W.W., 2014. *Fundamentals of fluid mechanics*. John Wiley & Sons.
2. Yunus, A.C. and Cimbala, J.M., 2006. Fluid mechanics fundamentals and applications. *International Edition, McGraw-Hill Publication*, *185201*.
3. White, F.M., 1999. Fluid mechanics, WCB. *Ed McGraw-Hill Boston*.
4. Elger, D.F. and Roberson, J.A., 2016. *Engineering fluid mechanics* (pp. 170-185). Hoboken (NJ): Wiley.
5. Pletcher, R.H., Tannehill, J.C. and Anderson, D., 2012. *Computational fluid mechanics and heat transfer*. CRC Press.
6. Monin, A.S. and Yaglom, A.M., 2013. *Statistical fluid mechanics, volume II: Mechanics of turbulence* (Vol. 2). Courier Corporation.

Materials & Metallurgy

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1
Total =4.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy Level	PLO
1.	**Acquire** the basic knowledge of materials engineering.	Cognitive	1	1
2.	**Understand** the importance of different types of composite materials.	Cognitive	3	1
3.	**Apply** the different methods to protect the materials from environmental degradation.	Cognitive	3	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction to Materials Engineering**
   a. Types of materials
   b. Source of materials and their extraction
   c. Crystalline and amorphous materials
   d. Application and selection of materials (basic criteria for different environments)
2. **Metallic Materials**
   a. Pure metals and alloys
   b. Nature and properties of metals and alloys
   c. Major properties of metal and alloys
   d. Single crystal and polycrystalline metals
   e. Crystal defects and the mechanism of deformation and fracture
   f. Plastic flow in polycrystalline materials
   g. Structure property relationship
   h. Macro and micro examination
   i. Structural aspect of solidification & solid phase transformation in binary systems
   j. Ferrous and non ferrous metals
   k. Steel making processes
   l. Heat treatments
   m. TTT diagram
   n. Surface hardening coatings
   o. Powder metallurgy
   p. Non destructive testing
3. **Ceramics, Glasses & Refractory Materials**
   a. Compositions
   b. Properties
   c. Structures of various non metallic materials
   d. Application of Ceramics
   e. Glasses, refractory materials
   f. Methods of manufacture
4. **Polymers & Rubbers**
   a. Polymerization
   b. Structural feature of Polymers
   c. Thermoplastic Polymers
   d. Thermo setting Polymers
   e. Additives
   f. Major mechanical properties
   g. Rubber (elastomers)
   h. Synthesis of rubber
5. **Composites**
   a. Introduction to composite materials
   b. Types of composite materials
   c. Method of fabrication of composite materials

d. Property averaging
e. Major mechanical properties

6. Environmental Degradation

a. Metal degradation by atmosphere
b. Aqueous & galvanic corrosion
c. Stress corrosion cracking
d. Methods of corrosion prevention
e. Behavior of metal at elevated temperature pyrometer
f. Oxidation, scaling and creep
g. Chemical degradation of ceramic & polymers
h. Radiation damage surface
i. Improvement against degradation

Practical:

1. To prepare metallurgical specimen for microscopic examination
2. To study microstructure of steel specimen using metallurgical microscopic.
3. To study microstructure of gray cast iron specimen using metallurgical microscopic
4. To carry out annealing of given steel specimen.
5. To carry out normalizing of given steel specimen
6. To carry out Hardening of given steel specimen
7. To carry out mounting of given specimen using PRONTOPRESS-2.
8. To measurement grain size of given steel specimen
9. To carry out injection molding of plastics using hand operated injection molding machine.
10. To carry out Jominy end quench test and draw the hardenability curves for steels.
11. To carry out pack carburizing of low carbon steel.
12. To carry out sand casting of non ferrous metals.
13. To carry out cold rolling of non ferrous metal and study its effect on properties.
14. To carry out the effect of various parameters on copper plating of steel sheet.
15. To prepare a composite part using hand layup technique.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Abbaschian, R., AbbaschianL., and ReedH. R.E. 2008. Physical Metallurgy Principles. Cengage Learning.
2. William D. C., 2007. Materials Science and Engineering 7th Ed. seven, John Wiley & sons.
3. Donald R. A. and Wendelin J. W., 2013. Essentials of Materials Science & Engineering, 3rd Ed.Cengage Learning.
4. Courtney, T.H., 2000. Mechanical Behavior of Materials 2nd Ed. McGraw-Hill Higher Education, Burr Ridge.

Post-Harvest Engineering

Contact Hours:
Theory =32
Practical = 48
Total =80

Credit Hours:
Theory =2
Practical =1
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of post-harvest engineering operations	Cognitive	1	1
2.	**Apply** the knowledge of physiological maturity of crops for optimum harvesting and handling cereals, fruits and vegetables	Cognitive	2	1
3	**Practice** on measuring physical characteristic of food products, size reduction machines and product handling equipment	Psychomotor	3	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction**
   a. Value addition
   b. Structure and composition of food grains and fruits
2. **Physiological maturity of grain, pulses, vegetable, fruit crops etc.**
3. **Harvesting, threshing, handling, transportation techniques**
   a. For grains
   b. For fruits
   c. For vegetables etc.
4. **Harvesting recommendations**
   a. For grains
   b. For fruits
   c. For vegetables etc.
5. **Grain, pulses, vegetable, fruit crops losses and their control**
   a. During harvesting
   b. Handling
   c. Transportation
6. **Material handling and transportation equipment**
   a. Belt conveyors
   b. Chain conveyors
   c. Bucket elevators
   d. Pneumatic conveyors
   e. Gravity conveyors and augers
   f. Trailer/ trucks
7. **Post-harvest losses**
   a. Losses forms
   b. Measurement of post-harvest losses
   c. Methods to control post-harvest losses
8. **Size reduction**
   a. Size reduction and screen analysis of solid foods
   b. Types of size reduction mills
   c. Fineness modulus
   d. Value of ground feed
   e. Size relationships
   f. Energy requirements
   g. Size reduction procedures
   h. Reducing devices
   i. Performance and characteristics of size reduction devices
   j. Mixing and types of mixers
9. **Food product storage, quality and their importance**
10. **Grades**
    a. Grade factors
    b. Grade standards

Practical:

1. Measurement of moisture content of various employing different methods / techniques
2. Measurement of size and shape
3. Measurement of density and specific gravity
4. Measurement of porosity
5. Measurement of angle of repose and coefficient of friction
6. Measurement of hardness
7. Measurement of cereal losses during harvesting, handling and transportation
8. Measurement of fruits and vegetable losses during harvesting, handling and transportation
9. Size reduction by different machines and determination of fineness modulus and uniformity index
10. Operation demonstration of material handling and transportation equipment: belt conveyors, chain conveyors, bucket elevators, pneumatic conveyors, gravity conveyors, augers, trailer/ trucks.
11. Food industrial visits (2-No)

Suggested Assessment:

- **Theory (100%)**
  - Quiz and Assignment (10%)
  - Midterm (30%)
  - Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Brennan, J.G. and Grandison, A.S. eds., 2012. *Food processing handbook*. John Wiley & Sons.
2. Jongen, W. ed., 2002. *Fruit and vegetable processing: Improving quality*. Elsevier.
3. Kumari, A. 2013. Post-harvest management of fruits & vegetables, Enkay Pub. House, New Delhi, India.
4. Nirala, V.K. 2011. Harvest technology of the horticultural crops. Vista International Pub. House, Delhi, India.
5. Sahay, K.M. and Singh, K.K., 1996. *Unit operations of agricultural processing*. Vikas Publishing House Pvt. Ltd..
6. Singh, D.K. 2012. Post harvesting engineering, Oxford Book Co., UK.

Mechanics of Materials

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**DETERMINE** resultant internal loadings and strains in structures, and model bending moment and shear force diagrams.	Cognitive	1	1
2.	**EVALUATE** geometrical properties of cross-sections and stiffness and strength properties of engineering materials.	Cognitive	2	1
3.	**ANALYZE** simple structures like shafts and beams by applying torsional formula and flexural formula to calculate torsional stress and bending stress respectively.	Cognitive	2	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑7	Environment and Sustainability	☐
2	Problem Analysis:	☐8	Ethics	☐
3	Design/Development of Solutions	☐9	Individual and Team Work	☐
4	Investigation	☐10	Communication	☐
5	Modern Tool Usage	☐11	Project Management	☐
6	The Engineer and Society	☐12	Lifelong Learning	☐

Course Outline:

1. **Stress and strains**
   a. Stress at a point
   b. Components of stress
   c. Analysis of plane stress
   d. Principle stresses
   e. Maximum shear stress
   f. Mohr's circle
2. **Axial loading**
   a. Stress due to axial forces,
   b. Properties of material under axial loading
3. **Bending and combined loading**
   a. Bending stresses in beams,
   b. Shear and bending moment diagrams
   c. Bending and torsion loading

4. **Deflection of beams**
   a. Double integration method with singularity function
   b. Area moment method
   c. Torsion
   d. Shearing stress and angle of twist
   e. Hollow and circular shafts
5. **Buckling**
   a. Pin ended column
   b. Eccentrically loaded column
   c. Initially curved column
   d. Critical loads and critical stresses
6. Curved beams and Cylinders and spheres
   a. Stresses in curved bars
   b. Stresses in thin and thick walled cylinders
7. **Fatigue loading.**
   a. Analysis
   b. Design

Practical:

1. To understand basic mechanical properties of materials
2. To determine the hardness of the given materials through Brinell Method
3. To determine the hardness materials by Rockwell Method
4. To determine the. ultimate shear strength of the given materials shear
5. To find the modulus of elasticity calculate ductility through tensile test
6. To determine the tensile strength of given wire with the help of Tinius Olsen Universal Testing Machine
7. To determine the Flexural Rigidity of bar material by method of deflection
8. To determine the following through the leaf spring test:
   - Stiffness
   - Graph between load and deflection
   - Strain energy
   - Proof load (the load at which the leaf Spring becomes straight)
9. To determine the stiffness of helical coil spring and calculate the strain energy at 140 kg and draw graph of toad vs deflection

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Ugural, A.C. and Fenster, S.K., 2011. *Advanced mechanics of materials and applied elasticity*. Pearson Education.
2. James M. Gere, Barry J. Goodno. 2011. Mechanics of Materials. Cengage Learning.
3. Hannah J. and R. C. Stephens, 1999. Mechanics of Materials: Advance theory and Examples, Vinod Vasishtha, India.
4. Muvdi, B.B. and McNabb, J.W., 2012. *Engineering mechanics of materials*. Springer Science & Business Media.

Engineering Economics and Management

Contact Hours:
Theory =48
Practical=0
Total =48

Credit Hours:
Theory =3.0
Practical=0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy Level	PLO
1.	**Acquire** the knowledge management fundamentals and project programs	Cognitive	1	1
2.	**Explain** the project scheduling and marketing management.	Cognitive	2	2
3.	**Analyze** the role of company in market place and economics accountability.	Cognitive	4	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Management Fundamentals**
   a. Management, Administration
   b. Leadership, Relationship Vs Task Management

2. **Project and Program**
   a. Project Life Cycle
   b. Trade Off. Line/Project Organization
3. **Functional Organization**
   a. Matrix organization
   b. Mixed organization
4. **Role and Responsibilities**
   a. Career Path, Special Demands on the Project Manager
   b. Common characteristics of a most effective
   c. Team, Selection of a project manager
5. **Project Scheduling and Control**
   a. Network Techniques
   b. PERT, CPM & GRANT Charts
   c. Use of project management software
   d. Crashing of a project
   e. Physical assets control
   f. Human resource control
   g. Financial Control
6. **Marketing Management**
   a. Selling versus Marketing
7. **Role of a company**
   a. Leader, Follower and Challenger
   b. Basics of Marketing, Place, Price and Promotion
   c. Role of a company in market place
8. **Economics and Accounting**
   a. Budgeting Methods
   b. Cost Estimation, Assets, Liabilities, Capital and Revenue Expenditure
   c. Depreciation, Depletion, Amortization, Owner's Equity Debentures
   d. Loan Financing, Accounting, Quards Ledgers, Profit and loss statement.

Suggested Teaching Methodology

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignments (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Surak, J.G., 2002. The certified quality auditor's HACCP handbook. *American Society for Quality, Milwaukee, WI*.
2. Meredith, J. R. and S. J. Mantel. (2000) Project Management, McGraw-Hill Co. Ltd. New Delhi, India.

3. Park, C.S., Kim, G. and Choi, S., 2007. *Engineering economics* (Vol. 22). Prentice Hall: Upper Saddle River, NJ, USA.

Statistics and Probability

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy Level	PLO
1.	**Understanding** the fundamental concepts in Probability and Statistics	Cognitive	2	1
2	**Observe** fitting binomial distribution and multiple bar diagrams	Psychomotor	1	1
3	**Applying** the rules and algorithms of Probability and Statistics to their relevant engineering problems..	Psychomotor	3	2
4	**Analyze** on data & produce mathematical probabilistic models for different problems and to interpret the results.	Cognitive	4	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☑	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Statistics**
   a. Introduction
   b. Types of data & variables
   c. presentation to data, object

d. classifications, Tabulation
e. Frequency distribution
f. Graphical representation
g. Simple & Multiple Bar diagrams
h. Sartorial & Pie-Diagram
i. Histogram
j. Frequency Polygon
k. Frequency Curves & their types

2. Measures Of Central Tendency And Dispersion

a. Statistics Averages
b. Median Mode, Quartiles
c. Range, Moments
d. Skew ness & Kurtosis
e. Quartile Deviation
f. Mean Deviation
g. Standard Deviation
h. Variance & its coefficient
i. Practical Significance in related problems

3. Curve Fitting

a. Introduction
b. Fitting of a first and second degree curve
c. Fitting of exponential and logarithmic curves
d. Related problems. Principle of least squares
e. Second order Statistics & Time series not in bit detail

4. Simple Regression & Correlation

a. Introduction
b. Scatter diagrams
c. Correlation & its Coefficient
d. Regression lines
e. Rank Correlation & its Coefficient, Probable Error (P.E)
f. Related problems.

5. Sampling And Sampling Distributions

a. Introduction, Population
b. Parameter & Statistic
c. Objects of sampling
d. Sampling distribution of Mean
e. Standard errors
f. Sampling & Non-Sampling Errors
g. Random Sampling
h. Sampling with & without replacement
i. Sequential Sampling
j. Central limit theorem with practical significance in related problems.

6. Statistical Inference And Testing Of Hypothesis

a. Introduction, Estimation
b. Types of Estimates

c. Confidence interval
d. Tests of Hypothesis
e. Chi-Square distribution/test
f. one tails & two tails tests. Application in related problems.

7. Probability

a. Basic concepts
b. Permutation & Combination
c. Definitions of probability
d. Laws of probability. Conditional probability
e. Bayes' rule. Related problems in practical significance

8. Random Variables

a. Introduction
b. Discrete & Continuous random variables
c. Random Sequences and transformations. Probability distribution
d. Probability density function
e. Distribution function
f. Mathematical expectations
g. Moment Generating Function (M.G.F.)
h. Markov random walks chain/ Related problems

9. Probability Distributions

a. Introduction
b. Discrete probability distributions
c. Binomial Poisson
d. Hyper geometric & Negative binomial distributions. Continuous probability distribution
e. Uniform, Exponential & Normal distributions & their practical significance

Practical:

1. Introduction to Minitab.
2. Ungrouped Data. Graphs, Measures of Central Tendency & Dispersion.
3. Grouped Data, Graphs, Measures of Central Tendency & Dispersion.
4. Introduction to Global-Macro in Minitab
5. Introduction to SPSS.
6. Frequencies and Data manipulation in SPSS.
7. Linear Regression Line and Correlation Analysis.
8. Multiple Regression Analysis and Non-Linear Models.
9. Discrete Probability Distributions.
10. Continuous Probability Distribution.

Suggested Teaching Methodology

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Lind, D.A., 2012. *Basic statistics for business and economics*. McGraw-Hill Higher Education
2. Choudhry, S. M. and Kamal, S.,1998.*Introduction to statistical theory partiandii.* Ilmi Kitab Khana, Kabir Street, Urdu Bazar, Lahore
3. Walpole, R.E., Myers, R.H., Myers, S.L. and Ye, K., 1993. *Probability and statistics for engineers and scientists* (Vol. 5). New York: MacMillan.
4. Bluman, A.G., 2013. *Elementary statistics*. Chennai: McGraw-Hill.
5. Montgomery, D.C. and Runger, G.C., 2010. *Applied statistics and probability for engineers*. John Wiley & Sons.

Food Microbiology

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Identify** the important pathogens and spoilage microorganisms in foods and the conditions under which they will grow and utilize laboratory techniques to identify these micro-organisms in food.	Cognitive	1	3
2.	**Identify** the conditions under which the important pathogens are commonly inactivated, killed or made harmless in foods.	Cognitive	1	4
3.	**Know** the principles involving food preservation via fermentation processes.	Cognitive	1	3
4.	**Observe** the laws of heat and optics	Psychomotor	1	1
5.	**Practice** on equipment related to sound, fluid and electromagnetism	Psychomotor	3	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☑	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **The scope and development of food microbiology**
   a. Microorganisms in food
   b. Food spoilage/preservation
   c. Food safety.
   d. Micro-organism in atmosphere
   e. Soil, air
   f. Water
   g. Equipments
   h. Plants and animal
   i. Raw meat
   j. Raw and pasteurized milk
   k. Vegetables fruits and nuts
   l. Canned foods
   m. Sugars and confectionaries
   n. Soft drinks etc.
2. **Microbial Metabolism of Food Components**
   a. Metabolism of food carbohydrates
   b. Fermentation
   c. Anaerobic aerobic respiration
   d. Metabolism of food proteins
   e. Metabolism of food lipids
3. **Factors affecting the Growth and Survival of Micro-organism**
   a. Intrinsic factors
   b. pH
   c. Moisture contents
   d. Oxidation reduction potential
   e. Nutrient content. Extrinsic factors
   f. Temperature of storage
   g. Concentration of gases
   h. Humidity
4. **Microbial Spoilage and Examination of Food**
   a. Spoilage
   b. Spoilage of various foods causes of spoilage

c. Types of spoilage. Examination
d. Sampling
e. Microbial test procedures
f. Indicator organisms
   Food poisoning organisms
g. Food spoilage organisms

5. Bacterial and Non-bacterial Agents of Food Borne Illness

a. Aeromonashy drophilia
b. Bacillus cereus and other species
c. Brucella
d. Compylobecter
e. Clostridium botulinum
f. Clostridium perfringens
g. Listeria monocy togenesis
h. Mycobacterium species
i. Plesiomonas Shigelloids
j. Samonella, Shigella, Vibrio
k. Yersinia
l. Enterocolitica
m. Scombrotoric fish poisoning
n. Helminths and Nematodes
o. Protozoa
p. Toxigenic algae and fungi
q. Food borne viruses
r. Spongiform encephalopathies

6. Beneficial activities of microbes in food

a. Fermented and microbial food
b. Yeast
c. Lactic acid bacteria
d. Fermented milks
e. Cheese
f. Fermented vegetable and meats

7. Controlling the Microbiological Quality of Food

a. Food preservation
b. Microbial control

Practical:

1. To determine aerobic plate count of the (psychrophiles, mesophiles, thermophiles).
2. To perform and analyze microbial swab testing
3. Perform Methylene Blue Reduction Test on given sample of milk.
4. Preparations of media (Agar) for growth of bacteria
5. Preparations of media (Broth) for growth of microorganism.
6. To Determine Total coliform count of food sample.
7. To detect the presence of E.coli in water sample by membrane filtration method.

8. To analyze personal hygiene before and after application of Sanitizer.
9. To compare microbial load of different environments.
10. Using the Most Probable Number Technique to count Coliform in water.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Ray, B. and Bhunia, A., 2007. *Fundamental food microbiology*. CRC press.
2. Frazier, W.C. and Westhoff, D.C., 1981. Food microbiology, Tata McGraw-Hill. *New Delhi*.
3. Montville, T.J. and Matthews, K.R., 2007. *Food microbiology: an introduction* (No. Ed. 2). ASM Press.
4. Robinson, R.K., 2014. *Encyclopedia of food microbiology*. Academic press.
5. Harrigan, W.F., 1998. *Laboratory methods in food microbiology*. Gulf professional publishing.
6. Doyle, M.P. and Buchanan, R.L. eds., 2012. *Food microbiology: fundamentals and frontiers*. American Society for Microbiology Press.

Food Engineering Operations - I

Contact Hours:
Theory =32
Practical =96
Total =128

Credit Hours:
Theory =2.0
Practical =2.0
Total =4.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of basic food engineering operations	Cognitive	1	1
2.	**Explain** the working principal and mechanism of food engineering operations.	Cognitive	2	1

3.	**Discuss** the applications of food engineering operations in industries.	Cognitive	2	1
4.	**Observe** the laws of food operations	Psychomotor	1	1
5.	**Practice** on equipment related to food engineering operations and project making.	Psychomotor	3	1,9,10,11

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☑
4	Investigation	☐	10	Communication	☑
5	Modern Tool Usage	☐	11	Project Management	☑
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Preliminary preparative operation**
   a. Cleaning
   b. Sorting
   c. Grading methods
2. **Size reduction**
   a. Particle size distribution
   b. Classification
   c. Screening and sieving
   d. Mechanism of size reduction
   e. Machinery for crushing and grinding
   f. Disintegration of fibrous materials
   g. Energy requirements for communication of solids
3. **Pneumatic and Hydraulic Conveying Systems**
   a. Types of conveyers
   b. Types of elevators
4. **Fluidization, mixing and agitation**
   a. Flow pattern and baffles
   b. Rate of mixing and power consumption
   c. Centrifugation theory and applications
5. **Agglomeration Phenomena and its application**
   a. Granulation
   b. Pelletization
   c. Tableting process and storage
6. **Filtration**
   a. Mechanism of filtration
   b. Filter media

c. Flow through filter cake or cloth
d. Cake resistance and relation between thickness of cake and volume of filtrate.

Practical:

1. Study of general laboratory safety procedures and rules
2. Studyof sample handling, sorting, grading and sample preservation techniques.
3. Demonstration of equipment used to carry out unit operations in food processing.
4. Study of different peeling techniques and peeling equipment.
5. Determination of Peeling losses and yield percentage. (A comparative study of manual, mechanical and chemical peeling)
6. Demonstration of types of Washers and their parts used for wet cleaning of fruits and vegetables.
7. Study of dry cleaning/separation equipment (Screens/sieves for separation of grains) and calculation of screen effectiveness and cleaning efficiency.
8. Study of Size reduction equipment used for cutting fruits, vegetables and meat.
9. Study of size reduction/milling equipment for grains. Characteristics of a good milling equipment (Identification of Equipment in Milling Room)
10. Milling of Wheat using Quadrumat Senior Mill and determination of minimum particle size to be nipped (D_p max).
11. Milling of Wheat using Buhler Mill, separation of different fractions of wheat flour and determination of D_p max.
12. Study of grinding laws and their derivation. Calculation of power/energy requirements to carry out grinding.
13. Study of different transportation and conveying equipment/systems.
14. Study of fruit and vegetable pre-treatment/preservation techniques (Blanching & sulphiting) to reduce enzymatic and non-enzymatic browning.
15. Demonstration of the parts and functions of can-body manufacturing equipment and development of a food grade Can-Body.
16. Study of unit operations carried out in Canning process for the preservation of fruits and vegetables.
17. Demonstration of Carbonation unit/beverage processing unit.
18. Study of unit operations of a juice processing and bottling industry.
19. Dehydration of foods using Forced Convection Dehydrator and Simple Drying oven, determination of moisture loss w.r.t. time. (A comparative study of two dehydrators)
20. Study of the unit operations in a potato chips processing plant.
21. Visit to relevant food industries.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Singh, R.P. and Heldman, D.R., 2001. *Introduction to food engineering*. Gulf Professional Publishing.
2. Barbosa-Canovas, G.V. and Ibarz, A., 2002. *Unit operations in food engineering*. Crc Press.
3. Irudayaraj, J.M. and Jun, S., 2008. *Food processing operations modeling: design and analysis*. CRC press.
4. Singh, R.P. and Heldman, D.R., 2001. *Introduction to food engineering*. Gulf Professional Publishing.
5. Barbosa-Canovas, G.V. and Ibarz, A., 2002. *Unit operations in food engineering*. Crc Press.

Heat and Mass Transfer

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understanding** of heat and mass transfer mechanisms,	Cognitive	1	1
2.	**Explain** the basic laws of heat and mass transfer, understand boiling and condensation also working principles and design of heat exchangers	Cognitive	2	1 ,3
3.	**Apply** the principles of heat and mass transfer operations to food industry	Cognitive	3	1 , 2
4.	**Observe** the laws of heat and mass	Psychomotor	1	1
5.	**Practice** on equipment related to heat and mass transfer	Psychomotor	3	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction to Heat Transfer**
   a. Overview
   b. Heat, Temperature, and Theories of heat
   c. Engineering techniques and terminologies used in heat transfer
   d. Different forms of energy
2. **Heat transfer mechanisms**
   a. Principles of convective, conductive and radioactive heat transfer
   b. Heat transfer coefficient correlation
   c. Steady state heat transfer
   d. Transient heat transfer
   e. Lumped system analysis
   f. Forced and free convection
   g. Boiling and condensation
3. **Heat Exchangers**
   a. Types of heat exchangers and their working principles
   b. Thermal design of heat exchanger
   c. LMTD method
   d. NTU-effectiveness method
4. **Mass Transfer**
   a. Introduction to mass transfer
   b. Analogy between heat and mass transfer
   c. Modes of mass transfer
   d. Principles of diffusion
   e. Simultaneous heat and mass transfer
   f. Industrial application of Heat & Mass transfer

Practical:

1. To study the temperature measuring devices.
2. To study the thermal insulations.
3. To study the working of adjustable bi-metallic type thermostat.
4. To study the working of a diaphragm type thermostat.
5. To study free convection in liquids.
6. To study natural convection in gases (air).

7. To compare the thermal conductivities of different materials.
8. To measure the temperature distribution for steady-state conduction of energy through a uniform plane wall and demonstrate the effect of a change in heat flow.
9. To under stand the use of the fourier rate equation in determining rate of heat flow through solid material for one-dimensional steady flow of heat.
10. To determine the thermal conductivity K (the constant of proportionality) of a metal specimen (good conductor).
11. To demonstrate the temperature gradient is inversely proportional to the cross-sectional area for one dimensional flow of heat in a solid material of constant thermal conductivity.
12. To demonstrate effect of contact resistance on thermal conduction b/w adjacent materials.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Bergman, T.L., Incropera, F.P., DeWitt, D.P. and Lavine, A.S., 2011. *Fundamentals of heat and mass transfer*. John Wiley & Sons.
2. Cengel, Y., 2014. *Heat and mass transfer: fundamentals and applications*. McGraw-Hill Higher Education.
3. Bergman, T.L., Incropera, F.P., DeWitt, D.P. and Lavine, A.S., 2011. *Fundamentals of heat and mass transfer*. John Wiley & Sons.
4. Thirumaleshwar, M., 2009. *Fundamentals of heat and mass transfer*. Pearson Education India.
5. Venkanna, B.K., 2010. *Fundamentals of heat and mass transfer*. PHI Learning Pvt. Ltd..

Advance Calculus & Linear Algebra

Contact Hours:
Theory =48
Practical = 0
Total = 48

Credit Hours:
Theory = 3.0
Practical = 0
Total = 3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Apply** methods of linear algebra to solve system of linear equations.	Cognitive	2	1& 2
2.	**Understand** eigen values and Eigen vectors	Cognitive	1	1& 2
3.	**Interpret** physical systems and process in term of vector calculus.	Cognitive	2	5
4.	**Evaluate** multiple integrals involves in engineering problems.	Cognitive	5	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. Linear Algebra

b. Linearity and linear dependence of vectors
c. Basis, dimension of a vector space
d. Field matrix and type of matrices
e. Singular
f. Non Singular
g. Symmetric
h. Non- symmetric
i. Upper
j. Lower
k. Diagonal tri-diagonal matrix
l. Rank of a matrix using row operations and special method
m. Echelon and reduced echelon forms of a matrix
n. Determination of consistency of a system of linear equation using rank
o. Transitions matrix
p. Basic concept of tensors
q. Eigen value and eigen vectors of a matrix
r. Diagonolization
s. Cayley-Hamiton theorem
t. Applications of linear algebra in Engineering.

2. **Euclidean Spaces and Transformation**
   a. Geometric representation of vector
   b. Norm of vector
   c. Euclidean inner product
   d. projections and orthogonal projections
   e. Euclidean n spaces n properties Cauchy-Schwarz inequality
   f. Euclidean transformations
   g. Apply geometric transfomations to plane figure
   h. Composition or transformations.
3. **Advance calculus**
   a. Define a stationary point of a function of several variables
   b. Define local maximum and saddle point for a function of two variables the stationary points of a several variables
   c. Obtain higher partial derivatives of simple functions of two or more variables
   d. Iterated integrals
   e. Double and triple integrations with applications
   f. Use multiple integrals in solutions of engineering problems
4. **Vector Calculus**
   a. Vector differential operator
   b. Directional derivative
   c. Gradient
   d. Divergence
   e. Curl of a vector field
   f. Laplacian operators with applications. (Solenoid, conservative, etc).
   g. Vector Integrations
   h. Evaluate line integrals along simple paths
   i. Apply line integrals to calculate work done
   j. Apply Green's theorem in the plane to simple examples, evaluate surface integrals over simple surface
   k. Use the Jacobean to transform a problem a new coordinate system
   l. Apply Gauss' divergence theorem to simple problems
   m. Apply Stokes theorem to simple examples

Suggested Teaching Methodology:

- Lectures
- Exercises
- Practice Problem

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Anton, H., 2010. *Elementary linear algebra*. John Wiley & Sons.
2. Strang, G., Strang, G., Strang, G. and Strang, G., 1993. *Introduction to linear algebra* (Vol. 3). Wellesley, MA: Wellesley-Cambridge Press.
3. Axler, S., 1997. *Linear algebra done right* (Vol. 2). New York: Springer.
4. Griffel, D.H., 1989. *Linear algebra and its applications. Vol. 1: a first course*. Halsted Press.
5. Anton, H., 2010. *Elementary linear algebra*. John Wiley & Sons.
6. Kolman, B. and Hill, D.R., 2004. *Elementary linear algebra*. Pearson Education.
7. Conte, S.D. and De Boor, C., 2017. *Elementary numerical analysis: an algorithmic approach* (Vol. 78). SIAM.
8. Kreyszig, E., 2010. *Advanced engineering mathematics*. John Wiley & Sons.

Communication & Presentation Skills

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory = 3.0
Practical= 0
Total = 3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of communication and presentation skills.	Cognitive	3	10
2.	**Demonstrate** intermediate to advanced level English language skills.	Cognitive	3	10
3.	**Enhance** ability in Communication Skills which can support real life.	Cognitive	3	10, 12
4.	**Practice** of presentation and communication skills	Psychomotor	1	10

Course Outline:

1. **Writing practice**
   a. Paragraph writing
   b. Practice in writing a good, unified and coherent paragraph
   c. Essay writing
   d. Introduction CV and job application
2. **Communication Skills**
   a. Translation skills Urdu to English

b. Study skills
c. Skimming and scanning
d. Intensive and extensive, and speed reading
e. Summary and précis writing and comprehension

3. **Verbal Communication**
   a. Strategies and Activities
   b. Group Discussions
   c. Brainstorming
   d. Interviewing
4. **Academic skills**
   a. Letter/memo writing
   b. Minutes of meetings
   c. Use of library and internet
5. **Presentation skills**
   a. Personality development (emphasis on content, style and pronunciation)

Practical:

1. Communication & Presentation Skills labs related to
   a. Speaking
   b. Speech making
   c.Listening
   d. Reading
   e. Writing

Note: Documentaries to be shown for discussion and review

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Dahama, O.P., 1988. *Education and communication for development*. Oxford and IBH Publishing.
2. Guffey, M.E. and Loewy, D., 2012. *Essentials of business communication*. Cengage Learning.
3. Mishra, S. and Muralikrishna, C., 2011. *Communication Skills for Engineers*. Pearson Education India.

4. Sawant, A.G., Sawant, G.K., Hansra, B.S. and Shinde, S.B., 2006. Farm communication through mass media in the new millennium. *Farm communication through mass media in the new millennium.*
5. Lindell, J.T., Communication and presentation skills. *Controller as Business Manager*, pp.263-279.

Instrumentation and Measurement

Contact Hours:
Theory =48
Practical =48
Total =96

Credit Hours:
Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Construct a general measurement system and relate experiment design, instrumentation, calibration, and testing with it.**	Cognitive	1	3
2.	**Analyze error and uncertainty of a measurement system using necessary statistical principles.**	Cognitive	1	4
3.	**Demonstrate operations of various devices used to measure temperature, pressure, flow and strain.**	Cognitive	1	3
4.	Observe the laws of heat and optics	Psychomotor	1	1
5.	**Practice** on developing transducers for practical applications	Psychomotor	3	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☑	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. Principles of Colour Measurement for Food

2. Colour Measurement of Foods by Colour Reflectance
3. Food Compositional Analysis Using Near Infra-red Absorption Technology Infra-red Remote Thermometry
4. In-line and Off-line FTIR Measurements
5. Microwave Measurements of Product Variables, Pressure and Temperature Measurement in Food Process Control
6. Level and Flow Measurement in Food Process
7. Ultrasound Propagation in Foods and Ambient Gases
8. Principles and Applications
9. Ultrasonic sensors for Food Industry
10. Rheological Measurements of Foods
11. Conductance/Impedance Techniques for Microbial
12. Chemosensors, Biosensors
13. Immunosensors, Electronic Noses and Tongues

Practical:

1. Describe the meter operation of the Wheatstone Bridge circuit.
2. Express mathematically the relationship between the legs of the bridge.
3. Use the bridge circuit to determine the value of unknown resistor.
4. Use potentiometer to measure the physical displacement.
5. Use bridge circuit to improve displacement measurement.
6. Determine the resolution of a measurement.
7. Describe the characteristics of a thermistor.
8. Describe the difference between a thermistor and a thermocouple.
9. Develop a circuit using a thermistor to measure temperature.
10. Describe the operation of photoresistor.
11. Use photoresistor with amplifier circuit.
12. Develop a basic control circuit which uses a photoresistor.
13. To study about basics of Arduino UNO Microcontroller.
14. To study about basic programming of Arduino UNO Microcontroller.
15. To blink an LED through Arduino.
16. Use PWM pins to fade an LED.
17. Interfacing potentiometer (variable resistor) with the Arduino.
18. Interfacing potentiometer (variable resistor) with the Arduino and
19. adjusting the brightness of an LED by potentiometer position.
20. Interfacing Temperature Sensor LM35 with the Arduino.
21. Interfacing Ultrasonic sensor (HC-SR04) with Arduino to detect distance.
22. To design the circuit of dark sensor transistor.
23. Interfacing humidity sensor DHT11 with Arduino.
24. Interfacing Ultrasonic sensor (HC-SR04) with Arduino to detect
25. speed of sound.
26. Controlling RGB LED with Arduino.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Bakshi U.A., Bakshi A.V., 2010. Measurements and Instrumentation Technical Publications.
2. DallyJ. W., RileyW. F. and McConnelK. G., 2009. Instrumentation for engineering measurements, 2nd Ed. John Willey and Sons, Inc. Singapore
3. Erika K.R. and Christopher J.B. B., 2001. Instrumentation and Sensors for the Food Industry Taylor & Francis Inc.
4. Ibtisam E. T., 2003. Rapid and On-line Instrumentation for Food Quality Assurance CRC Press.

Food Engineering Operations II

Contact Hours:
Theory =16
Practical =96
Total =112

Credit Hours:
Theory =1.0
Practical =2.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of advance food engineering operations	Cognitive	1	1
2.	**Explain** the working principal and mechanism of food engineering operations.	Cognitive	2	1
3.	**Discuss** the applications of food engineering operations in industries.	Cognitive	2	1
4.	**Observe** the laws of food operations	Psychomotor	1	1
5.	**Practice** on equipment related to food engineering operations and project making.	Psychomotor	3	1,9,10,11

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☑
4	Investigation	☐	10	Communication	☑
5	Modern Tool Usage	☐	11	Project Management	☑
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Process of freeze drying**
   a. Working principal
   b. Equipment
   c. Types
2. **Heat exchangers**
   a. Principles
   b. Types design
   c. Their parameters
3. **Thermal processing**
   a. Pasteurization
   b. Sterilization
   c. Thermization
   d. UHT
4. **Extrusion**
   a. Introduction and importance
   b. Working Principle
   c. Single screw extruders
   d. Twin screw extruders
   e. Applications
   f. Advantages and disadvantages
   g. Textured vegetables proteins, breakfast cereals etc.
5. **Distillation process**
   a. Calculation of number of plates required for binary separations
   b. McCabe-Thiele methods
   c. Column design
   d. Designcapacity
   e. Efficiency
6. **Adsorption Technique**
   a. The nature of adsorbents
   b. Adsorption equilibria
   c. Adsorption equipment and regeneration of spent adsorbents

7. **Liquid-Liquid Extraction**
    a. Introduction
    b. extraction Processes
    c. extraction equipment
8. **Absorption**
    a. Extension of design techniques
    b. Wetted wall columns method
    c. determination of transfer coefficients
    d. Equipment for gas absorption

Practical:

1. Determination of overall heat transfer coefficient of the walls of a cold storage.
2. Study of Extrusion technique and different types of extruders and their uses.
3. Demonstration of the working principle of a single screw extruder.
4. Demonstration of the working principle of a twin screw extruder and its parts.
5. Study of Evaporation technique, types of Evaporators, their specifications, advantages & uses
6. Design of Single-effect evaporator and calculation of steam economy.
7. Design of multi-effect evaporator and determination of steam requirements, steam economy and overall heat transfer coefficient of the evaporator area using Microsoft Excel.
8. Study of different types of heat-treatments to increase the shelf-life of liquid foods.(Thermization, Pasteurization, sterilization, UHT)
9. Frying of Foods using an Air-Fryer and determination of time-temperature relationship.
10. Study of the types of drying and dehydration equipment for the long term storage of foods.
11. Study of different types of a freeze-dryer/lyophilizer, demonstration of its components and its uses.
12. Demonstration of drying of foods using a Drum Dryer.
13. Drying of Foods using Spray Dryer, demonstration of its parts and study of different types of atomizers.
14. Demonstration of the Liquid-liquid extraction Equipment.
15. Design of an alcohol distillation process and determination of its process efficiency.
16. Study of the unit operations in a potato chips processing plant.
17. Introduction to boiler and its parts, classification of boilers and demonstration of working principle of different types of boilers.
18. Study of the maintenance of boilers according to Boiler Act.
19. Visit to relevant industries.

Suggested Teaching Methodology

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Aguilera, J.M. 2011. *Food Engineering* Interfaces. Publisher Springer Berlin Heidelberg, Germany.
2. Albert Ibarz, Gustavo V. Barbosa-Cánovas. 2007, Unit operations in food engineering. CRC Press LLC International Standard Book, USA.
3. Parker, M.E. 2012. Elements of Food Engineering, V3: Unit Operations 2. Literary Licensing, LLC.
4. Riaz, M.N (ed.). 2003. *Extruders in food applications.* Technomic Pub. Co. Inc., Lancaster, Pennsylvania, USA**.**
5. Singh, R.P., R.P. Singh, and D.R. Heldman. 2008. Introduction to Food Engineering, Food Science and Technology, International Series

Materials And Energy Balance

Contact Hours:
Theory =48
Practical = 0
Total =48

Credit Hours:
Theory =3
Practical = 0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Convert** different system of unites from one system to another	Cognitive	1	1
2.	**Explain** basic concepts, of stoichiometry, single and multiphase systems and necessary for applying material and energy balance	Cognitive	2	1
3.	**Apply** simultaneous material and energy balance strategy forfor solving recycle, purge and by-pass for single and multiple unit problems	Psychomotor	3	1,9,10,11
4.	**Extract** thermodynamic information from Steam tables, pressure-enthalpy charts etc. and use in	Psychomotor	3	1,9,10,11

	calculating internal energy and enthalpy changes in single phase and multiphase systems			

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☑
4	Investigation	☐	10	Communication	☑
5	Modern Tool Usage	☐	11	Project Management	☑
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction to fundamental**
   a. Systems of units, dimensions
   b. Basic principles of material balances for processes with and without chemical reaction
   c. Gases and vapors, saturation and humidity
2. **Types of process situations**
   a. Continuous and batch process
   b. Mass and energy balance for both process.
3. **Energy balance**
   a. Physical, chemical heat effects
   b. Enthalpy, latent heat, sensible heat
   c. Freezing drying, canning
   d. Other form of energy, use of steam tables
   e. Freezing drying, canning, other form of energy, use of steam tables.
4. **Simultaneous material and energy balances**

Suggested Teaching Methodology

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Anonymous. 2004. Unit operations in Food Processing. (web ed). The New Zealand Institute of Food Science and Technology.

2. Jackson, A.T. and J. Lamb. 1991. Calculations in Food and Chemical Engineering. McMillan publishing Co., Inc. New York. 10022.
3. Sahay, K. M. and K. K. Sing. 2002. Unit Operations of agricultural processing (2nd ed). Vikas Publishing House, Pvt., Ltd. New Delhi, India.

Engineering Numerical Analysis

Contact Hours:
Theory =32
Practical=48
Total =80

Credit Hours:
Theory = 2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Comprehend** the roots of an algebraic equation by numerical method	Cognitive	1 & 3	1& 2
2.	**Solve** a differential equation using an appropriate numerical technique	Cognitive	3	1
3.	**Analyze** a definite integral using an appropriate numerical method	Cognitive	4	2
4.	Apply appropriate techniques, tools and formula to determine solution up to the desired decimal places of accuracy	Cognitive	4 & 5	5
5.	**Estimate** a function using a suitable numerical method	Cognitive	6	2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Error Analysis**
   a. Types of errors (relative, Absolute, inherent, round off, truncation),
   b. Significant digits and numerical instability
   c. Flow chart.
   d. Use any Computational tools to Analysis the Numerical Solutions.

2. **Linear Operators**
   a. Functions of operators
   b. Difference operators and the derivative operators
   c. Identities.
3. **Difference Equations**
   a. Linear homogeneous and non homogeneous difference equations.
4. **Solution of Non-linear Equations**
   a. Numerical methods for finding the roots of transcendental and polynomial equations (Secant, Newton – Raphson Chebyshev's and Graeffe's root squaring methods),
   b. Rate of convergence and stability of an iterative method.
5. **Solution of Linear Equations**
6. Numerical methods for finding the solutions of system of linear equations (Gauss-Elimination, Gauss-Jordan Elimination, triangularization, Cholesky, Jacobi and Gauss – Seidel).
7. **Interpolation &- Curve Fitting**
   a. Lagrange's
   b. Newton
   c. Hermit
   d. Spline
   e. least squares approximation. (Linear and non-linear curves)
8. **Numerical Integration & Differentiation**
   a. Computation of integrals using simple Trapezoidal rule
   b. 1/3th Simpson's rule
   c. 3/8th Simpson's rule
   d. Composite Simpson's and Trapezoidal rules
   e. computation of solutions of differential equations using (Euler method, Euler modified method
   f. Runge Kutta method of order 4). Numerical Solutions of Partial differential Equations
   g. Optimization problem (Simplex Method). Steepest Ascent and Steepest Descent Methods.

Practical:

Numerical solution techniques will be elaborated and demonstrated using MATHCAD and Excel Sheet

Suggested Teaching Methodology:

- Lectures
- Exercises

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Chapra S.C., and Raymond O. C., 2015. Numerical Methods for Engineers, 7thEd. McGraw-Hill.
2. Richard L. B., Douglas J.F. and Annette M. B. 2015. Numerical Analysis 10th Ed. Cengage Learning.
3. Stanley D.,Constantinides A. and Prabhas V. M., 2006. Numerical Methods in Biomedical Engineering. 1st Ed. Academic Press.
4. Steven C. and Raymond C. 2009. Numerical Methods for Engineers 6th Ed. McGraw Hill.

Entrepreneurship

Contact Hours:
Theory =32
Practical =0
Total =32

Credit Hours:
Theory =2.0
Practical =0
Total =2.0

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Acquire the basic knowledge and objectives for engineers	Cognitive	1	1
2.	Explain the Entrepreneurship importance for engineers	Cognitive	2	10
5.	Practice on Business Planning & Execution and developing Strategies for Technology Companies	Psychomotor	3	11, 12

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☑
5	Modern Tool Usage	☐	11	Project Management	☑
6	The Engineer and Society	☐	12	Lifelong Learning	☑

Course Outline:

1. **Introduction to Entrepreneurship**
   a. Introduction to Technology
   b. Entrepreneurship and Technology Ventures,
   c. Attributes and Myths of Technology Entrepreneurs.

2. **Entrepreneurship importance for engineers**
   a. Engineers as Entrepreneurs,
   b. Mindset of the Entrepreneurial Leader,
   c. Creating and Selling the Entrepreneurial Value Proposition.
3. **Idea Generation and Feasibility Analysis**
   a. Entrepreneurial Idea Generation
   b. Feasibility Analysis
   c. Technology Commercialization Potential, Paths and Barriers from Idea to Market,
   d. Assessing and Presenting the Opportunity
4. **Business Planning and Execution**
   a. Business Structuring and Strategy,
   b. Business planning and the Business Plan,
   c. Financial Analysis and Projections;
   d. Market and Competitive Analysis,
   e. Break Even Analysis,
   f. Presentation of the Opportunity,
   g. Intellectual Property
5. **Strategies for Technology Companies**
   a. Marketing, Sales and Distribution Strategies,
   b. Investment and Financial Strategies,
   c. Venture Growth and Value Harvesting.

Suggested Readings:

1. Anonymous, 2004. EntrepreneurialIdeaGenerationTheArtoftheStart:Thetime-tested,battle-hardenedguideforanyone starting anything, Kawasaki, Guy; ISBN: 1591840562, Portfolio– a member of Penguin Group
2. Dorf, Richard, Byers, Thomas, Nelson and Andrew. 2009. Technology Ventures: From Idea to Enterprise, ISBN 978-0073380186; 3rd Edition,

Food Storage Engineering

Contact Hours:	**Credit Hours:**
Theory =32	Theory =2.0
Practical =48	Practical =1.0
Total =80	Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of food storage engineering and conditions	Cognitive	1	1
2.	**Explain** the principles of food storages	Cognitive	2	1 ,3
3.	**Discuss** the different types food storage systems	Cognitive	2	1 , 2
4.	**Practice** on available equipments to optimize the storage condition	Psychomotor	3	1 ,12

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction**
   a. Review of psychrometric chart
   b. Grain Drying
   c. Grain storage conditions
2. **Cold Storages**
   a. Needs and types
   b. Design and conditions
   c. Temperature
   d. Humidity controls
   e. Heat load
   f. Air conditioning
   g. Aeration
   h. Requirements
   i. Insulation refrigeration system and load
   j. Automation of cold storages
3. **Storage of fresh and processed fruits and vegetables**
   a. Principles of storage
   b. Mechanical refrigeration
   c. Controlled atmosphere storage (CA)

d. Vacuum storage
e. Storage in polymeric films
f. Transportation and marketing

4. Low temperature preservation

a. Methods and equipment
b. Thermal properties of foods
c. Refrigeration of fruits and vegetables
d. Refrigeration of meat, milk and milk products, bakery products, poultry, eggs and aquatic foods
e. Food freezing
f. Variability in storage conditions
g. Maintenance and control of storage conditions
h. Modified atmospheric packaging for food storage.

Practical:

1. Measurement of bulk density of raw fruits, vegetables
2. Determination of physico-chemical properties of meat, milk
3. Determination of transpiration of fruits, vegetables, and other food products
4. Determination of refrigeration of fruits, vegetables, meat, milk, etc
5. Calculation of load of storage structures, mobile vans, CA compartmental storages
6. Determination of dehydration characteristics of fruits/ vegetables employing psyschrometry
7. Design of Godown Structure
8. Determination of bulk density & test weight using bushel apparatus
9. Introduction to Mastitis disease in dairy cattle
10. Detection of Mastitis disease
11. Visit to food storage structures and food industries

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings

1. Karel, M. and Lund, D.B., 2003. *Physical principles of food preservation: revised and expanded* (Vol. 129). CRC Press.
2. Sivasankar, B., 2002. *Food processing and preservation*. PHI Learning Pvt. Ltd..

3. Brennan, C. and Tiwari, B.K., 2017. Food processing and preservation.
4. Salunkhe, D.K., Bolin, H.R. and Reddy, N.R., 1991. *Storage, processing, and nutritional quality of fruits and vegetables. Volume I. Fresh fruits and vegetables* (No.Ed.2).CRC press

Final Year Project-I

Contact Hours:

Theory =0.0
Practical =144
Total =144

Credit Hours:

Theory =0.0
Practical =3.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**PLAN** the project activities to fulfill the proposed research problems	Cognitive	4	2,4
2.	**MANAGE** the project plan to accomplish project objectives	Cognitive	3	3
3.	**EXECUTE** the project plan	Psychomotor	4	11
4.	**ANALYZE** project results using appropriate technique or tools	Cognitive	4	5
5	**PRODUCE** a project report in accordance with specified standard format	Cognitive	4	10
6	**PRESENT and Defend** the project outcomes effectively	Affective	3	9,11

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☐	7	Environment and Sustainability:	☐
2	Problem Analysis:	☑	8	Ethics:	☐
3	Design/Development of Solutions:	☑	9	Individual and Team Work:	☑
4	Investigation:	☑	10	Communication:	☑
5	Modern Tool Usage:	☑	11	Project Management:	☑
6	The Engineer and Society:	☐	12	Lifelong Learning:	☑

Industrial Safety and Maintenance Management

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1-0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy Level	PLO
1	**Interpret** and apply legislative requirements, industry standards, and best practices in a variety of workplaces.	Cognitive	3	3
2	**Design**, support, and evaluate health and safety programs and implement procedures appropriate to the task.	Psychomotor	6	2
3	**Collect**, manage, and interpret information and data to identify trends and issues in the workplace.	Cognitive	3	1,2,5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction**
   a. Accident and loss statistics
   b. Public perception of chemical industry
   c. The accident process
2. **Some significant disasters as case studies**
3. **Toxicology**
   a. How toxicants enter and are eliminated from biological organisms, effects of toxicants
   b. Dose versus response models
   c. Threshold limit values

4. **Industrial Hygiene**
5. Government regulations
6. Identification and evaluation and control of various exposures in chemical industry
7. **Fires and explosions**
    a. Fire triangle
    b. Flammability characteristics of liquids and vapors
    c. Design to prevent fires and explosions
    d. Hazard identification and risk assessment
    e. Accident investigations and case histories
    f. Forms of maintenance
    g. Scheduling of maintenance
    h. Computerized Maintenance
    i. Non destructive testing techniques
    j. Forms of corrosion,
8. **prevention and inhibition;**
    a. Preparation for startup and shutdown
    b. Preventive and predictive maintenance

Practical:

1. To Study the Personnel Protective Equipment (PPE)
2. To study various Safety Precautions III a Typical Welding Shop
3. To study the Safety Precautions on a floor
4. To study the First Aid and its importance in the Industry
5. To study Various Injuries and the use of Standard First Aid Boxes
6. To study various Environmental Injuries
7. To study the types or Fire and Fire Extinguishers

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**
    Quiz and Assignment (10%)
    Midterm (30%)
    Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Charles D. R., 2017. Occupational Health and Safety Management: A Practical Approach, 3rd Ed. CRC Press.
2. Chakrabarty 2010. Management Information System for Industrial Safety, Health and Environment Laxmi Publications.
3. Mohamed B.D., Salih O. D., Abdul R., Jezdimir K. and Daoud A.K.2009. Handbook of Maintenance Management and Engineering Springer.

4. DeshmukhL. M. 2005. Industrial Safety Management: Hazard Identification and Risk Control McGraw Hill Publication
5. Charles D. R. 2017. Occupational Safety and Health: Fundamental Principles and Philosophies CRC Press

Food Regulations and Legislations

Contact Hours:
Theory =32
Practical =0
Total =32

Credit Hours:
Theory =2.0
Practical =0
Total =2.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** government statutes and regulations that contribute to a safe, nutritious, and wholesome food supply.	Cognitive	2	6
2.	**Analyze** how technological, social and political forces interact in the development of food laws and regulations and food policies domestically and globally.	Cognitive	4	6
3.	**Acquire** the current structure of the food regulatory system in the Pakistan.	Cognitive	1	8
4.	**Understand** more about the law and the US legal system including: jurisdictional issues, administrative law labor and criminal law issues relevant to the regulation of the manufacture and sale of food and supplements.	Cognitive	2	8

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☑
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☑	12	Lifelong Learning	☐

Course Outline:

Food law & legislation

1. Pure food rules
2. Food adulteration
3. Sampling techniques
4. Flour and Rice Milling Control and Management Ordinance 1977
5. Ghee Industry Act 1973
6. Pakistan Hotel and Restaurants Act 1976
7. Food labeling
8. Education act, NLEA in cereal and baking products
9. WTO implications to food business
10. International Food Standards and Codex Alimentarius
11. Islamic food laws: lawful, unlawful
12. Factory laws: food and workers safety

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Problem based learning

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Reading:

1. Janjua Z I., 1987. Food laws manual. Law Times Pub., Lahore, Pakistan.
2. Rasco, B., 2014. Food Laws and Regulations. *Food Processing: Principles and Applications, Second Edition*, pp.275-291.
3. Curtis, P. A., 2005. *Guide to food laws and regulations*. Blackwell Publishing.
4. Islamic codex alimentarius. Awan JA 1992. Sci. Tech. in Islamci World 10(1): 7-18
5. Rees, N. and Watson, D., 2000. *International standards for food safety*. Springer Science & Business Media.

Food Packaging

Contact Hours:	**Credit Hours:**
Theory =32	Theory =2.0
Practical =48	Practical =1.0
Total =80	Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the basic knowledge of Food Packaging.	Cognitive	1	1
2.	**Explain** the Physical properties of Food Packaging material.	Cognitive	2	1
3.	**Practice** on equipment used in food packaging	Psychomotor	3	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑	7	Environment and Sustainability:	☐
2	Problem Analysis:	☑	8	Ethics:	☐
3	Design/Development of Solutions:	☑	9	Individual and Team Work:	☐
4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☐	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

Course Outline:

1. **Introduction:**
   a. Introduction
   b. Importance of food packaging
   c. Evolution, functions and selection of packaging
2. **Polymer:**
   a. Structure and related properties of plastic polymers
   b. Optical and mechanical properties of thermoplastic polymers
3. **Permeability of thermoplastic**
   a. Introduction
   b. Polymers and its processing
4. **Packing**
   a. Paper and paper based packaging materials
   b. Metal packaging materials and its corrosion
   c. Glass packaging materials
   d. Deteriorative reactions in food
5. **Food preservation and processing techniques**
   a. Techniques
   b. Shelf life of foods
   c. Aseptic packaging of foods
   d. Packaging of microwavable and flesh foods

e. Packaging of horticulture produce
f. Dairy, cereal and snack foods
g. Packaging of beverages
h. Safety and legislative aspects of packaging

6. **Packaging guidelines**
   a. Retail containers, shipping containers
   b. Factors influencing design and selection of packaging materials
   c. Product distribution
   d. Marketing
   e. Packaging operation, cost
7. **Printing Processes**
   a. Inks
   b. Adhesives
   c. Filling and labeling
   d. Safety and legislation
   e. Novel food packaging techniques
   f. Food labeling: importance, types, methods

Practical:

1. Preparing a tube style/tray style folding carton
2. Preparing a rigid box
3. To find the peel strength of a given sample
4. Determining GSM of a given paper board using Vernier calliper
5. Calculation of Burst strength
6. Calculate the Cobb value of paper and board
7. Calculate the Scuff resistance of a printed sample
8. Calculate the Tearing strength of a given sample
9. Study of the relationship between the can closing temperature and the resultant vacuum
10. Edge crush testing procedures
11. Ring compression testing procedures

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Lee, D.S., Yam, K.L. and Piergiovanni, L., 2008. *Food packaging science and technology*. CRC press
2. Robertson, G.L. ed., 2009. *Food packaging and shelf life: a practical guide*. CRC Press.
3. Robertson, G.L., 2005. *Food packaging: principles and practice*. CRC press.
4. Han, J.H. ed., 2005. *Innovations in food packaging*. Academic Press.
5. Ahvenainen, R. ed., 2003. *Novel food packaging techniques*. Elsevier.
6. Yam, K.L. and Lee, D.S. eds., 2012. *Emerging food packaging technologies: principles and practice*. Elsevier.
7. Wagner Jr, J.R. ed., 2016. *Multilayer flexible packaging*. William Andrew.

Food Plant Layout & Design

Contact Hours:
Theory =32
Practical=48
Total =80

Credit Hours:
Theory =2.0
Practical=1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Recognize** the strategic importance of a plant layout and its Location selection	Cognitive	1	1
2.	**Identify** and Explain the major elements of plant design, its layout and engineering economics.	Cognitive	2	1
3.	**Analyze**the problems, Identifies the constrains related to Food Plant layout and its design	Cognitive	4	2
4.	**Integrate** the flow sheet synthesis and process equipment design concepts with the principles of engineering.	Cognitive	5	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑	7	Environment and Sustainability:	☐
2	Problem Analysis:	☑	8	Ethics:	☐
3	Design/Development of Solutions:	☑	9	Individual and Team Work:	☐

4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☐	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

Course Outline:

1. **Basic principles**
   a. Basic principles of designing a food factory.
   b. Feasibility survey, preliminary
   c. Detailed cost estimation.
2. **Optimization**
   a. Optimization of operating conditions.
   b. Design of equipment used in food industry.
   c. Special examples of designed food factories.
   d. Literature review and feasibility survey of food factories.
   e. Equipment design specific to food factories.
3. **Plant design and layout**
   a. Objectives and functions
   b. Financial requirements
   c. Plant location
   d. Site selection
   e. Space requirement
   f. Building design and construction, floors, drains, walls, doors, windows, ceiling, ventilation, lighting, auxiliary facilities.
4. **Plant layout**
   a. Selection of novel products from food industry through market survey
   b. Food product development
   c. Selection of the local preparation of the plant layout
   d. Material and energy balance
   e. Design of the major units and sizing
   f. Auxiliary equipment including services, health and safety considerations, plant and product cost estimation.
5. **Food plant equipment**
   a. Layout of equipment, requirements
   b. Design, construction, and choice of materials
   c. Use of computer for layout
   d. Environmental impact
   e. Material handling and equipment process flow chart

Practical:

1. Layout of Food storage wares and godowns
2. Layout and design of cold storage
3. Layout of preprocessing house /prepackaging unit
4. Layout of Milk and Milk product plants
5. Lay out of Bakery and related product plant
6. Fruits processing plants

7. Vegetable processing plants
8. Freeze drying processing plant
9. Drying and dehydrating processing plant
10. Waste treatment and management of food plant
11. Visit to food processing plant
12. Preparation of project report
13. Preparation of feasibility report

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Moore, J.M., 1962. *Plant layout and design*. Prentice Hall..
2. Antonio López Gómez, Gustavo V. Barbosa-Cánovas., 2007. Food plant design. Taylor & Francis inc.
3. Food processing plant. By Slade, F.H., Leonardhill Books, London.
4. Peters, M.S., Timmerhaus, K.D., West, R.E., Timmerhaus, K. and West, R., 1968. *Plant design and economics for chemical engineers* (Vol. 4). New York: McGraw-Hill.

Final Year Project-II

Contact Hours:		**Credit Hours:**	
Theory	=0.0	Theory	=0.0
Practical	=144	Practical	=3.0
Total	=144	Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**PLAN** the project activities to fulfill the proposed research problems	Cognitive	4	2,4
2.	**MANAGE** the project plan to accomplish project objectives	Cognitive	3	3
3.	**EXECUTE** the project plan	Psychomotor	4	11
4.	**ANALYZE** project results using appropriate technique or tools	Cognitive	4	5
5	**PRODUCE** a project report in accordance with specified standard format	Cognitive	4	10
6	**PRESENT and DEFEND** the project outcomes effectively	Affective	A3	9,11

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☐	7	Environment and Sustainability:	☐
2	Problem Analysis:	☑	8	Ethics:	☐
3	Design/Development of Solutions:	☑	9	Individual and Team Work:	☑
4	Investigation:	☑	10	Communication:	☑
5	Modern Tool Usage:	☑	11	Project Management:	☑
6	The Engineer and Society:	☐	12	Lifelong Learning:	☑

UNIVERSITY ELECTIVES:

Electronics

Contact Hours:

Theory	=32
Practical	=48
Total	=80

Credit Hours:

Theory	=2.0
Practical	=1.0
Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

CLO	Domain	Taxonomy Level	PLO
Explain basic concepts of semiconductor physics and electronic components.	Cognitive	2	1
Identify and Analyze electronic circuits involving capacitors, DC supplies, diodes, BJTs and FETs.	Cognitive	4	2
Employ electronic instruments to perform experiments.	Psychomotor	4	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑	7	Environment and Sustainability:	☐
2	Problem Analysis:	☑	8	Ethics:	☐
3	Design/Development of Solutions:	☐	9	Individual and Team Work:	☐
4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☑	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

Course Outline:

1. **Conduction in Solid**
   a. Introduction
   b. Mechanics of conduction
   c. Mobility
   d. Bohr's model for the elements
   e. Energy level diagrams for solids
   f. Conductors, Intrinsic and extrinsic semiconductors
   g. Electron hole pairs in an intrinsic semiconductor
   h. Distribution of electrons and holes in conduction and valence bands
   i. Recombination and lifetime.

2. **Semiconductors and Diodes**
   a. Donor and acceptor impurities
   b. Zero biased
   c. Forward biased and reverse biased junction diodes
   d. Junction diode current equations
   e. Depletion barrier width and junction capacitance,
   f. Zener and avalanche breakdown,
   g. Hall effect,
   h. Fabrication of p-n junction diodes.
3. **Electron Emission Devices**
   a. Type of electron emission
   b. Thermionic diodes
   c. Thermionic Triode
   d. Parameters and characteristics
   e. Tetrode, Pentode and beam power tubes
4. **Simple Diode Circuits and Applications**
   a. Mathematical and graphical analysis of diode circuits,
   b. The ideal and non ideal diodes
   c. Piecewise linear models
   d. Analysis of piecewise linear models of vacuum tube and junction diodes
   e. The half wave rectifier
   f. The inductance filter
   g. The inductance capacitance filter circuit
   h. Zener & gas diode
   i. Voltage regulator circuits
   j. Clipping & Clamping circuits
5. **Bipolar and Field Effect Transistors:**
   a. Transistor biasing and thermal stabilization
   b. The operating point,
   c. Bias stability Collector to base bias
   d. Fixed bias
   e. Emitter feedback bias
   f. Stabilization for the self biased circuits
   g. Field effect transistors,
   h. Basic principles and theory, Types
   i. FET characteristics, Different configurations, Common gate, Common source and common drain, The FET, Small signal model, Parameters, Biasing of the FET.
6. **Amplifier Circuits**
   a. Introduction
   b. Hybrid model for transistor
   c. Elementary treatment
   d. Low frequency transistor amplifier circuits, Stage cascade LF.

Practical:

1. To study about electrical symbols and laboratory equipments.

2. To study the characteristic curve of Silicon diode.
3. To study the characteristic curve of Germanium diode.
4. To analyze the Half wave rectifier.
5. To analyze the Full wave rectifier
6. To analyze the Bridge rectifier.
7. To study the operation of filters for smooth DC supply.
8. To study the operation of Diode Limiters.
9. To study the operation of Diode Clampers.
10. To study the characteristic curve of Zener diode and find zener voltage.
11. To identify the type of transistor & find its mode of operation on different values of Vcc.
12. To find emitter; base, collector voltage and S currents by applying different supply voltage and find mode of operation.
13. To investigate the operation of common emitter amplifier.
14. To investigate the operation of common base amplifier.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested Reading:

1. Rashid, M.H. ed., 2017. *Power electronics handbook*. Butterworth-Heinemann.
2. Floyd, T.L. and Buchla, D., 2009. *Electronics fundamentals: circuits, devices & applications*. Prentice Hall Press.
3. Streetman, B.G. and Banerjee, S.K., 2016. *Solid State Electronic Devices: Global Edition*. Pearson education.
4. Theraja, B.L., 2005. *Basic Electronics: Solid State*. S. Chand Limited.
5. Boylestad, R.L. and Nashelsky, L., 2012. E*lectronic Devices and Circuit theory*. Prentice Hall.

Food Biochemistry and Enzymology

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** knowledge of biochemical and biophysical process at molecular level	Cognitive	1	1
2.	**Explain** the structure, classification and functional properties of food nutrients and enzymes	Cognitive	2	3
3.	**Analyze** metabolic pathways and activity of biomolecules at cellular level (bioenergetics)	Cognitive	3	2
4.	**Detect/Demonstrate** the basic elements present in food with the help of digital and electronic devices	Psychomotor	3	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☑7	Environment and Sustainability	☐
2 Problem Analysis:	☑8	Ethics	☐
3 Design/Development of Solutions	☑9	Individual and Team Work	☐
4 Investigation	☐10	Communication	☐
5 Modern Tool Usage	☑11	Project Management	☐
6 The Engineer and Society	☐12	Lifelong Learning	☐

Course Outline:

1. **Basic Concept of Biochemistry**
   a. Overview of cellular structure and process
   b. Lipids and membranes
   c. Acid, base and buffers
   d. Viscosity
   e. Surface tension
2. **Carbohydrates & its Metabolism**
   a. Structure

b. Classification
c. Dietary fiber
d. Digestion of carbohydrates
e. Oxidation of glucose (glycolysis)
f. Citric acid cycle and production of energy

3. Lipids

c. Structure
d. Classification
e. Fatty acids and triacylglycerides
f. Digestion of lipid
g. Fatty acid oxidation

4. Amino acids and Proteins,

a. Classification of amino acids
b. Protein structure and functions
c. Protein digestion and amino acid absorption

5. Micronutrients

a. Vitamins
b. Mineral elements

6. Enzymes:

a. Chemical structure of enzymes
b. Coenzymes and co-factors
c. Lock and key model, Induced fit model
d. Classification of enzymes
e. Mechanism of enzymes reactions
f. Basic kinetics of enzymes
g. Factors affecting rate of enzymatic reactions (pH, temperature, substrate concentration, Inhibitors)
h. Enzymes application in food industries

7. Bioenergetics

a. Thermodynamics of biological processes;
b. Adenosine triphosphate (ATP) and phosphoryl group transfers;
c. Oxidation-reduction reactions;
d. ATP synthesis via oxidative phosphorylation in mitochondria.

Practical:

1. How to prepare the Solution in Lab
2. To detect carbohydrate in a given sample by Molisch test
3. To detect presence of sugars in the sample by Benedict test
4. To detect amino acids and proteins in a given sample
5. Estimation of blood glucose level with the help of spectrophotometer
6. Determination of total proteins by kit
7. Estimation of serum cholesterol by humalyzer
8. To observe effect of chemical treatment on enzymatic browning.
9. To observe action of lipase on mille.
10. To observe effect of pH on activity of pepsin on egg white.

11. Determination of the activity of amylase and the effect of enzyme concentration.
12. Detect enzymes on the basis of their substrate hydrolysis.
13. Observe activity of papain on gelatin.
14. To perform Blanching and analyze for its affectivity.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  - Quiz and Assignment (10%)
  - Midterm (30%)
  - Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Nelson DL and Cox MM, 2012. Lehninger Principles of Biochemistry. 6th Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
2. Stryer et al., 2006. Biochemistry. 6th Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
3. Voet D and Voet TG, 2008. Biochemistry. Fourth Edition; John Wiley and Sons, New York.
4. Murray et al., 2012. Harper's Illustrated Biochemistry. 29th Edition; McGraw-Hill Medical Publishing.
5. Ferrier DR, 2013. Lippincott's Biochemistry. 6th Edition; Lippincott Williams &Wilkin Publishing Company.
6. Schantz JT, 2007. A Manual for Biochemistry Protocols. World Scientific Publishing.

Post-Harvest Handling of Fruits and Vegetables

Contact Hours:		**Credit Hours:**	
Theory	=32	Theory	=2.0
Practical	=48	Practical	=1.0
Total	=80	Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy Level	PLO
1.	**Acquire** the knowledge of post-harvest handling and technology	Cognitive	1	3
2.	**Explain** the physiological matureness and color indices for different fruits and vegetables.	Cognitive	2	3
3.	**Discuss** the pack house operations and transport of important fruits and vegetables.	Cognitive	2	3
4.	**Observe** the tools and machinery used in harvest and post-harvest management;	Psychomotor	1	5
5.	**Practice** on equipment related to determination of maturity indices	Psychomotor	3	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Importance of postharvest science and technology**
   a. Introduction
   b. Types of post-harvest techniques
2. **Classification of fruits and vegetable**
   a. Based on climate
   b. Based on location
3. **Maturity indices**
   a. Physiological maturity
   b. Color indices
4. **Harvest and postharvest handling**
   a. Cleaning,
   b. sorting,
   c. grading methods

5. **Pack house operations and transport of important fruits and vegetables.**
    a. Packaging
    b. Palatalizing
    c. Storage
6. **Quality standards**
    a. Texture
    b. Colour
    c. pH
    d. TSS

Practical:

1. Tools and machinery used in harvest and post harvest management Determination of maturity indices
2. Assessment of quality standards
3. Visit to fruit and vegetable markets and progressive farms for experience inn post harvest handling of important fruits and vegetables.

Suggested Teaching Methodology:

a. Lecturing
b. Written Assignments
c. Report Writing

Suggested Assessment:

- **Theory (100%)**

    Quiz and Assignment (10%)
    Midterm (30%)
    Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Florkowski, W.J., Prussia, S.E., Shewfelt, R.L. and Brueckner, B. eds., 2009. *Postharvest handling: a systems approach*. Academic Press.
2. Rees, D., Farrell, G. and Orchard, J. eds., 2012. *Crop Post-Harvest: Science and Technology, Volume 3: Perishables* (Vol. 3). John Wiley & Sons.
3. Thompson, K., 2008. *Fruit and vegetables: harvesting, handling and storage*. John Wiley & Sons.
4. Vázquez, M. and Ramírez de León, J.A., 2011. *Advances in post-harvest treatments and fruit quality and safety*. Nova Science Publishers.
5. Kader, A.A., 2002. *Postharvest technology of horticultural crops* (Vol. 3311). University of California Agriculture and Natural Resources.
6. Kitinoja, L. and Kader, A.A., 2002. *Small-scale postharvest handling practices: a manual for horticultural crops*. University of California, Davis, Postharvest Technology Research and Information Center.

Business Communication & Ethics

Contact Hours:
Theory =32
Practical =0
Total =32

Credit Hours:
Theory =2.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Conform to the framework of Communication in all professional and organizational communications	Affective	3	8
2.	Communicate orally in interpersonal and presentation situations	Cognitive	3	8
3.	Develop written communications effectively using variety of technical genres	Cognitive	3	8
4	Know framework of professional ethics that incorporates moral, legal, societal ethical principles connected with the applied engineering ethics.	Affective	3	10

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☑
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☑
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Communication Skills (oral)**
   a. Definitions and Conditions
   b. Modes of communication
   c. Language
   d. perception
   e. Non-verbal

f. Personal and interpersonal skills
g. Communication dilemmas and problems
h. Public Speaking
i. Presentations
j. Interviews.

2. Business Writing

a. Formal / Business letters, e-mails
   i. Job applications and resumes / cv
   ii. Enquiries
   iii. Complaints / adjustments
   iv. Orders
   v. Quotations
   vi. Banking etc.
b. Memos
   i. Layout
   ii. Language
   iii. Style
   iv. Meeting management
   v. Notice
   vi. Agenda
   vii. Conducting / participating
   viii. Writing minutes
   ix. Contracts and agreements (basic theoretical knowledge and comprehension)
c. Research / scientific reports
   i. Types
   ii. Structure
   iii. Layout / presentation
   iv. Writing process etc.
   v. Tenders (basic theoretical knowledge and comprehension).

3. Engineering / Business Ethics

a. Need and objectives for code of ethics and its importance, Type of ethics, involvement and impact in daily life Problems / conflicts / dilemmas in application (case studies), Sexual Harassment / discrimination in the workplace, why it occurs, (b) myths regarding sexual harassment, (c) how to deal with it, gender equality, (e) respect etc.
b. Codes of conduct: Pakistan Engineering Council, (b) Code for Gender Justice, (c) Brief study of other codes of conduct.

Suggested Teaching Methodology:

- Lectures
- Meeting simulation
- Presentation
- Classroom tasks

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Bovee, Thill and Schtzman, 2003, *Business Communication Today*, 7th Edition, Pearson Education
2. Mary Ellen Guffey, 2003, *Business Communication Process and Product*, 4th Edition, Thomson, South-Western
3. Raymond V. Lesikar , Marie E. Flatley, 2005, *Basic Business Communication Skills For Empowering The Internet Generation*, 10th Edition, McGraw-Hill Irwin–Boston
4. Charles B. Fleddermann, 2004, *Engineering Ethics*, 2nd Edition, Pearson Education New Delhi

Introduction to Applied Agriculture

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the basic knowledge of crop production	Cognitive	1	5
2.	**Explain** crop production, Seed Technology, different farming Systems, tillage Practices and dry Land Farming	Cognitive	2	5
3.	**Discuss** the applications of crop production technologies for boosting crop yield	Cognitive	2	5
4.	**Apply** the principles of farm mechanization technologies	Psychomotor	1	5
5.	**Practice** on equipment related to crop production	Psychomotor	3	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☐7	Environment and Sustainability	☐
2 Problem Analysis:	☐8	Ethics	☐
3 Design/Development of Solutions	☐9	Individual and Team Work	☐
4 Investigation	☐10	Communication	☐
5 Modern Tool Usage	☑11	Project Management	☐
6 The Engineer and Society	☐12	Lifelong Learning	☐

Course Outline:

1. **Crop production:**
   a. Major crops of Pakistan
   b. Factors affecting crop production and distribution
   c. Requirements for production of crops
   d. Classification of field crops based on agronomic use
   e. Special purpose and other basis
2. **Seed technology**
   a. Role of seed in crop production
   b. Concept of seed technology
   c. Dormancy
   d. Seed production and its quality
   e. Seed processing and seed storage
3. **Farming systems and till age practices**
   a. Crop rotation
   b. Definition and computation of cropping intensity
   c. Farming systems and its kinds.
   d. Objective soft ill age. Effect of till age on soil conditions
   e. Plant diseases and insects
4. **Dry land farming**
   a. Introduction
   b. Importance, Rain fall pattern
   c. Barani cultivation practices
   d. Barani agro-ecological zones
   e. Problems and constraint sofdryl and
   f. Dry land improvement
   g. Dry land management
   h. Barani cropping system
5. **Land resources and management**
   a. Soil zones and soil resources of Pakistan
   b. Sustain ability ofl and resources
   c. Managing soil resources
6. **Agro-Meteorology**
   a. Introduction
   b. Weather and climate

c. Climatic components
d. Classification of climates
e. Climatic factors and crop production

7. Agro-Ecology

a . Introduction
b . Agro-ecological features of Pakistan
c . Agro-ecological zones of Pakistan

Practical?

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  - Quiz and Assignment (10%)
  - Midterm (30%)
  - Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Ahrens, C.D., 2012. *Meteorology today: an introduction to weather, climate, and the environment*. Cengage Learning
2. Basra, A. ed., 2006. *Handbook of seed science and technology*. CRC Press
3. Chandrasekaran, B., Annadurai, K. and Somasundaram, E., 2010. *A textbook of agronomy*. New Age International Limited
4. Cheema, Z.A. and Farooq. M., 2007. *Agriculture in Pakistan*. Allied Book Centre, Urdu Bazar Lahore, Pakistan
5. Khan, S.R.A., 2004. *Crop Management in Pakistan: With Focus on Soil and Water*. Government ernment of the Punjab, Agriculture Department.
6. Martin, J.H., Waldren, R.P., and Stamp, D.L., 2006. P*rinciples of field crop production*, 4th Edition, MacMillan Co., New York. USA
7. Nazir, S., Bashir, E. and Bantel, R., 1994. *Crop production*. National Book Foundation, Islamabad
8. Reddy, S.R., 2004. *Agronomy of filed field crops*. Kalyani Publishers, New Delhi, India

Analytical Chemistry

Contact Hours:		**Credit Hours:**	
Theory	=32	Theory	=2.0
Practical	=48	Practical	=1.0
Total	=80	Total	=3.0

Course Learning Outcomes:

On completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	To learn the fundamental principles of analytical chemistry. Understand how different sampling techniques and instrumental methods can be used for particular analysis.	Cognitive	1	1
2.	Assess and suggest a suitable analytical method for a specific purpose, and evaluate sensitivity, important sources of interferences and errors.	Cognitive	5	3
3.	The laboratory course gives the students experience with quantitative methods of working.	Psychomotor	2	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑	7	Environment and Sustainability:	☐
2	Problem Analysis:	☐	8	Ethics:	☐
3	Design/Development of Solutions:	☑	9	Individual and Team Work:	☐
4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☑	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

Course Outline:

1. **Introduction to analytical chemistry**
   a. Review of some basic concepts
   b. Sampling, sample presentations
   c. Quantitative analysis
   d. Statistical analysis: mean, median, mode, standard deviation, relative standard deviation and variance
2. **Gravimetric and volumetric analysis**
   a. Gravimetric analysis
   b. Precipitation method
   c. Thermo gravimetric method and volatisation method.
   d. Volumetric Analysis: Neutralization, redox, complexometric and precipitation titration
3. **Aqueous solution**
   a. Standard solution

b. Primary and secondary standards
c. Concentration of solutions
d. Chemical equilibrium calculation

4. **Potentiometric Techniques**
   a. Potential difference
   b. Standard electrode potential
   c. Potentiometric titrations and use of potentiometry for qualitative analysis
   d. pH meter (pH, buffer solution, pH of poly functional acids)
5. **Chromatography**
   a. Basic concept
   b. Efficiency
   c. Resolution,
   d. High performance liquid chromatography
   e. Ion exchange chromatography, paper chromatography, thin layer Chromatography, electrophoresis.
6. **Spectroscopic Methods**
   a. Atomic and Molecular spectroscopy

Practical?????

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**

  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

- **Laboratory (100%)**

Suggested Readings:

1. Fifield, F.W. and Kealey, D., 1995. *Principles and practice of analytical chemistry*. Blackie academic & professional
2. Skoog, D.A., Holler, F.J. and Crouch, S.R., 2017. *Principles of instrumental analysis*. Cengage learning
3. Harris, D.C., 2007. *Quantitative chemical analysis* (Vol. 61). New York: WH Freeman
4. Skoog, D.A., West, D.M., Holler, F.J. and Crouch, S., 2013. *Fundamentals of analytical chemistry*. Nelson Education

ELECTIVES BREADTH

Machine Design

Contact Hours:
Theory =48
Practical = 0
Total =48

Credit Hours:
Theory =3.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy Level	PLO
1.	**Acquire** the basic knowledge of machine design relevant to food engineering.	Cognitive	1	1
2.	**Explain** the basic concepts of shafts and columns, shaft materials and design of circular shaft under load	Cognitive	2	1
3.	**Apply** the design and applications of gears relevant to food engineering.	Cognitive	3	3
4.	**Understand** the importance of design standards	Psychomotor	3	2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Basic principles**
   a. Basic principles of designing a food factory
   b. Feasibility survey, preliminary
   c. Detailed cost estimation
2. **Optimization**
   a. Optimization of operating conditions
   b. Design of equipment used in food industry
   c. Special examples of designed food factories
   d. Literature review and feasibility survey of food factories

e. Equipment design specific to food factories

3. **Shafts and columns**
   a. Static
   b. Cyclic and Shock Loads
   c. Torsional stiffness, Critical speed
   d. Shaft Materials and Design of Circular Shafts under normal and combined loading
   e. Introduction to flexible shafting
   f. Connecting rods and crank shafts
4. **Friction and Wear**
   a. Lubrication theory
   b. Bearing types and materials
   c. Detailed design of Journal and Thrust slider bearings
   d. Design of roller bearing including spherical and tapered roller bearings
5. **Pressure Vessel Design**
   a. Introduction to the design of pressure vessels
   b. Tanks and piping system
6. **Gear Theory**
   a. General gear design theory
   b. Design of the spur gear
   c. Design of Helical, Worms, Bevel, Novikou and Hypoid Gears
   d. Design of Gear Boxes and Gear Trains
7. **Design Codes**
   a. Introduction to Industrial Design Codes
   b. Application of at least one design standards i.e. ASME, BS, ANSI, JIS, DIN, and ISO in the design of machine elements and assemblies
8. **MEMS**
   a. Manufacturing
   b. Lithography
   c. Etching
   d. Micromachining
   e. MEMS Devices, Sensors, Actuators, Springs and Fluid Flow devices

Suggested Teaching Methodology:

- Lecturing
- Quizzes and Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Robberts T. C., 2013. Food Plant Engineering Systems, CRC Press, *University of Minnesota, Crookston, Minnesota, USA.*
2. Holah J., Campden B. and Lelieveld H. L. M., 2011. Hygienic design of food factories formerly Unilever R&D, Netherlands.
3. Gomez A. L., and Barbosa G. V., 2005. Food Plant Design. *Universidad Politecnica de Cartagena, Spain,* CRC Press. *Washington State University, Pullman, USA Washington State University, Pullman, USA.*
4. Brennan J. G., Butters J. R., Cowell N. D. and Lilly A. E. V., 1995. Food Engineering Operations. 3rdEd., Elsevier Science B. V., Amsterdam - Lausanne - New York, USA.

Industrial Organization and Management

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

CLO		Domain	Taxonomy Level	PLO
1	Able to understand and apply basic management principles.	Cognitive	1	11
2	Understand and critically assess the environment, social and ethical responsibilities of management with in industries.	Cognitive	1	7 & 8
3	Practice the process of management's four functions: planning, organizing, leading, and controlling.	Psychomotor	2	9

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☐	7	Environment and Sustainability:	☑
2	Problem Analysis:	☐	8	Ethics:	☑

3	Design/Development of Solutions:	☐	9	Individual and Team Work:	☑
4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☐	11	Project Management:	☑
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

Course Outline

1. Introduction and History
2. Company and Organization
3. Facility Location and Layout Planning
4. Operation Planning and Control
5. Marketing and Distribution
6. Total Quality Management, Project Management
7. Maintenance Management
8. Financial Management
9. Human Resources
10. Other Topics and Recent Trends in Management

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Operation Management by Jay Heizer and Barry Render.
2. Operation Management, B. Mahaderan.
3. Operation Management, William Stevenson.

Renewable Energy Resources for Food Industry

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=2.0
Practical	=16	Practical	=1.0
Total	=64	Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the fundamentals of renewable energy resources	Cognitive	1	1
2.	**Explain** the different resources of renewable energy utilize efficiently in food industry	Cognitive	2	1 ,3
3.	**Compare** different renewable energy resources and optimize the results	Cognitive	2	1 , 2
4.	**Practice** on available equipments to check the efficiency different renewable energy resources	Psychomotor	3	1 ,5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline

1. **Introduction**
   a. Fundamentals of renewable energy resources
   b. Utilization of renewable energy resources
2. **Solar Energy**
   a. Solar radiation and its measurement
   b. Solar thermal energy collectors
   c. Solar thermal energy conversion systems
   d. Solar photovoltaic system
3. **Wind energy**
   a. Small hydropower
   b. Electric power generation by ocean energy
4. **Biomass energy**
   a. Fuel cells
   b. Biomass gasification
   c. Liquid bio-fuel /biodiesel.
5. **Wind Power**
   a. Wind energy potential

b. Vertical and horizontal axis wind mills
c. Wind operated pumps and water lifts
d. Other applications of wind power in agriculture.

6. Energy and Environment

a. Energy for crop production
b. Dairy farming
c. Poultry farming
d. Energy consumption for waste water treatment and solid wastes
e. Energy conservation
f. Greenhouse effect
g. Energy dissipation through industrial and engine emissions and their impact on environment.

Practical:

1. Demonstration of different components of solar water heater
2. Differentiation of active and passive solar systems
3. Performance evaluation of solar water heater in the laboratory
4. Demonstration of different components of Photovoltaic panels
5. Determination of voltage, Ampere and resistance of PV modules in parallel and in series circuits
6. Production of bio-diesel from agricultural seeds/plants in the laboratory
7. Visits to different biogas plants and demonstration of different components of fixed dome and floating drum type bio gas plants.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Abbasi, T and S. A. Abbasi. 2010. Renewable Energy Sources. PHI Learning Private Limited.
2. Ho and On P.N. 1981. Methane production from agricultural and domestic wastes. Applied Sci. Publishers Ltd, London, UK. Jewell, W.J. 1996. Energy, agriculture, and waste management. Ann Arbor Science. Publisher Inc. Ann Arbor, Michigan, USA.
3. Kothari. 2009. Renewable Energy Sources and Emerging Technologies. PHI Learning Private Limited

4. Pimental, D. 1993. Hand book of energy utilization in Agriculture. CRC Press Inc. 2000 corporate. Blvd. Florida, USA.
5. Stout, B.A. 1990. Hand book of energy for world Agriculture. Elsevier Science B.V., Amsterdam - Lausanne - New York, USA.
6. Threlkeld, J.L. 1993. Thermal environmental engineering. Prentice Hall, Inc. Englewood Cliffs, N.Y. USA.

Fluid Flow System

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of fluid flow systems	Cognitive	1	1
2.	**Explain** the principles of water suction and pumping	Cognitive	2	1 ,3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. Definition
   a. Types and use so f hydraulic machinery
   b. Hydraulic Turbo-machines
   c. CF Din Hydro Turbo-machines

2 . Hydraulic turbines
   a. Definition, types of turbines
   b. Suitability of turbines
   c. Components of turbines
   d. Hydraulic design of a Pelton turbine

e. Mechanical design of Francis and Pelton turbines
f. Inlet and outlet velocity diagrams, guide blade angle
g. Inlet and outlet vane angles WHP and BHP of turbine
h. Hydraulic, mechanical and overall efficiency of turbines
i. Factors influencing the performance of turbines.

3. Pumps

a. Purposes
b. Pump components
c. Pump classification centrifugal
d. Jet, positive displacement, turbine pumps, submersible pumps, propeller and mixed flow pumps and gas or air lift pumps
e. Types of impellers (open, semi-closed, closed)
f. Terminology in pumping systems-specific speed
g. Priming, pumping energy
h. Total dynamic head pump problems and their remedies.

4. Characteristic curves

a. TDH-Q curve
b. Cavitation
c. Net positive suction head
d. Affinity laws
e. Pump testing
f. Maintenance of pumps
g. System head curves and its components for pumps selection
h. Pumps in parallel
i. Pumps in series
j. Pumping system head and power requirements
k. Suction lift
l. Well draw down
m. Friction head loss
n. Operating head seasonal variation in system head curve
o. Pumps selection, prime mover electric
p. Diesel and their selection
q. Feasibility of prime mover selection, determining pumping head, brake horsepower; water horse power; input horse power; pumping plant efficiency.

5. Steady in compressible flow in pressure conduits

a. Laminar and turbulent flow in circular pipes,
b. Major and minor energy losses in pipes,
c . Branching pipes, pipes in series,
d. Pipes in parallel and pipe network analysis,

Practical:

1. Impact of jet on stationary flat and curved vanes.
2. Performance evaluation of hydraulic turbines
3. Determination of turbines efficiency
4. Measurement of various losses through pipes and pipefittings.

5. Study of components and operational characteristics of centrifugal pumps.
6. Study of components and operational characteristics of positive drive pumps.
7. Development and Use of characteristic curves of centrifugal pumps.
8. Development and Use of characteristic curves of positive drive pumps.
9. Determination of centrifugal pumps efficiency
10. Determination of positive drive pumps efficiency
11. Determination of head losses through pipes and pipe fittings

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Munson, B.R., Okiishi, T.H., Rothmayer, A.P. and Huebsch, W.W., 2014. *Fundamentals of fluid mechanics*. John Wiley & Sons.
2. Rajput, R.K., 2002. A textbook of fluid mechanics and hydraulic machines, S1 Version, S. *Chad and Company Ltd, New Delhi*.
3. Daugherty, R.L., 1989. *Fluid mechanics with engineering applications*. Tata McGraw-Hill Education.
4. Khurmi, R.S., 1987. *Textbook of Hydraulics, Fluid Mechanics and Hydraulic Machines*. S. Chand.

Theory of Machines

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of power transmission systems, friction to movement etc.	Cognitive	1	1
2.	**Explain** the principles of velocity,	Cognitive	2	1 ,3,

	acceleration diagrams and functions of governors in the control of speed and torque			5
5.	**Practice** on developing velocity and acceleration diagram of various mechanisms	Psychomotor	3	1 ,3, 12

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☑	7 Environment and Sustainability	☐
2 Problem Analysis:	☐	8 Ethics	☐
3 Design/Development of Solutions	☑	9 Individual and Team Work	☐
4 Investigation	☐	10 Communication	☐
5 Modern Tool Usage	☑	11 Project Management	☐
6 The Engineer and Society	☐	12 Lifelong Learning	☑

Course Outline:

1. **Introduction to theory of machines**
   a. introduction and applications of theory of machines for design and development of food machinery

2. Friction

   a. Friction between un-lubricated surfaces,
   b. Motion on inclined plane,
   c. Screw threads and efficiency,
   d. Friction of pivot and collar, journal and thrust bearings,

4. **Mechanisms**
   a. Link, lower and higher pair joints,
   b. Kinematic chain, frame, linkage,
   c. Kinematically equivalent mechanisms,
   d. Degree of freedom, connectivity and mobility, inversion,
   e. Grash of rules,
   f. Motion limit for slider crank mechanism,
   g. Graphical and analytical position,
   h. Velocity and acceleration analysis of four bar and slider crank mechanism,
   i. Relative velocity and relative acceleration analysis (linkages with rotating sliding joints, quick return mechanism analysis, rolling contact analysis, cam contact analysis),
5. **Power transmission systems**
   a. Spur gears,
   b. Condition for constant velocity, involutes,

c. Gear terminology and standards,
d. Contact ratio,
e. Rack and pinion,
f. Internal gears, interference, helical, bevel and worm gears
g. Gear trains (simple, compound, concentric and planetary gear trains).
h. Chains and sprockets, bands and shoe brakes.

6. **Governors, cams, flywheels**
   a. Dead weight and spring loaded governors,
   b. Effort and power, sensitivity,
   c. Controlling force and stability,
   d. Crank effort diagram, flywheels ,
   e. Profile cam design
   f. Hook's joint,
   g. Steering mechanism,
7. **Balancing**
   a. Balancing, balancing of rotating and reciprocating masses,
   b. Balancing of in-line engines, V-engines and radial engines,
   c. Balancing machines
8. **Miscellaneous topics**
   b. Geneva mechanism,
   c. Gyroscope and its stabilization,
   d. theory and applications of dynamometers, force analysis of mechanisms
   e. slider crank mechanism,
   f. spur, helical, bevel and worm gears, cam,
   g. torques on gear trains,

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Books:

1. Mechanics of Machines, Elementary theory and Examples by John Hannah and R.C Stephens
2. Mechanics of Machines, Advanced theory and Examples by John Hannah and R.C Stephens
3. Kinematics, Dynamics and Design of Machinery by Kenneth J. Waldron/ Gary L Kinzal
4. Mechanics of Machines by W.L Cleghorn

5. Theory of Machines and Mechanisms by John J. Uicker, Gordon R. Pennock, Joseph E. Shigley
6. Kinematics and Dynamics of Machinery by Charles E. Wilson, J.Peter Sadler
7. Kinematics, Dynamics and design of Machinery by Kenneth J. Waldron/ Gary L. Kinzal
8. Kinematics and Dynamics of Machinery by Charles E. Wilson, J.Peter Sadler

Food Processing and Preservation

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, **the students will be;**

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Describe** about knowledge on the causes of food spoilage and methods of processing and preserving food.	Cognitive	2	4
2.	**Understand** principles and practices of food processing	Cognitive	2	1
3.	**Understand** unit operations employed in food processing with respect to their function and effects on food materials and the equipment employed.	Cognitive	2	4
4.	**Select** processing equipment and preservation methods appropriate for specific food.	Cognitive	6	1
5.	**Describe** the effects of preservation methods on the quality of food.	Cognitive	4	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☑	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Preparatory operations**
   a. Cleaning
   b. Sorting
   c. Grading
   d. Size reduction
   e. Blanching and sulphiting
2. **Heat processing methods**
   a. Thermisation
   b. Pasteurization
   c. HTST
   d. Commercial sterilization
   e. UHT
3. **Canning**
   a. Unit operations
   b. Retort operation: equipment.
   c. Effect of heat processing: nutrients, microorganisms.
   d. Low temperature preservation
   e. Refrigeration
   f. Methods and equipments
4. **Use of chemical additives**
   a. Contaminants
   b. Adulterants
   c. Additives
5. **Food additives**
   a. Classification, Criteria for selection
   b. GRAS additives
   c. Permissible limits
   d. Food safety
   e. Preservation by fermentation technology
   f. Fermented foods:
   g. Bread, wine, vinegar, yoghurt, sausages, pickles.
6. **Food irradiation**
   a. Principles
   b. Applications
   c. Equipments
   d. Safety aspect
   e. Effect on food properties
   f. Detection methods.

Practical:

1. Bottling of selected fruits, vegetables
2. Canning of selected fruits, vegetables
3. Cold storage of fruits
4. Cold storage of vegetables
5. Freezing of fruits

6. Freezing of vegetables
7. Dehydration of fruits
8. Dehydration of vegetables
9. Use of chemicals in preservation of food products
10. Production of vinegar
11. Production of yoghurt
12. Production of pickles
13. Evaluation of bottled, frozen and dehydrated products
14. Ohmic heating procedure for food quality test.
15. Visit to food industries

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Project
- Video

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Brennan, JG. 2006. Food processing handbook. Wiley-VCH Verlag GmbH & Co. KGa A, Weinheim, Germany.
2. Fellow, P.J. 2005. Food processing technology: principles and practices, 2nd ed. CRC Press, Taylor & Francis Group, Boca Raton, Florida.
3. Rahman, M.S. 2007. Handbook of food preservation. CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA.

Process Control in Food Industry

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Describe** the needs and incentives for controlling a process in food industry	Cognitive	1	1

2.	**Analyze** the characteristics of a control system and to formulate the problems that must be solved during its design	Cognitive	2	1
3.	**Design**and evaluate control systems used in food processing industries by using mathematical modeling.	Cognitive	4	2,3,5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Importance of Process Control in the Food industry**
   a. Importance
   b. Introduction to process control principles
   c. Definition of control objectives
2. **Mathematical Modelling**
   a. Basics of mathematical modeling
   b. Process control elements
   c. Definition of open and closed loop systems
   d. Transfer functions and block diagrams
3. **Types and Selection of Controllers**
   a. Types and selection of control scheme
   b. Process control of selected food engineering operations
4. **Process**
   a. Bioreactors
   b. Blanching
   c. Pasteurization and sterilization
   d. Drying, freezing
   e. Evaporation and concentration
   f. Baking and extrusion

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Presentation

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Introduction to Process Control by Jose A. Romagnoli, Ahmet Palazoglu, 2nd ed.
2. Chemical Process control by George Stepehnopolous
3. Introduction to Process Control by Jose A. Romagnoli, Ahmet Palazoglu, 1st ed.

Food Biotechnology

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

After this course and completion of an appropriate amount of independent study, students will be able to;

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of biotechnology and food fermentation	Cognitive	1	1
2.	**Explain** the production of major nutrients through biotechnology/ microorganisms	Cognitive	2	3
3.	**Apply** biotechnology knowledge in production of fermented food products	Cognitive	2	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑ ☐	7	Environment and Sustainability:	☐
2	Problem Analysis:	☐	8	Ethics:	☐
3	Design/Development of Solutions:	☑	9	Individual and Team Work:	☐
4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☑	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

Course Outlines:

1. **Introduction**
   a. Introduction to biotechnology
   b. Historical perspective of food biotechnology
   c. Microbial metabolism
   d. Genetic concept of replication, transcription and translation
   e. Concept of metabolic engineering
   f. Developments in metabolic and biochemical engineering
2. **Fermentation and metabolites**
   a. Concept of fermentation
   b. Primary and secondary metabolites
   c. Fermentation process
   d. Components of fermentation process
   e. Industrial fermentation
   f. Starter cultures
   g. Fermentation media, design and types of fermenters
   h. Process of fermentation
   i. Recovery, purification of fermentation products/downstream processing
3. **Production of food ingredients**
   a. Production of organic acids
   b. Industrially important enzymes
   c. amino acids
   d. Single cell proteins
   e. Single cell oils
   f. Carotenoids
   g. Fermented food products and their importance
4. **Further applications**
   a. Recycling of agriculture waste
   b. Renewable energy generation
5. **Social aspects of food biotechnology**
   a. Genetically modified microorganisms
   b. Genetically modified animals and plants
   c. Myths and realities of GMO foods
   d. Various point of views of GMO foods

Practical:

1. Isolation and preservation of industrially important microorganisms.
2. Isolation, purification and maintenance of yeast and bacterial cultures.
3. Aerobic and anaerobic fermentation and production of various fermented food products.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Practical performance
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignment (10%)
  Midterm (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. El-Mansi, F. M. T, Bryee, C. F. A, Demain, A. L. and Allman, A. R. 2007. Fermentation microbiology and biotechnology. CRS press, Taylor & Francis Group, Boca Raton, Florida, USA.
2. Borem, A., Santos, F. R. and Bowen, D. E.2004. Understanding Biotechnology. Pearson Education Inc., New Jersey, USA.
3. Shetty, K.; Paliyath, G.; Pommeto, . 2006; Levin, R.E. Food biotechnology. 2nd, Taylor and Francis Group, LLC, USA
4. Stahl, U.; Donalies, U.E.B. 2008; Nevoigt, E. Food biotechnology. Advances in biochemical engineering /biotechnology. Springer-Verlag Berlin Heiderberg.
5. Jeffrey, M.B.; Caldwell, G.A. 1996; Zachgo, E.A. Biotechnology, A laboratory course. 2nd edition, Academia Press, California USA.

POST GRADUATE SCHEME OF STUDIES IN FOOD ENGINEERING

MASTER (ME)

Semester	Course Code	Subjects	Credits
First	FE/FD-XXX	Major	3
	FE/FD-XXX	Major	3
	FE/FD-XXX	Minor	3
		Total	**9**
Second	FE/FD-XXX	Major	3
	FE/FD-XXX	Minor	3
	FE/FD -XXX	Minor	3
		Total	**9**
Third	FE/FD-XXX	Minor	3
	FE/FD -XXX	Minor	3
		Total	**6**
Fourth	FE/FD -699	Master Thesis	6
		Total	**30**

DOCTORATE (PhD)

Semester	Course Code	Subjects	Credits
First	FE/FD-XXX	Major	3
	FE/FD-XXX	Major	3
	FE/FD-XXX	Major	3
	FE/FD-XXX	Minor	3
		Total	**12**
Second	FE/FD-XXX	Major	3
	FE/FD-XXX	Minor	3
		Total	**6**
Third Fourth Fifth Sixth		PhD Dissertation / Research	-
		Total	**18**

NOTE:

The department may offer Major/Minor courses from the given list (but not limited to) according to the availability of resources.

Suggested List of Post Graduate Courses

A. Major Courses

Course No	Course Name	Cr. hr.
FE/FD -XXX	Predictive Modeling in Food Engineering	3(2-1)
FE/FD - XXX	Bioprocess Engineering	3(2-1)
FE/FD - XXX	Sustainability in Food Process Engineering	3(2-1)
FE/FD - XXX	Food Structure Engineering	3(3-0)
FE/FD - XXX	Automation and Process Control	3(2-1)
FE/FD - XXX	Biopolymer Engineering	3(3-0)
FE/FD - XXX	Advanced Thermodynamic	3(3-0)
FE/FD - XXX	Advanced Heat and Mass Transfer	3(3-0)
FE/FD - XXX	Advanced Unit Operations	3(3-0)
FE/FD - XXX	Advances in Food Physics	3(2-1)
FE/FD - XXX	Applied Food Engineering	4(3-1)
FE/FD - XXX	Food Machinery Design and Software Applications	3(1-2)
FE/FD - XXX	Heating, Ventilation and Air Conditioning Engineering	3(2-1)
FE/FD - XXX	Transfer Phenomena in Food Process Engineering	3(2-1)
FE/FD - XXX	Food Powders Engineering	3(2-1)
FE/FD - XXX	Food Process Systems Engineering	3(2-1)
FE/FD - XXX	Dairy Engineering	3(2-1)
FE/FD - XXX	Sugar Engineering	3(2-1)
FE/FD - XXX	Advanced Food Process Engineering	3(2-1)
FE/FD - XXX	Quantitative Techniques for Industrial Food Engineers	3(2-1)
FE/FD - XXX	Non Thermal Processing in Food Engineering	3(3-0)
FE/FD - XXX	Meat Process Engineering	3(2-1)
FE/FD - XXX	Beverages Process Engineering	3(2-1)
FE/FD - XXX	Food Machinery Development and Maintenance	2(1-1)
FE/FD - XXX	Special Problem	1(1-0)
FE/FD - XXX	Seminar	1(1-0)

B. Minor Courses

Course No	Title	Cr. hr
FE/FD- XXX	Grain Preservation and Processing Engineering	3(2-1)
FE/FD- XXX	Energy Management in Food Processing Industries	3(2-1)
FE/FD- XXX	Advanced Engineering Properties of Food Materials	3(2-1)
FE/FD- XXX	Post-harvest management in fruits and vegetables	3(3-0)
FE/FD- XXX	Milling of Cereal	3(2-1)
FE/FD-XXX	Advances in Food Microbiology	3(2-1)
FE/FD- XXX	Advances in Food Chemistry	3(2-1)
FE/FD- XXX	Advances in Meat Technology	3(2-1)
FE/FD- XXX	Nanotechnology in Food Engineering	3(3-0)
FE/FD- XXX	Experimental Statistics	3(3-0)
FE/FD -XXX	Advanced Food Biochemistry	3(3-0)
FE/FD - XXX	Safety and Quality in the food processing	3(3-0)
FE/FD - XXX	Polymer Engineering	3(3-0)
FE/FD - XXX	Advanced Reaction Engineering	3(3-0)
FE/FD - XXX	Process Safety Management	3(3-0)
FE/FD - XXX	Functional Foods	3(3-0)
FE/FD - XXX	Environmental Impact Assessment	3(2+1)
FE/FD - XXX	Solid Waste Management	3(3-0)

DETAILS OF POST GRADUATE COURSES IN FOOD ENGINEERING PROGRAMME (ME/PhD)

A - MAJOR COURSES

FE/FD - Predictive Modeling in Food Engineering 3(2-1)

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Develop an understanding of modeling techniques and model validation	Cognitive	1	1,2
2.	Be able to develop statistical as well as mathematical models and test their applicability to a given food system	Cognitive	2	1,2 ,3
3.	Use of relevant modeling soft wares	Psychomotor	2	5
4.	Develop models for prediction of behavior of a food system	Psychomotor	3	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☑	7 Environment and Sustainability	☐
2 Problem Analysis:	☑	8 Ethics	☐
3 Design/Development of Solutions	☑	9 Individual and Team Work	☐
4 Investigation	☐	10 Communication	☐
5 Modern Tool Usage	☑	11 Project Management	☐
6 The Engineer and Society	☐	12 Lifelong Learning	☐

Course Contents:

1. **Modeling**
   a. Applications for food production
   b. Importance of kinetics in quality modeling,
   c. Simulation and regression

2. **Statistical aspects of modeling**
    a. Statistics and the scientific method
    b. Regression, linear and non-linear model
    c. Transformations
    d. Model discrimination
    e. Error propagation
    f. Experimental design
    g. Approaches in statistics
    h. Bayesian statistics
    i. Resampling
    j. Multi-response modeling
3. **Microbial growth and inactivation**
    a. Growth models
    b. Inactivation models
    c. Enzyme kinetics
    d. Michaelis-Menten kinetics
    e. Enzyme inhibition
4. **Modeling of Food Matrix**
    a. Specific effects in aqueous solutions
    b. Transport phenomena and molecular mobility
    c. Micellar effects
    d. Molecular crowding in the food matrix

Practical:

1. Computer based exercise using Math Cad on Simulations, Simple kinetics
2. Development of Linear models, Nonlinear models using statistical software Statistical evaluation of models, Error propagation, Bootstrap, Jackknife Methods
3. Growth/Inactivation models for microbes
4. Monte Carlo simulation
5. Model discrimination
6. Uniresponse versus multi-response modeling
7. Equilibrium and kinetics for enzymatic hydrolysis, Enzyme kinetics.
8. Develop a simulation model for specific food/bio system

Suggested Readings:

1. Boekel, V.M.A. 2008. Kinetic Modeling of Reactions in Foods. Taylor & Francis.
2. Sablani, S.S., A.K. Datta, S. Rahman, and A.S. Mujumdar. 2006. Handbook of Food and Bioprocess Modeling Techniques. Taylor & Francis.
3. Kuhn, M., and K. Johnson. 2013. Applied Predictive Modeling. Springer.
4. Anderson de Souza Sant'Ana. 2017. Quantitative Microbiology in Food Processing: Modeling the Microbial Ecology. John Wiley & Sons, Ltd.

FE/FD - Bioprocess Engineering 3(2-1)

Contact Hours		**Credit Hours**
Theory	=32	Theory =2.0
Practical	=48	Practical =1.0
Total	=80	Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, **the students will be;**

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Describe** fundamental principles for basic methods in production technique for biologically based products..	Cognitive	1	1
2.	**Understand** existing and new of food processing techniques	Cognitive	2	5
3.	This course strongly benefited by practical courses where students can actively experience the interconnection between biology, engineering, and physical sciences	Psychomotor	4	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Contents:

1. **Unit Operations in Bioprocess Engineering:**
   Downstream Processing, Cell Removal Operations, Filtration, Centrifugation, Cell Disruption, The Ideal Stage Concept, Aqueous Two-Phase Liquid Extraction, Precipitation, Adsorption, Membrane Filtration, Chromatography, Crystallization, Drying. Reactor Engineering: Bioreactor Configurations, Practical Considerations for Bioreactor Construction, Monitoring and Control of Bioreactors, Ideal Reactor Operation, Sterilization, Sustainable Bio-processing. Kinetic Theory and Reaction

Kinetics: Elementary Kinetic Theory, Collision Theory of Reaction Rates, Reaction Rate Analysis/Approximation, Unimolecular Reactions, Free Radicals, Kinetics of Acid Hydrolysis.

Practical:

Designing lab scale bioreactors, Inoculum development and sterile techniques, On-line measurements (e.g. CO_2 and O_2), Off-line measurements: glucose, lactate, L-glutamine, and ammonia. Experiments using immobilized enzymes in membrane bioreactors. Kinetics of reaction in bioreactors: measurement and calculation of cellular consumption rates, Process evaluation and control. Proteins separation and purification techniques.

Suggested Readings:

1. Liu, S., 2016. *Bioprocess Engineering: Kinetics, Sustainability, and Reactor Design*. Elsevier.
2. Doran, P.M., 2013. *Bioprocess Engineering Principles*: Academic Press.
3. Simpson, R., and S.K. Sastry., 2013. *Chemical and Bioprocess Engineering*: Fundamental Concepts for First-Year Students: Springer, New York
4. Dochain, D. ed., 2013. *Automatic control of bioprocesses*. John Wiley & Sons..
5. Shuler, M.L., Kargi, F. and DeLisa, M., 2017. *Bioprocess engineering: basic concepts* (Vol. 576). Englewood Cliffs, NJ: Prentice Hall.
6. Datta, A.K., Sablani, S.S., Mujumdar, A.S. and Rahman, M.S., 2006. *Handbook of food and bioprocess modeling techniques*. CRC Press.
7. Berk, Z., 2018. *Food process engineering and technology*. Academic press.

FE/FD - Sustainability in Food Process Engineering 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of sustainability in food process Engineering	Cognitive	1	1,7
2.	**Explain** exergy analysis of different process to produce sustainable products	Cognitive	2	1,3

3.	**Discuss** the applications of food engineering in food industries.	Cognitive	2	1,2
4.	**Observe** the complex (continuous) production systems	Psychomotor	1	1
5.	**Practice** the working principals and mechanisms involved in food process Engineering	Psychomotor	3	1,2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☑
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Contents:

Challenges for sustainable food production processes, Impact of food production on environment, Quantitative indicators for energy, water, and raw material use; Energy use in supply chain and food processing, Embodied energy content, Virtual water content. Pinch technology; Grand Composite Curve (GCC), Interaction of heating and power utilities requirements. Exergy Analysis; Types of exergy, process comparison, Exergy consumption and cumulative exergy consumption. Exergy diagrams, Exergy and Psychrometry; Exergy of moist air, Applications of Exergy in industry, Process Innovation and Intensification; Effective production efficiency), Food production resource optimization.

Practical:

Development of Sankey diagrams, Drying with zeolites, Analyzing a competitor's process, Case Studies in Exergy Analysis; Heat exchanger, ice cream, cooking at home, Disposable cups or ceramic, multi-use cups, cost of waste water, Analysis of evaporator and drier.

Suggested Readings:

1. Kemp, I.C., 2007. *Pinch Analysis and Process Integration*, Second Edition: A User Guide on Process Integration for the Efficient Use of Energy, 2nd edition, Butterworth-Heinemann.
2. Ibrahim, D., and Rosen, M.A., 2012. *Exergy: Energy, Environment and Sustainable Development*, 2nd Edition. Newnes Publishers.
3. Ibrahim D. and Zamfirescu, C, 2011. *Sustainable Energy Systems and Applications*. Springer Science & Business Media.

4. Mehmet, K., Cengel, A.Y., and Dincer, I., 2012. *Efficiency Evaluation of Energy Systems*. Springer Science & Business Media.

FE/FD - Food Structure Engineering 3(3-0)

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand the** basic concepts of Structured Food	Cognitive	1	1
2.	**Explain** the processes used for the production of multiphase food systems and dynamics related to those processes, enabling them to design multiphase food productsthe environmental issues to analyze them	Cognitive	2	1 , 2
3.	**Observe** the phase transition and Structuring emulsion based foods	Psychomotor	1	1 ,2,3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline

1. **Introduction to Food structure**
   a. Formation
   b. Essentials and principles
   c. Building blocks
2. **Essentials or principles of food product**
   a. Structure formation

3. **Building blocks for food structuring**
    a. Solid-liquid transitions
    b. Crystallization
    c. Glass transition
    d. Role of water as plasticizing agent.
4. **Structuring emulsion based foods**
    a. Multilayer
    b. Pickering
    c. Complex and aerated emulsions.
5. **Food structure and sensory perception**.
6. **Structuring**
    a. Dairy
    b. Cereals
    c. Fruits & vegetables
    d. Oil seed products
    e. Sugar confectionaries.
7. **Heat transfer and food structuring**
8. **Structures of barriers in foods**
    a. Coating
    b. Heterogeneous films and their applications

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Quiz and Assignment (10%)
    Mid Term (30%)
    Final Term (60%)

Suggested Readings:

1. Boland, M., Golding, M. and Singh, H. eds., 2014. *Food structures, digestion and health*. Academic Press.
2. McClements, D.J. ed., 2007. *Understanding and controlling the microstructure of complex foods*. Elsevier.
3. Dickinson, E., 2008. Interfacial structure and stability of food emulsions as affected by protein–polysaccharide interactions. *Soft Matter*, *4*(5), pp.932-942.
4. Bhandari, B. and Roos, Y.H., 2012. *Food materials science and engineering: An overview* (pp. 1-25). Wiley-Blackwell.
5. Telis, V.R.N. ed., 2012. *Biopolymer engineering in food processing*. CRC Press.

FE/FD - Automation and Process Control 3(2-1)

Contact Hours		**Credit Hours**
Theory	=48	Theory =3.0
Practical	=0	Practical =0
Total	=48	Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Evaluate** the analogue control and monitoring of complex industrial processes, focusing on the possible problems and devising solutions to these problems.	Cognitive	5	1,2,3
2.	**Analyse** the stability of non-linear systems.	Cognitive	4	2
3.	**Formulate** a self-tuning regulator example	Cognitive	6	3
4.	**Apply** concepts of automatic control, including measurement, feedback and feedforward regulation for the operation of continuous and discrete systems	Cognitive	3	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Process Models**
   a. Development of Process Models
   b. Dynamic Behavior of Linear Systems
2. **System Response Analysis**
   a. Frequency Analysis
   b. Stability Analysis

3. **Feedback and Feed Forward Control Systems**
    a. Feedback Control Systems
    b. Feed-forward and ratio control
    c. Multivariable system
    d. cascade control
    e. Over-ride control
    f. selective control
    g. Dead time Compensation
    h. Inferential control
    i. Adaptive control
    j. Multi-input and output systems
    k. Process and control loop interactions, control systems
    l. Digital control system implementation
4. **Sensors and Transducers**
    a. Static and Dynamic Characteristics
    b. Final Control Elements
    c. Control Valves
    d. Valve Positioners
    e. Specifying and Sizing Control Valves
    f. Accuracy in Instrumentation
    g. Calibration of Instruments
    h. Dynamic Measurement Errors

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
    Quiz (12%)
    Assignment (8%)
    Midterm(30%)
    Final Term (50%)
- **Laboratory (0%)**

Suggested Readings:

1. William L. L. 2013. Process Modeling, Simulation and Control for Chemical Engineers 2nd Ed. McGraw-Hill.
2. Mehta B.R. and Reddy Y. J. 2014. Industrial Process Automation Systems: Design and Implementation 1st Ed. Butterworth-Heinemann.
3. Terry L.M. Bartelt 2010. Industrial Automated Systems: Instrumentation and Motion Control 1st Ed. Delmar Cengage Learning.
4. George S., 2008. Chemical Process Control 1st Ed. PEARSON Prentice Hall.
5. Jose A. R. 2006. Introduction to Process Control 1st Ed. Taylor & Francis.

FE/FD - Biopolymer Engineering 3(3-0)

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:

After this course and completion of an appropriate amount of independent study, students will be able to;

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of techno-functional properties of various biopolymers	Cognitive	1	1
2.	**Explain** the impact of various processing techniques on behavior of food	Cognitive	2	2
3.	**Explain** the interaction of physico-chemical characteristics of biopolymers with the complex food matrix	Cognitive	2	1,2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑	7	Environment and Sustainability:	☐
		☐			
2	Problem Analysis:	☑	8	Ethics:	☐
3	Design/Development of Solutions:	☐	9	Individual and Team Work:	☐
4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☐	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

Course Contents:

1. **Techno-functional characteristics of polysaccharides**
   a. Thickening and gel formation
   b. Stabilization
   c. Film formation
   d. Aroma binding
   e. Glue properties
   f. Filling properties
2. Functionality of proteins
   a. Techno and bio-functional properties
   b. Composition and solubility

c. Molecular properties of proteins
d. Interfacial properties of proteins
e. Gelation properties of proteins
f. Functionality of protein-polysaccharide blends

3. Lipids
   a. Importance of fats/oils
   b. Melting behavior of different fatty acids and cocoa butter
   c. Structured lipids
4. Rheological behavior of biopolymer suspensions
   a. Effect of shear
   b. Viscoelastic behavior
   c. Pressure drop and heat transfer during flow of biopolymer suspensions
5. Effect of extrusion on biopolymers: thermoplastic behavior

Suggested Readings:

1. Telis, V.R.N. ed., 2012. *Biopolymer engineering in food processing*. CRC Press.
2. Endres, H.J. and Siebert-Raths, A., 2011. Engineering biopolymers. *Eng. Biopolym*, *71148*.
3. Thakur, M.K., Rana, A.K., Liping, Y., Singha, A.S. and Thakur, V.K., 2015. *Surface modification of biopolymers* (pp. 1-19). John Wiley & Sons, Inc.
4. Stephen, A.M. and Phillips, G.O., 2016. *Food polysaccharides and their applications*. CRC press.
5. Rao, M.A., Rizvi, S.S., Datta, A.K. and Ahmed, J., 2014. *Engineering properties of foods*. CRC press.
6. Harris, P., 2012. *Food gels*. Springer Science & Business Media.

FE/FD - Advanced Thermodynamics (3+0)

Contact Hours		**Credit Hours**
Theory	=48	Theory =3.0
Practical	=0	Practical =0
Total	=48	Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Discuss** the consequences of the thermodynamic main laws and how they are important for man and environment.	Cognitive	2	1,7

2.	**Discuss** the connection between intermolecular interactions and state equations and changes of state	Cognitive	2	1
3.	**Solve** thermodynamic calculations on different types of mixtures and reaction and phase equilibria.	Cognitive	3	2
4.	**Calculate** changes in thermodynamic properties for various types of changes of state, both within a phase and for phase transitions.	Cognitive	4	3
5.	**Calculate** thermodynamic properties from spectroscopic data and discuss how the properties at molecular level are linked to the equilibrium properties for a macroscopic system.	Cognitive	4	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs

1	Engineering Knowledge	☑	7	Environment and Sustainability	☑
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline

1. **Review of First and Second Laws of Thermodynamics**
   a. Entropy Calculations
   b. Maxwell Relations
   c. Development of Equation of State
2. **Thermodynamics of Phase Equilibria**
   a. Gibbs Deuham Equation
   b. Chemical Potential
   c. Activity Coefficient
   d. Fugacity and Fugacity Coefficient
   e. Excess Gibbs Free Energy
   f. Phase Equilibrium at low to moderate pressure
   g. Ideal and Non-Ideal Solutions
   h. Residual and Excess property relation
   i. Property changes of mixing

j. Heat Effects of Mixing

3. **VLE with Cubic Equation of state**
   a. Mixing Rules
   b. Liquid models using UNIFAC
4. **UNIQUAC**
   a. Chemical Reaction equilibrium
   b. Gibbs Free Energy Change and Equilibrium Constant
   c. Evaluation of Equilibrium and conversions
   d. The Phase Rule and Duhem Theorem for Reaction Systems
   e. Statistical Thermodynamics

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Readings:

1. Michael J. M., 2014. Fundamentals of engineering thermodynamics 8th Ed. Wiley.
2. Milo D. K. 2013. Engineering & chemical thermodynamics 2nd Ed. Wiley.
3. Yunus A. C. 2008. Thermodynamics: an engineering approach 7th Ed. Mc Graw Hill.
4. Smith J.M. and Ness H.C.V. 2005. Introduction to chemical engineering thermodynamics 7th Ed. McGraw Hill.

FE/FD - Advanced Heat and Mass Transfer 3(3+0)

Contact Hours		**Credit Hours**
Theory	=48	Theory =3.0
Practical	=0	Practical =0
Total	=48	Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	I**dentification** of mechanisms of heat and mass transfer. Formulation of rate equations.	Cognitive	1	1
2.	**Solution** of problems; involving convective heat and mass transfer in one phase and two phase systems	Cognitive	3	3

3.	**Solutions** of the differential equations for steady-state, one-dimensional problems; solutions for non-steady state problems.	Cognitive	3	3
4.	**Development** of transport models based on the differential equations of heat and mass transfer and their simplified forms; identification of suitable boundary conditions.	Cognitive	5	3
5.	**Estimation** of heat and mass transfer coefficients based on dimensional analysis, boundary layer analysis and similarity between momentum, heat and mass transfer.	Cognitive	6	4

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☑	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Optimal design of shell and tube heat exchangers**
   a. Pinchtechnology
   b. Flow arrangements of increased heat recovery
   c. Condensation of single vapours
   d. Condensation of single and mixed vapours
2. **Vaporizers, evaporators and reboilers**
   a. Extended surfaces heat transfer
   b. Cooling towers
   c. Furnace design and operation
   d. Process design of equipment of heat transfer operation based on performance and economic optima
3. **Diffusive and convective mass transfer**
   a. Applications of the Stefan-Maxwell equation
   b. Fick's Law
   c. Prediction of Diffusion Coefficients

d. Convective Mass Transport
e. Correlations for mass transfer coefficients
f. Film Theory, Penetration Theory
g. Higbie's Theory
h. Gas-Liquid Mass
i. Transfer with Chemical Reaction
j. Analogies with Heat Transfer
k. Boundary Layers with Mass Transfer
l. Mass Transfer with CFD

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Readings:

1. Yunus A. Ç., 2007. Heat and mass transfer: a practical approach McGraw-Hill.
2. Frank P. I., and David P. D. 2013. Principles of Heat and Mass Transfer, John Wiley & Sons.
3. John H. L. 2013. A Heat Transfer Textbook 4th Ed. Courier Corporation.
4. Theodore L. B., Adrienne S. L. and Frank P. I. 2011. Fundamentals of Heat and Mass Transfer 7th Ed. Wiley.

FE/FD - Advanced Unit Operations 3(3+0)

Contact Hours		**Credit Hours**
Theory	=48	Theory =3.0
Practical	=0	Practical =0
Total	=48	Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Discuss** the operation of elementary tools used for size separation and mixing.	Cognitive	1	1
2.	**Solve** engineering problems by using the knowledge of various size reduction and mixing equipments.	Cognitive	3	2

3.	**Assess** fluid type and processing requirements to determine appropriate pump type	Cognitive	2	2
4.	**Describe** how various unit operations work individually and together.	Cognitive	2	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Size Separation and mixing**
   a. Equipment for crushing
   b. Grinding
   c. Screening sieves, equipment and use
   d. gravity separation in settling process removal of solid from gases
   e. Separation of coarse particle in liquid sedimentation and thickening
   f. Centrifugal and settling process
   g. Cyclone, hydrocyclone
   h. Sludge separation
   i. Dust filters, dust precipitators
   j. Electrostatic dust precipitators
   k. Colloidal particles and their removal
   l. Froth floatation
   m. Magnetic separation
   n. Scrubbers
   o. Chemical process
   p. mud as resources
   q. Ion exchange separation
   r. Membrane separation
   s. Osmosis and reverse osmosis
2. **Drying**
   a. Drying processes
   b. Tray tunnels, drum and spray driers
   c. Equipment for determination of moisture in solids

d. Liquids and gases

3. **Utilities in Industry**
   a. Fuel, boilers, water, steam, air, fluid flow
   b. Pumps, heat exchange equipment
4. **Gaseous systems**
   a. Gas adsorption, principles
   b. Factors for controlling adsorption of gases
   c. Solution of gases
   d. Removal of gases from liquids
   e. Removal of gases from bulk solids and surfaces
   f. Degassing
   g. Sublimation
   h. Vacuum sublimation and applications

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm(30%)
  Final Term (50%)
- **Laboratory (0%)**

Suggested Readings:

1. Warren L.M., Julian S. and Harriot P. 2013. Unit operations of Chemical engineering" ,7th Ed. McGraw Hill Chemical Engineering Series.
2. Richardson C. 2017. Chemical Engineering', volume 1 & 2, 7th Ed. Butterworth-Heinemann.
3. Rhodes M. 2008. Introduction to particulate technology 2nd Ed. John Wiley & Sons.

FE/FD - Advances in Food Physics 3(2-1)

Contact Hours:	**Credit Hours:**
Theory =32	Theory =2.0
Practical =48	Practical =1.0
Total =80	Total =3.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of **Food Systems and their interactions**	Cognitive	1	1
2.	Explain physico-chemical behavior of Gels, Fats, oils and fatty acids and mass transport through solid packaging materials	Cognitive	2	1
5.	**Practice on** applying engineering techniques for measuring physico-chemical behavior of food products their mass transport	Psychomotor	3	3, 5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Theory

1. **Types of Food Systems and Length scales relevant to food products**
   a. Solid
   b. Liquid
   c. Gas,
   d. Glass
2. **Interactions in food systems**
   a. Relation between force and interaction potential,
   b. Colloidal interactions,
   c. Electrostatic attraction and repulsion,
   d. Hydrogen bonds
   e. Hydrophobic interactions
   f. Salt bridges
   g. Interactions due to polymer adsorption depletion interaction
3. **Gels**
   a. Gel structures in foods
   b. Fractal cluster-cluster aggregation of rod
   c. Particle gels, polymer gels

d. Mixed gels
e. Filled gels.

4. **Fats, oils and fatty acids**
   a. Melting behavior and crystal structures.
   b. Surface active molecules,
   c. Surface tension and interfacial free energy,
   d. Emulsions and emulsion stability.
5. **Physico-chemical behavior of products**
   a. Starches
   b. Powders
   c. Granular materials
6. **Mass transport through solid packaging materials**
   a. Permeability,
   b. Conductivity,
   c. Resistance and their applications.
   d. Nucleation and crystallization.

Practical:

1. Preparation of colloids: homogenizers, membranes, microfluidics.
2. Evaluation of emulsions for drop sizes and their distribution, stability, viscosity.
3. Analysis of gel structures in foods
4. Determining melting behavior and crystal structures
5. Measurement surface and interfacial tension
6. Determination of surface wettability through contact angle measurement.
7. Measuring permeability, conductivity and resistance of Mass transport through solid packaging materials

Suggested Readings:

1. Belton, P. 2007. The chemical physics of food. Blackwell publishing, USA.
2. Dickinson, E. and Van, V.T. 2003. Food colloids: biopolymers and materials. Royal Society of Chemistry, UK.
3. Figura, L. and Teixeira, A.A. 2010. Food Physics: Physical properties, measurement and applications. Springer, USA.

FE/FD - Applied Food Engineering **4(3-1)**

Contact Hours:	**Credit Hours:**
Theory =48	Theory =3.0
Practical =48	Practical =1.0
Total =96	Total =4.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Acquire the basic knowledge of machines and equipment employed for processing cereals, pulses, meat, fish, poultry, dairy products etc.	Cognitive	1	1
2.	Explain mechanizing processing operations of cereals, pulses, meat, fish, poultry, dairy products etc.	Cognitive	2	1
5.	**Practice on** mechanizing processing operations of cereals, pulses, meat, fish, poultry, dairy products etc.	Psychomotor	3	3

Theory:

1. **Cereals and Pulses**
   a. Transportation and storage of Cereals;
   b. Processing of cereals including wheat, maize, barley etc;
2. **Milling of Cereals and Pulses**
   a. Dry and wet milling equipment and processes
   b. Wet milling and starch extraction
   c. Physical factors influencing flow characteristics
   d. Mechanics of bulk solids
3. **Conveyors for Cereals and Pulses**
   a. Types of conveyors and Parameters their design conveyors
   b. Design of conveyers
4. **Fruits and Vegetables**:
   a. Refrigerated and Controlled/Modified Atmosphere Storage,
   b. Processing fresh-Cut Fruits,
   c. Juice Processing,
   d. Dehydration Mechanisms of Fruit and Vegetables,
   e. Freezing and Thermal Processing.
5. **Dairy products**
   a. Milking machines and milking parlors
   b. Unit operations/equipment of dairy processing
   c. Engineering design and layout of dairy equipment; dryers, dehydrators, chillers, homogenizer. Milk transport equipment and packaging of dairy products.
6. **Meat, Fish and Poultry**:
   a. Pre- and post-slaughter operations
   b. Slaughtering equipment
   c. Design of slaughter house.

d. Chilling, Freezing and Packaging of meat, Poultry, and Fish.

Practical:

1. Determining physical attributes of food materials (cereals, fruits and vegetables, dairy, meat)
2. Dry and wet milling of cereals
3. Measuring milling fractions and their sieve analysis.
4. Calculating efficiency of processing equipment.
5. Optimization of pasteurizers, evaporators, dehydrators, membrane filtration, (flow rate/residence time, time temperature relationships).
6. Visits to food industries and slaughter houses.

Suggested Readings:

1. Bylund, G. 2003. Dairy processing handbook. Tetra Pak Processing Systems AB.
2. Chakraverty A. 1995. *Post-harvest Technology of Cereals, Pulses and Oilseeds*. Oxford & IBH.
3. Chooksey MK. 2003. *Fish Processing and Product Development*. CIFE, Kochi.
4. Coimbra, J.S. and Teixeira, J.A. 2009. Engineering Aspects of Milk and Dairy Products. CRC Press.
5. Kutz, M. 2013. Handbook of Farm, Dairy and Food Machinery Engineering. Elsevier Science.
6. Owens, C.M, Alvarado, C and Sams, A.R. 2010. Poultry Meat Processing (2nd ed.) Elsevier
7. Pearson, A.M. and Tauber, F.W. 2012. Processed Meats, https://books.google.com.pk */books?isbn=9401096929*
8. Sinha, N, Y. Hui, Siddique, M, Evranuz, H, and Ahmad, J. 2010. Handbook of Vegetables and Vegetable Processing. John Wiley & Sons, Technology & Engineering
9. Srivastava, R. P. and Sanjeev, K. 2006. Fruit and Vegetable Preservation Principles and Practices, https://books.google.com.pk/books?id=BBZcnQEACAAJ

FE/FD - Food Machinery Design and Software Applications 3(1-2)

Contact Hours:		**Credit Hours:**	
Theory	=32	Theory	=2.0
Practical	=48	Practical	=1.0
Total	=80	Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of food machinery design and solid work	Cognitive	1	1
4.	**Apply** mechanical automation software package to design, build parts, assemblies and drawings of food processing machinery.	Cognitive	3	2, 3
5.	**Practice** on solid work software to design food machinery	Psychomotor	4	1, 3

Course Outline:

1. **Introduction**
   a. SolidWorks Basics
   a. Application of Engineering Design with SolidWorks for the design and development of food product development machinery
   b. Fundamentals of part modeling
   c. Fundamentals of assembly modeling
2. **Fundamentals of drawing**
   a. Extrude and revolve features
   b. Swept, lofted and additional features
   c. Top-down assembly modeling and sheet metal parts
3. **Software applications**
   a. Simulation Xpress,
   b. Sustainability and DFM Xpress
   c. Intelligent modeling techniques

Practical:

1. Create drawings with custom properties
2. Exploded isometric views
3. Development of product parts with extruded Boss/Basic feature and the instant 3D tool.
4. Development flashlight assembly of product parts.
5. Create product components and modify them in-context of the assembly.
6. Development of layout sketch using Top-Down assembly modeling approach.
7. Application of Explicit equation, Driven curve tool, Curve through XYZ Points Tool, Assemblies and Drawings
8. Design and development of food machinery employing SolidWorks

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignments (10%)
  Mid Term (30%)
  Final Term (60%)
- **Laboratory (100%)**

Text and Reference Books:

1. Planchard, D., Engineering Design with Solid Works 2015 and Video Instruction. 2014: SDC Publications.
2. Bethune, J.D., Engineering Design and Graphics with Solid Works. 2010: Prentice Hall.
3. Matsson, J., An Introduction to Solid Works Flow Simulation 2014. 2014: Schroff Development Corporation.

FE/FD - Heating, Ventilation and Air Conditioning Engineering 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of heat and mass transfer in food	Cognitive	1	1
2.	**Explain** the basic laws of heat and mass transfer, boiling and condensation also working principles and design of heat exchangers	Cognitive	2	1 ,2
3.	**Discuss** the applications of transfer phenomenon in food industry	Cognitive	2	1 , 2
4.	**Practice** on equipment related to heat and mass transfer	Psychomotor	3	2,3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Psychrometrics**
   a. Heat and Moisture Transfer Calculations
   b. Indoor and Outdoor Design Conditions

2. **Air conditioning processes**
   a. Cooling with Dehumidification
   b. Heating with Humidification
   c. Adiabatic Mixing of Two Air Streams
   d. Evaporative Cooling
3. **Load estimation**
   a. Calculating Design Heating Loads
   b. Cooling load calculations
4. **Refrigeration Systems**
   a. Refrigerants
   b. Refrigeration Cycles
5. **Air Systems**
   a. Components—Fans, Coils, Filters, and Humidifiers
   b. Basics and Constant-Volume Systems
   c. Minimum Ventilation and Controls
6. **Air Conditioning Systems**
   a. System Classification
   b. Selection, and Individual Systems
   c. Evaporative Cooling Systems
   d. Evaporative Coolers
   e. Central Systems and Clean-Room Systems
   f. Thermal Storage Systems.

Practical:

1. Charging of a vapor compression plant
2. Recovering of the working fluid

3. Dynamics of the refrigeration plant to varying the external conditions.
4. Designing refrigeration system
5. Designing air conditioning plants, Load calculations for energy management and control systems.
6. Designing evaporative cooler
7. Designing thermal Storage Systems.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignments (10%)
  Mid Term(30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Pita, E.G.. Air Conditioning Principles and Systems: An energy approach, 2001Wiley
2. Pita, E.G.. Refrigeration principles and systems: an energy approach, 1984 Wiley.
3. Wang, S. Handbook of Air Conditioning and Refrigeration. 2014.McGraw-Hill Education. www.goodreads.com/book/.../3054634-air-conditioning-principles.

FE/FD - Transfer Phenomena in Food Process Engineering 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Acquire the basic knowledge Heat and mass transfer Phenomena	Cognitive	1	1
2.	Explain the principles of Heat and mass transfer Phenomena in foods	Cognitive	2	2

	and application of Math Cad for problem solving			
3.	Practice on steady and non-steady heat and mass transfer in foods	Psychomotor	3	2, 3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introductio**n
   a. Heat and mass transfer Phenomena
   b. Analogous behavior of heat and mass transfer
2. **Heat conduction**
   a. Steady and unsteady state heat conduction,
   b. Analytical and numerical solution of unsteady state heat conduction equations
   c. Use of Gurnie-Lurie and Heisler Charts in solving heat conduction problems
   d. Applications in food processing including freezing and thawing of foods
3. **Convective heat transfer in food processing systems**
   a. Convective heat transfer involving laminar and turbulent flow
   b. Heat transfer in boiling liquids,
   c. Heat transfer between fluids and solid foods.
4. **Functional design of heat exchangers**:
   a. Shell type
   b. Tube type
   c. Plate and scraped surface heat exchangers,
   d. Jacketed vessels.
5. **Radiation heat transfer**
   a. Introduction of radiation heat transfer
   b. Applications Radiation heat transfer governing laws in food processing.
6. **Molecular diffusion**
   a. **Molecular diffusion in various of g**ases foods, liquid foods and solid foods
   b. Molecular diffusion in biological solutions and suspensions
   c. Unsteady state mass transfer and mass transfer coefficients
   d. Molecular diffusion with convection and chemical reaction,

e. Diffusion of gases in porous solids and capillarie
f. Mass transfer applications in food processing.

7. **Equilibria and potentials**
   a. Gravitational potential
   b. Chemical potential of solids, liquids, gases and vapors
   c. Non-equilibrium: driving forces, gravity and chemical potential.
8. **Flow in packed beds**
   a) Flow through structured slit shaped channels (membrane spacers)
   b) Flow around spheres
9. **Heat transfer and mass transfer**
   a. Coupled heat and mass transfer
   b. Mass transfer and fluxes
10. **Membrane processes**
   a. Reverse osmosis
   b. Nano-filtration
   c. Ultrafiltration
   d. Dialysis
   e. Pervaporation

Practical:

1. Solving problems on steady and unsteady state conduction with or without generation
2. Numerical analysis of problems in natural and forced convection; radiation
3. Design of heat exchangers
4. Performing experiments on heat conduction, convection and radiation heat transfer.
5. Working with Math Cad,
6. Determination of phase equilibria in products and processes. Determination of diffusion constant, Measuring the properties of an edible barrier material,
7. Determination of flux and mass transfer in membranes.

Suggested Readings:

1. Benitez, J. 2011. Principles and Modern Applications of Mass Transfer Operations. John Wiley & Sons.
2. Christie, G.J 2003. Transport Process and Unit Operations (3rd ed.). Prentice Hall PTR;
3. Lienhard, J.H . 2008. Heat Transfer Textbook (3rd ed.) Phlogistan Press, Massachetts.
4. McCabe, W.L. & Smith, J.C. 1999. Unit Operations of Chemical Engineering. McGraw Hill.
5. Treybal, R.E. 1981. Mass Transfer Operations. McGraw-Hill.
6. Wesseling, J.A and Krishna, R. 2006. Mass Transfer in Multi-component Mixtures. Delft University Press, The Netherlands.

FE/FD - Food Powders Engineering 3(2-1)

Contact Hours:
Theory =48
Practical =48
Total =96

Credit Hours:
Theory =2
Practical =1
Total =3.0

COURSE LEARNING OUTCOMES:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of food powder properties.	Cognitive	1	1
2.	**Understand** engineering properties of powder products and processes	Cognitive	1	1
3.	**Observe** tools to stimulate new ideas of development and improvement of powder products and processes	Psychomotor	2	2
4.	**Practice** modern powder and tablet technology	Psychomotor	3	2,3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Physical properties of food powders**
   a. Moisture content
   b. Size and shape
   c. Densities (bulk, tapped and true)
   d. Angle of repose
   e. Angle of wall friction
   f. Angle of internal friction

2. **Characteristics of particles**
    a. Rheology
    b. Compressibility
    c. Reconstitution
    d. Application of fine powders and problems in food industry
3. **Storage and flow properties of powders**
    a. Flow properties
    b. Cohesion index
    c. Cohesion coefficient
    d. Caking strength
    e. Caking height and powder flow speed dependency (PFSD)
    f. Fluidization
4. **Pressure density relationship and modeling**
    a. Kawakita and Ludde Model,
    b. Heckel Model and
    c. Panelli-Filho Model., Response
5. **Mixture analysis**
    a. Surface Methodology (RSM).
    b. Modeling/simulation of powder products
    c. Powder production and safety explosion.

Practical:

1. Determination of densities (bulk)
2. Determination of densities (tapped)
3. Determination of densities (true)
4. Determination of angle of repose
5. Determination of angle of internal wall friction

Analyze powder flow properties
Mixture analysis using design of experiment software.

Suggested Reading:

1. Bhandari, B.N., Bansal, M. Zhang, and P. Schuck, 2013. Handbook of Food Powders: Processes and Properties: Wood head Publishing.
2. Fayed, M., and Otten, L., 2013. Handbook of Powder Science & Technology, Springer.
3. Rivas, E.O and P. J. liano and H. Yan. 2006. Food Powders: Physical Properties, Processing, and Functionality by Principles of powder technology, Springer Science & Business Media.
4. Onwulata, C. 2005. Encapsulated and Powdered Foods. Taylor & Francis Group, LLC

FE/FD - Food Process Systems Engineering 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Acquire the knowledge of **Food Process Systems Engineering**	Cognitive	1	1
2.	Explain methods and tools for food product quality control, food plant and product system optimization and food process analyzers	Cognitive	2	2, 3
5.	**Practice on** , food plant and product system optimization and food process analyzers	Psychomotor	3	2, 3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑ 7	Environment and Sustainability	☐
2	Problem Analysis:	☑ 8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Food Process Systems Engineering**
   - **a.** Theory of food process systems
   - b. Application of process systems engineering for food industries
   - c. Advanced process analytical technology
2. **Food product quality control**
   - a. Real-time quality control
   - b. Multivariate data analysis
   - c. Advanced statistical process control
   - d. Advanced control methods and strategies

3. **Food Plant and product system optimizatio**n
    a. Food System planning approach
    b. Food System design a approach
    c. Food System control approach
    d. Real-time optimization
    e. Control and processing.
4. **Process analyzers**
    a. Design, data acquisition and analysis tools
    b. Process control tools
    c. Knowledge management and continuous improvement tools.

Practical:

1. Design and application of Fusion of models for product optimization
2. Design and application of sensors for process and product optimization. Application of computer assisted tomography and viscosity monitoring for the dairy industry
3. Multivariable models for deep analysis of a process for its optimization
4. Multivariate statistical process control
5. Eco-efficient control of processes and scale up of food extraction processes.
6. Use of targeted models for optimization. Control performance assessment, coffee roasting, and rotary mixing control.

Suggested Readings:

1. Pistikopoulos, E.N., Georgiadis, M.C. and Dua, V, 2014. Process systems engineering. Wiley-VCH Verlag GmbH & Co. KGaA. Print ISBN: 9783527316847 Online ISBN: 9783527631209.
2. Singh, R.P. and Medina, A.G. 1989. Food Properties and Computer-Aided Engineering of Food Processing Systems. California, USA. ISBN: 978-94-010-7567-1 (Print) 978-94-009-2370-6 (Online). Book metrix

FE/FD - Dairy Engineering 3(2-1)

Contact Hours:		**Credit Hours:**	
Theory	=32	Theory	=2.0
Practical	=48	Practical	=1.0
Total	=80	Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, **the students will be;**

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Understand the chemistry underlying the properties and reactions of various components within a dairy food as they are influenced by processing conditions.	Cognitive	1	1
2.	Describe unit operations, process control and sanitation protocols as they relate to the production and preservation of dairy-based foods.	Cognitive	2	1
3.	Apply critical thinking and reasoning skills while ethically applying scientific principles to resolving issues associated with dairy food products and processing systems.	Cognitive	3	2, 3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑ 7	Environment and Sustainability	☐
2	Problem Analysis:	☑ 8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	☐ 11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Dairy Plant Design**
   a. Importance of Dairy Plant Design
   b. Milk Procurement
   c. Milk Reception
2. **Classification of Dairy Plants**
   a. Location of Fluid Milk Plant and Milk Product Plant
   b. Site Selection
3. **Location of Milk Product Plant**
   a. Planning and principles of dairy plant design
   b. Dairy building planning
   c. Space requirement for dairy plant
   d. Estimation of service requirements including peak load consideration

e. General points of consideration for designing dairy plant
f. Different types of layouts
g. Single or multilevel design
h. Service pipe-line layout
i. Equipment layout.
j. Layout of offices and workshops
k. Material handling

4. Preparation of detail layout with model planning

a. Building construction materials and type of building construction
b. Choice of building construction materials - Brick, sand, cement, lime etc.,
c. Building materials – stones, wood, metal, glass etc.,
d. General requirement of dairy floors and floors for different sections
e. Structural Aspects of Foundations, Roofs, Ceilings, Walls, Doors and windows , Drain and drain layout for small and large dairies,
f. Ventilation, Illumination and fly control , Paints, coatings and mold prevention

5. Aseptic Processing Systems

a. Tubular heat exchangers
b. Plate heat exchangers
c. Scraped heat exchangers
d. Surface heat exchangers, direct heating systems, direct steam injection system
e. Direct steam infusion system; Thermal processes, ohmic, microwave, residence time distribution.

Practical:

1. Organoleptic Quality Tests for milk
2. Test detection of urea
3. Detection of detergents in milk
4. Test for detection of sugar in milk
5. Test for detection of starch
6. Test for detection of formalin
7. Clot on Boiling Quality Tests for milk
8. Alcohol Quality Tests for milk
9. Acidity Test (Titration)
10. Determination of pH milk
11. Specific gravity (Lactometer test)
12. *Skimming test for milk*
13. *Butterfat Quality Tests for milk*
14. *Curd test*
15. *Quality control of pasteurized milk*
16. *Design Dairy Plant layout*

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Project
- Video

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    i. Quiz (12%)
    ii. Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Text and Reference Books:

1. Park, Y.W. and Haenlein, G.F.W. 2013. Milk and dairy products in human nutrition: production, composition and health. Wiley-Blackwell Publishers, USA.
2. Patel, S.M and A.G. Bhadania. 2016. Dairy Plant Design and Layout. AgriMoon.com
3. Chandan, R.C., Kilara, A. and Shah, N.P. 2008. Dairy processing and quality assurance. Wiley-Blackwell, Iowa, USA.
4. Britz, T.J. and Robinson, R.K. 2008. Advance dairy science and technology. Blackwell Publishing Ltd, Oxford, UK
5. Meghwal, M, M. R. Goyal and R.S. Chavan. 2017. Dairy Engineering: Milk Processing and Milk Products (4th Ed.). CRC Press, Taylor & Francis Group. Publisher: Apple Academic Press, NJ 08758 USA

FE/FD - Sugar Engineering 3(2-1)

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** knowledge of sugar cane preparation	Cognitive	1	1
2.	**Explain** factory operations for sugar cane milling, processing and refining.	Cognitive	2	2
3.	**Analyze** settings of sugar cane milling, processing, and refining	Cognitive	3	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☑7	Environment and Sustainability	☐
2 Problem Analysis:	☑8	Ethics	☐
3 Design/Development of Solutions	☑9	Individual and Team Work	☐
4 Investigation	☐10	Communication	☐
5 Modern Tool Usage	☐11	Project Management	☐
6 The Engineer and Society	☐12	Lifelong Learning	☐

THEORY:

1. **Introduction**
   a. Sugar industry in Pakistan
   b. Supply and handling of sugarcane / sugar beet
   c. Preparation
2. **Cane Milling**
   a. Objective of Cane milling
   b. Sugar cane Mill and its components functioning;
   c. Diffusion- mechanism of Juice extraction,
   d. Diffusers and their design
   e. Design of mill and bagasse conveyors;
3. **Raw Juice Preparation**
   a. Raw juice handling and heating
   b. Clarification
   c. Filtration
   d. Evaporation
   e. Extraction of sucrose
   f. Minimum extraction of non-sugars
   g. Minimum sucrose in final bagasse
   h. Syrup clarification
   i. Crystallization
   j. Centrifugal separation
   k. Molasses exhaustion
   l. Handling and storage
4. **Drying and storage of Sugar**
   a. Condensers and vacuum equipment design
   b. Optimum moisture in final bagasse Optimum power/energy consumption
   c. Thrust Areas for Efficient Cane milling Management
   d. Preparation of cane Specific fiber loading
   e. Hydraulic Load Proper setting of mills
5. **Imbibition Cane Mill**
   a. Economizer heating surface and its Outlet Flue Gas Temperature Calculation
   b. Determining economizer heating surface in thermal power plants

c. Use of sensible heat content of high temperature combustion gases leaving the boiler, at a high temperature (generally above the saturation temperature)
d. Liquid volume calculations for vertically mounted cylindrical tank partitioned portion - Application of different Formulas for vertical cylindrical tank volume and its partitioned section volume
e. Circle segment area
f. Acre length
g. Chord length measurement
h. Calculation of circle segment area

Practical:

1. Determination of Liquid volume calculations for vertically mounted cylindrical tank partitioned portion
2. Application of different Formulas for vertical cylindrical tank volume and its partitioned section volume
3. Determination of Circle segment area of Cane mill
4. Determination of Acre length
5. Determination of Chord length measurement
6. Determination of Calculation of circle segment area
7. Calculation of Clarifiers Flash tank design
8. Concepts in Condenser System (Vacuum Equipment)
9. Design Calculation of Direct Contact Heater (DCH)
10. Calculating Economizer heating surface and its Outlet Flue Gas Temperature
11. Calculating Liquid- Liquid Heater (Condensate or Duplex Juice Heater).
12. Analysis of sugar cane/ sugar beet for TSS,
13. Analysis of sugar cane/ sugar beet for pH,
14. Analysis of sugar cane/ sugar beet for ash
15. Analysis of sugar cane/ sugar beet for polarization
16. Study Visit of sugar industries

Suggested Readings:

1. Rein, P. 2016. Cane sugar Engineering. Verlag Dr Albert Bartens, berlin, Germany
2. Asadi, M. 2007. Beet sugar handbook. John Wiley & Sons, Inc., New York, USA.
3. Chen, J.C.P. 2007. Meade-Chen cane sugar handbook. John Wiley & Sons, Inc., New York, USA.
4. Chen, C.C. 2000. Handbook of sugar refining: a manual for the design and refining facilities. John Wiley & Sons, Inc., New York, USA.
5. Panda, H. 2011. Sugarcane processing and by-products of molasses (with analysis of sugar, syrup and molasses). Asia Pacific Business Press Inc., India.
6. Lionnet, G.R.E. 1999. Sugar technology for students. Lang Fred, Durban, South Africa.

FE/FD - Advanced Food Process Engineering 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of advanced food processing	Cognitive	1	1
2.	**Enhance** a student's primary qualification of food process engineering with advanced knowledge and skills which will increase his or her prospects of a successful career in the food industry	Cognitive	2	2
3.	**Apply** engineering principles to solve the problems in processing of food using advanced processing technique	Psychomotor	3	2 ,3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑7	Environment and Sustainability	☐
2	Problem Analysis:	☑8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Advanced theory**
   a. Understanding of food process modelling
   b. Advanced food process engineering operations.
2. **Advanced food unit operations**
   a. High pressure processing (HPP)
   b. Pulsed electric field (PEF)
   c. Other "cold" technologies

d. Ohmic heating
e. Advanced packaging

3. **Optimization of food process systems**
   a. Measurement,
   b. Monitoring
   c. Control
4. **Quality control (QC) and statistical process control (SPC)**
5. **Control methods and strategies for food processes**
6. **Process impact on**
   a. Food safety,
   b. Quality
   c. Preservation
7. **Advanced process control**
8. **Advanced process dynamics and control**
9. **Food process optimization**

Practical:

1. Study of advances in Nanotechnology as Applied to Food Systems
2. Study of Molecular-Based Modeling and Simulation
3. Studies of Water–Water and Water–Macromolecule Interactions in Food and Their Effects on Food Dehydration
4. Study of Transport Properties in Food Process Design
5. Non-thermal Technologies to Extend the Shelf Life of Fresh-Cut Fruits and Vegetables
6. Visit of food Industry

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment

- **Theory (100%)**
  Quiz and Assignments (10%)
  Mid Term (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Sahu, J.K. ed., 2014. *Introduction to advanced food process engineering*. CRC Press.
2. Yanniotis, S., Taoukis, P., Stoforos, N.G. and Karathanos, V.T. eds., 2013. *Advances in food process engineering research and applications*. Springer.
3. Berk, Z., 2018. *Food process engineering and technology*. Academic press.
4. Bimbenet, J.J., Schubert, H. and Trystram, G., 2007. Advances in research in food process engineering as presented at ICEF 9. *Journal of food engineering*, *78*(2), pp.390-404.

FE/FD Quantitative Techniques for Industrial Food Engineers 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Acquire the knowledge of Quantitative Techniques for food industries	Cognitive	1	1
2.	Explain methods and tools of Quantitative Techniques in food industries	Cognitive	2	2
5.	Practice on Quantitative Techniques with examples in food industries	Psychomotor	3	1, 3, 5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑7	Environment and Sustainability	☐
2	Problem Analysis:	☑8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	☑11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Contents:

1. **Quantitative techniques**
   a. Concepts and methods of quantitative techniques
   b. Activity-based formulation.
2. **Decision making approaches for food industries**
   a. Under risk situation
   b. Under uncertainty situation
   c. Under certainty situations
3. **Product and Service Design**
   a. Capacity Planning for food industry
   b. Process design facility layout

c. Design of work system

4. **Mathematical and Optimization models**
   a. Transportation model
   b. Trans-shipment Model
   c. Assignment Model
   d. Network Models
   e. Waiting Line Models
   f. Inventory Models
   g. Probabilistic Inventory Models,
5. **Simulation**
   a. Types of simulation
   b. Monte Carlo simulation
   c. Simulation problems.
6. **Motion study**
   a. Principles of motion — economy
   b. Time study-standard time
7. **Production Planning & Control**
   a. Aggregate planning. Sequencing
   b. Line balancing
   c. Flow control
   d. Dispatching
   e. Expediting
   f. Gantt chart
   g. Line of balance
   h. Learning curve
   i. Modern Trends in Manufacturing.

Practical:

1. Mathematical Models – deterministic and probabilistic with food industry examples.
2. Optimization models – Linear Programming, formulation, graphical solution, simplex method, Big M methods, Sensitivity Analysis.
3. Transportation model; – Initial Basic Feasible solutions, optimum solution for non – degeneracy and degeneracy model; Trans-shipment Model, Assignment Model.
4. Network Model; networking – CPM – critical path, Time estimates – critical path – crashing, Resource levelling, Resources planning. Waiting Line Model.
5. Inventory Models – Deterministic – Economic Order Quantity (EOQ) – EOQ with Price Breaks – Probabilistic Inventory Models, Competition problems of food industries.
6. Visit of food industries.

Suggested Readings:

1. Bureau of Labor Statistics. 2009. Industrial Engineering and Operations Research. University of Massachusetts Amherst Massachusetts 01003.
2. James L. and Riggs, J.M. 2004. Production Systems: Planning, Analysis and Control (4th ed.): Amazon.co.uk. Publisher: John Wiley & Sons. www.amazon.co.uk/Production-Systems-Planning-Analysis-Control/dp/0471858889.
3. Mishra, P.N and Jaisankar, S, 2007. Quantitative Techniques for Management Excel Books Private Limited, A-45, Naraina, Phase-I, New Delhi-110028 For School of Distance Education Bharathiar University Coimbatore-641046
4. Nahmias, S. 2016. Production and Operations Analysis (6th ed.). McGraw-Hill. Boston Burr Ridge, IL Dubuque, IA Madison, Wl New York San Francisco St. Louis. Bangkok Bogota Caracas Kuala Lumpur Lisbon London Madrid Mexico City. Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto. ISBN-13: 9780073377858
5. Riggs, J.L. 2015. Production Systems: Planning, Analysis & Control (4th ed.) John Wiley & Sons. ISBN-13: 978-0881336580; ISBN-10: 0881336580.
6. Slack, N, A. Brandon-Jones and Johnston, R, 2013. Operations Management (7th ed.) MyOMLab pack. ISBN13: 9780273776291; ISBN10: 0273776290

FE/FD - Non Thermal Processing in Food Engineering 3(3-0)

Contact Hours:

Theory =48
Practical =0
Total =48

Credit Hours:

Theory =3.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of of non thermal food processing	Cognitive	1	1
2.	**Demonstrate** different hybrid technologies that integrate suitable non-thermal, technologies to conventional technologies and their applicability in industrial context.	Cognitive	2	2

3.	**Analyze** Critically scientific and technological literature related to innovative and emerging non-thermal food processing technologies and effectively work in team environment and take individual initiative.	Cognitive	3	2,3,7

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑ 7	Environment and Sustainability	☑
2	Problem Analysis:	☑ 8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Non-thermal techniques for processing foods**
   a. High hydrostatic pressure (HHP)
   b. Pulsed Electric Field (PEF)
   c. Pulsed Light and Ozone applications
   d. Food Irradiation
   e. Osmotic Dehydration
   f. Ultrasound Applications
   g. Plasma processing
2. **Engineering systems**
   a. Theory
   b. Effects on microbiological food systems
   c. Effects on structural food systems
   d. Effects on biochemical systems of foods
3. **Quality and shelf-life evaluation of foods**
4. **Hybrid Non-thermal technologies**
   a. Novel hybrid technologies (e.g. high hydrostatic pressure,
   b. UV and gamma irradiation,
   c. Ultrasound, radio frequency that combine both classical and novel technologies (e.g. ultrasound assisted freezing and thawing, radio frequency or microwave assisted drying).

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignments (10%)
  Mid Term (30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Knorr, D., Froehling, A., Jaeger, H., Reineke, K., Schlueter, O. and Schoessler, K., 2011. Emerging technologies in food processing. *Annual review of food science and technology*, *2*, pp.203-235.
2. Koutchma, T., 2009. Advances in ultraviolet light technology for non-thermal processing of liquid foods. *Food and Bioprocess Technology*, *2*(2), pp.138-155.
3. Niemira, B.A. and Gutsol, A., 2011. Nonthermal plasma as a novel food processing technology. *Nonthermal processing technologies for food*, pp.272-288.
4. Raso, J. and Barbosa-Cánovas, G.V., 2003. Nonthermal preservation of foods using combined processing techniques.
5. Tonello, C., 2011. Case studies on high-pressure processing of foods. *Nonthermal processing technologies for food*, pp.36-50
6. Zhang, H.Q., Barbosa-CÃ, G.V., Balasubramaniam, V.B., Dunne, C.P., Farkas, D.F. and Yuan, J.T. eds., 2011. *Nonthermal processing technologies for food* (Vol. 45). John Wiley & Sons.

Meat Process Engineering

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of heat and mass transfer in food	Cognitive	1	1
2.	**Explain** Slaughtering**,** processing and preservation of meat for the food security in the country and focus on the principles and techniques employed by the meat industry in the production of meat products.	Cognitive	2	2

3.	**Discuss** the applications of meat slaughtering and processing machinery / technology	Cognitive	2	2
4.	**Apply** food engineering principles to optimize meat slaughtering machines, products' quality and safety.	Cognitive	3	3
5.	**Practice** on equipment related meat slaughtering, processing and packaging	Psychomotor	3	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑7	Environment and Sustainability	☐
2	Problem Analysis:	☑8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	□ 11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Introduction**
   a. Sources of meat and meat products
   b. Importance meat and meat products in national economy
   c. Technological quality of Meat for Processing
   d. Chemical composition of Meat
   e. Microscopic structure of meat.
2. **Butchery /Slaughter house**
   a. halal method of slaughtering
   b. meat cuts and packaging
   c. Packaging techniques
   d. Machine operation
   e. Maintenance and repair of machines
   f. Design of hygienically safe slaughter house
3. **Management on meat production and quality**
   a. Effect of feed
   b. Breed
   c. Slaughtering of animals and poultry
   d. Inspection and grading of meat
   e. Factors affecting post-mortem changes
   f. Properties and shelf-life of meat

4. **Meat quality evaluation**
    a. Meat decontamination
    b. Mechanical deboning
5. **Preservation techniques for meat**
    a. Meat tenderization
    b. Aging
    c. Freezing/Thawing
    d. Curing
    e. Thermal Processing
    f. Fermentation
    g. Drying
    h. Pickling
    i. Smoking
    j. Recent trends in meat processing
6. **Meat processing plant sanitation**
    a. Methods
    b. Safety
    c. By product utilization.
7. **Fish processing**
    a. Types of fish
    b. Composition
    c. Structure
    d. post-mortem changes in fish
    e. Handling of fresh water fish.
    f. Canning, smoking, freezing and dehydration of fish.
    g. Radiation processing of meat

Practical:

1. Slaughtering and dressing of meat animals,
2. Study of post-mortem changes of meat,
3. Mechanized Meat cutting and handling,
4. Evaluation of meat quality.
5. Experiments in dehydration, freezing, canning, curing, smoking and pickling of fish and meat
6. Shelf-life studies on processed meat products.
7. Estimation of meat : bone ratios
8. Preparation of meat products, canned, dehydrated, barbecued sausages, loaves, burger, fish finger.
9. Design of modern safe slaughter house

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment

- **Theory (100%)**
  - Quiz and Assignments (10%)
  - Mid Term(30%)
  - Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Fidel Toldrá. Handbook of Meat Processing.2010, Blackwell Publishing. ISBN 978-0-8138-2182-5.
2. Y. H. Hui Handbook of Meat and Meat Processing, Second Edition. CRC Press, 2012. ISBN 1439836833, 9781439836835.
3. Leo M.L. Nollet, Fidel Toldra. Advanced Technologies For Meat Processing. CRC Press. ISBN-13: 978-1-4200-1731-1.
4. Joseph P. Kerry, John F. Kerry, David Ledward. Meat Processing: Improving Quality. Wood head publishing Ltd. CRC Press, ISBN: 1-85573-583-0

Beverage Process Engineering

Contact Hours:		**Credit Hours:**	
Theory	=32	Theory	=2
Practical	=48	Practical	=1
Total	=80	Total	=3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of fruit juices and beverages industry	Cognitive	1	1
2.	**Explain** different water treatment and bottle washing plant.	Cognitive	2	2
3.	**Discuss** the applications of different packaging material in juice and beverages industry	Cognitive	2	2
4.	**Practice** laboratory techniques to analyze and measure important physiochemical parameters of fruit juices and beverages.	Psychomotor	3	2,3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑ 7	Environment and Sustainability	☐
2	Problem Analysis:	☑ 8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	☐ 11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Overview of fruit juices and beverage industry**.
   a. Raw material handling
   b. Juice extraction techniques
2. **Water treatment plants**
   a. Water purification systems.
   b. R.O. Plant
3. **Bottle washing plants**
   a. Operations and inspection,
   b. Detergents used in bottle washing.
4. **Plant sanitation**
   a. CIP systems for beverage plants,
   b. Cleaning and disinfection:
5. **Packaging materials**
   a. Glass bottles, pet bottles, metal cans, tetra-pack, plastic containers; container closures
   b. Plastic, aluminum and metal closures.
6. **Raw material handling and storage**
   a. Syrup room operation
   b. Pasteurization, sterilization, stabilizers and emulsifiers.
7. **Filling systems**
   a. Premix, post mix,
   b. Three stage processes.
8. **Composition and formulation of carbonated and non-carbonated beverages**
   a. Carbon dioxide and carbonation.
   b. Trouble shooting in beverage industry:
9. **Spoilage detection and control**
   a. Physical, chemical and microbiological spoilage.
   b. Factors affecting shelf life.

Practical:

1. Production and sensory evaluation of different instant and powdered mixes/drinks,
2. Production and sensory evaluation of fermented, still, etc. products
3. Production and sensory evaluation of carbonated and non- carbonated beverages.
4. Storage study of prepared products under different conditions employing laboratory tests (physical)
5. Storage study of prepared products under different conditions employing laboratory tests (chemical),
6. Storage study of prepared products under different conditions through employing laboratory tests (microbiological examination)

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignments (10%)
  Mid Term(30%)
  Final Term (60%)
- **Laboratory (100%)**

Suggested Readings:

1. Philip R. Ashurst. Production and Packaging of Non-Carbonated Fruit Juices and Fruit Beverages, 1999 Springer Science Publishing Ltd. ISBN: 978-1-4419-5191-5.
2. Steven Nagy, Chin Shu Chen, Philip E. Shaw. Fruit Juice Processing Technology. Agscience, 1993. ISBN 0963139711, 9780963139719.
3. Philip R. Ashurst. Chemistry and Technology of Soft Drinks and Fruit Juices. Blackwell Publishing Ltd. ISBN:9781444333817
4. Y. H. Hui, Lisbeth Meunier-Goddik, Jytte Josephsen, Wai-Kit Nip, Peggy S. Stanfield. Handbook of Food and Beverage Fermentation Technology. 2004CRC Press, ISBN: 0-8247-4780-1
5. Tammy Foster, Purnendu C. Vasavada. Beverage Quality and Safety., CRC Press. 2015 ISBN-13: 978-0-203-49120-1.
6. James Agalloco, James Akers. Advanced Aseptic Processing Technology. 2004 CRC Press. ISBN-13: 978-1-4398-2543-3.

Food Machinery Development and Maintenance

Contact Hours:
Theory =16
Practical =48
Total =64

Credit Hours:
Theory =1.0
Practical =1.0
Total =2.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the fundamentals of machinery development	Cognitive	1	1
2.	**Implementation** of preventative maintenance program in food industries	Cognitive	3	2,3
3.	**Inspection** of the areas that have undergone maintenance to ensure that there is not potential for contamination.	Psychomotor	2	2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑7	Environment and Sustainability	☐
2	Problem Analysis:	☑8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	☐11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Machine Development**
   a. Making the written statement
   b. Calculations of transmitted forces
   c. Auto-cad and software applications
   d. Material selection
   e. Calculation of allowable stresses
   f. Dimensions of the machine elements

2. **Keeping sanitary process environment during repairs**
    a. Clothing
    b. Footwear
    c. Health
    d. Loose objects, dust, debris, water
    e. Washing
3. **Maintenance checks**
    a. Maintenance plan
    b. Maintenance checklist and plan
    c. Legal requirements for maintenance
    d. Official control requirements
4. **Good practices**
    a. Model checklist
    b. Buildings
    c. Surfaces
    d. Articles, fittings and equipment
    e. Frequency of maintenance checks
5. **Documentation and training**
    a. Welding records
    b. Lubrication record
    c. Fast moving part record

Practical:

1. Preventive maintenance time scheduling
2. Differentiation of active and passive maintenance procedures
3. Determining the causes of breakdowns and remedies.
4. Documenting maintenance procedures.
5. Visits to different food industries during shutdowns

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
        Quiz (12%)
            Assignment (8%)
    Mid term(30%)
    Final Term (50%)
- **Laboratory (100%)**

Suggested Readings:

1. Carnero, M., 2006. An evaluation system of the setting up of predictive maintenance programmes. *Reliability Engineering & System Safety*, *91*(8), pp.945-963.
2. Moya, M.C.C., 2004. The control of the setting up of a predictive maintenance programme using a system of indicators. *Omega*, *32*(1), pp.57-75.
3. Norman, D.A., Ortony, A. and Russell, D.M., 2003. Affect and machine design: Lessons for the development of autonomous machines. *IBM Systems Journal*, *42*(1), pp.38-44.
4. Robert, L.N., 2006. Machine design an integrated approach. *Pearson Prentice Hall Publishers, USA*.
5. Shigley, J.E., 2011. *Shigley's mechanical engineering design*. Tata McGraw-Hill Education.
6. Tsarouhas, P., 2007. Implementation of total productive maintenance in food industry: a case study. *Journal of Quality in Maintenance Engineering*, *13*(1), pp.5-18.
7. Ullman, D., 2009. *The mechanical design process*. McGraw-Hill Science/Engineering/Math.

FE/FD - Special Problem 1(1-0)

Search out most recent scientific work and compile information for future research.

FE/FD - Seminar 1(1-0)

Presentation skill of research work done.

DETAILS MINOR COURSES

B –EMINOR COURSES

FE/FD - Grain Preservation and Processing 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Acquire the knowledge of grain preservation and processing	Cognitive	1	1
2.	Explain methods and tools employed for grain preservation and processing	Cognitive	2	2
5.	Practice on natural & heated grain drying, grain preservation and storage and grain size reduction methods	Psychomotor	3	2, 3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑7	Environment and Sustainability	☐
2	Problem Analysis:	☑8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	☐11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Theory:

1. F**ood grain respiration**
2. **Food Grain storage and preservation**
   a. Grain Preservation Methods storage

b. Grain weight changes due to changes in moisture content and grain quantity
c. Grain shrinkage measurement,
d. Grading of grain and test weight
e. Grain quality measurement techniques
f. Grain sampling
g. Grain deterioration indicators and causes
h. Allowable grain storage time

3. Grain ensiling processes

a. Chemicals used for grain treatment
b. Ensiling process

4. **Psychrometry**

a. Psychrometry and its application for grain preservation

5. Grain drying

a. Principles of grain drying
b. Fan types and their use
c. Grain resistance to air flow
d. Ergun equation and Shred's cures
e. Predicting fan- grain system performance,
f. Types of drying models
g. Thin larger drying simulation
h. Deep bed drying simulation accuracy
i. Causes of storage losses
j. Cooling of grain from the dryer
k. Insect control in stored grain

6. Grain conveying

a. Type of grain conveying devices
b. important design factors for grain conveyors
c. Safety considerations in the design of grain conveyors
d. Grain breakage in conveyor

7. Size reduction

a. Mechanics of sieve analysis
b. Requirements of size reduction
c. Mechanism and devices of size reduction

Practical:

1. Moisture measurement in grains
2. Bushel weight measurement of grains
3. Study of Psychometric variables
4. Selection of Fans and Blowers
5. Problem solving for natural and heated air drying
6. Designing and working of grain conveyors
7. Study of different models for drying
8. Visit of processing industries.

Suggested Readings:

1. Misra. 1989. Preservation and Storage of Grain Seeds and Their by Products. McGraw-Hill Books Company
2. Pandey, H., Sharma, H.K. and Chauhan, R C. 2006 Experiments in Food Process Engineering. CBS Publishers India.
3. Rehman M. S. 2007. Handbook of Food Preservation (2nd ed). Taylor and Francis CRC Press

FE/FD- Energy Management in Food Processing Industries 3(2-1)

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of energy forms and units in energy perspective, norms and scenario.	Cognitive	1	3
2.	**Explain** the different energy sources used in food industries	Cognitive	2	3
3.	**Discuss** the process of energy auditing and energy accounting and analyses the problems	Cognitive	2	3
4.	**Observe** the different energy used pattern in various processing industries	Psychomotor	1	3
5.	**Practice** on computer-based energy management systems and energy efficient processing machines.	Psychomotor	3	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐7	Environment and Sustainability	☐
2	Problem Analysis:	☐8	Ethics	☐

3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	☑11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Energy forms and units**
   a. Energy perspective,
   b. Norms and scenario
2. **Energy sources**
   a. Passive heating,
   b. Passive cooling,
   c. Sun drying and use of solar energy
   d. Biomass energy and
   e. Other non-conventional energy sources in agro-processing industries
3. **Energy auditing**
   a. Data collection for energy conservation in food processing industries
   b. Analysis for energy conservation in food processing industries.
4. **Reuse and calculation**
   a. Used steam
   b. Hot water
   c. Chimney gases and
   d. Cascading of energy sources.
5. **Energy accounting methods**
   a. Measurement of energy
   b. Design of computer-based energy management systems
   c. Economics of energy use

Practical:

1. Study of energy use pattern in various processing units;
   a) Rice mills,
   b) Sugar mills,
   c) Pulses mills,
   d) Oil mills,
   e) Cotton-ginning units,
   f) Milk plants, food industries etc.
2. Energy audit study and management strategies in food processing plants.
3. Identification of energy efficient processing machines.
4. Assessment of overall energy consumption, production and its cost in food processing plants
5. Visit to related food processing industry.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  - Quiz and Assignments (10%)
  - Mid Term(30%)
  - Final Term (60%)
- **Laboratory (100%)**

Text and Reference Books:

1. Chen, C.J.. Physics of Solar Energy. Published by John Wiley & Sons, Inc.,2011. Hoboken, New Jersey, Published simultaneously in Canada
2. Pimentel, D. Energy Inputs in Food Crop Production in Developing and Developed Nations.2009*Energies,* ISSN 1996-1073, www.mdpi.com/journal/energies
3. Riva, G, E. Foppapedretti, and C.D. Carolis. . Handbook on Renewable Energy Sources. Renewable 2012 Project Funded by European Union.

FE/FD- Advanced Engineering Properties of Food Materials 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

Learning Objectives:

This course will enable the students to understand the fundamental physical attributes of raw, semi processed and processed foods and their relation to the knowledge of food science, physical chemistry and engineering.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of physical properties of food material.	Cognitive	1	1
2.	Measure engineering properties of food material.	Cognitive	2	1
4.	Estimate engineering properties from food composition	Psychomotor	1	5

5.	Apply knowledge of physical properties of food materials in process calculations.	Psychomotor	3	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Contents:

1. **Thermal Properties**
   a. Thermal Conductivity
   b. Specific Heat
   c. Enthalpy
   d. Latent Heat
2. **Surface Properties**
   a. Surface and Interfacial Tension
   b. Colloidal Systems (Emulsions, Foams, Gels);
3. **Interactions In Foods**
   a. Colloidal Interactions
   b. Electrostatic Interaction
   c. Hydrogen Bonds
   d. Hydrophobic Interactions
   e. Salt Bridges
   f. Interactions Due to Polymer Adsorption
   g. Depletion Interaction
4. **Rheological Properties**
   a. Rheological Classification
   b. Measurement of Rheological Properties
5. **Mechanical and Textural Properties**
   a. Strength
   b. Elongation at Break
   c. Toughness, Compression, Fracture
   d. Young's Modulus
   e. Texture Profile Analysis
6. **Water Activity And Sorption Isotherms**
   a. Prediction and Measurement
   b. Effect of Temperature and Pressure on Water Activity
   c. Adjustment of Water Activity.

Practical:

Measurement of Viscosities: Tube Viscometer, Rotational Viscometer; Measurement of Textural Properties: Firmness and Fracture Tests; Measurement of Mechanical Properties: Tensile Strength, Elongation, Young's Modulus; Measurement of Optical Properties: Colorimeter and Spectrophotometer; Measurement of Water Activity of Foods.

Suggested Readings:

1. Figura, L. O. and A. A. Teixeira. 2007. Food Physics: Physical Properties-measurement and Applications. Springer, New York, NY, USA.
2. Norton, I. T., F. Spyropoulos and P. Cox. 2010. Practical Food Rheology: An Interpretive Approach. John and Wiley Sons, Hoboken, NJ, USA.
3. Norton, J. E., P. Fryer, and I. T. Norton. 2013. Formulation Engineering of Foods. John and Wiley Sons, Hoboken, NJ, USA.
4. Rao, M. A., S. S. H. Rizvi and A. K. Datta. 2005. Engineering Properties of Foods. CRC Press, Taylor & Francis Group, Boca Raton, FL, USA.
5. Serpil, S. and S. S. Gulum. 2006. Physical Properties of Foods. Springer, New York, NY, USA.
6. Arana, I. 2012. Physical Properties of Foods: Novel Measurement Techniques and Applications (Contemporary Food Engineering).
7. Figura, L. 2010. Food Physics: Physical Properties - Measurement and Applications; Publisher Springer Berlin Heidelberg, Germany.
8. Friberg S. E., KIre Larsson and Johan Sjoblom. 2004. Food Emulsions (4th ed.). Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016, U.S.A.
9. Engineering properties of foods / edited by M.A. Rao, Syed S.H. Rizvi, Ashim K. Datta, Jasim Ahmed. Boca Raton CRC Press, Taylor & Francis Group, 2014.

FE/FD - Post-harvest Management in Fruits and Vegetables 3(3-0)

Contact Hours:	**Credit Hours:**
Theory =48	Theory =3.0
Practical =0	Practical =0
Total =48	Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of post harvest handling and management	Cognitive	1	1, 3
2.	**Determine** the feasible / optimum solution of management problems regarding fruits and vegetables	Cognitive	2	3
3.	**Explain** physiology and biochemistry of fruits and vegetables along with latest techniques of post-harvest processing for perishable horticultural commodities and their value addition.	Cognitive	3	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑7	Environment and Sustainability	☐
2	Problem Analysis:	□8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	□11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline

1. **Fruits and vegetables**
   a. Classification
   b. Physiology
   c. Biochemistry
   d. Maturity and senescence
2. **Pre-harvest factors of fruits and vegetables**.
   a. Handlings
   b. Ethylene perception
   c. Polyphenols, Polyamines and their effects
3. **Postharvest handling and pack house operations**
   a. Sanitizers
   b. Vapor heat treatment
   c. Waxing
   d. Transportation

e. Packaging and storage

4. Postharvest processing technologies

a. Drying techniques and
b. Microwave food processing
c. High hydrostatic pressure
d. Minimal processing
e. Use of chemical additives
f. Irradiation
g. Cold chain management
h. Bio-preservation of food
i. Modified atmospheric storage and packaging
j. Controlled atmosphere

5. Legislation Aspect

a. Microbiological safety and quarantine measures for pest management
b. Regulatory and safety aspects of processed fruits and vegetables
c. Consumer issues and quality assurance.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**

  Quiz and Assignments(10%)
  Mid Term (30%)
  Final Term (60%)

Suggested Readings:

1. Sun, D. 2014. Emerging Technologies for Food Processing. Elsevier Applied Science, London, UK.
2. Saraswathy, S., T.L. Preethi, S. Balasubramanyan, J. Suresh, N. Revanthy and S. Natarajan. 2013. Postharvest Management of Horticultural Crops. Agrobios, Jodhpur, India.
3. Baldwin, E.A., R. Hagenmaier and J. Bai. 2012. Edible Coatings and Films to Improve Food Quality. 2nd Ed. CRC Press, Taylor & Francis Group, Boca Raton, FL, USA.
4. Bhat, R., A.K. Alias, and G. Paliyath. 2012. Progress in Food Preservation. Wiley-Blackwell, Hoboken, NJ, USA.
5. Brody, A.L., H. Zhuang and J.H. Han. 2011. Modified Atmosphere Packaging for Fresh Cut Fruits and Vegetables. Wiley-Blackwell, Hoboken, NJ, USA.

FE/FD - Milling of Cereals 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the process of milling for different cereals along with their safety and quality control parameters	Cognitive	1	1
2.	**Explain** the different mechanisms involved in milling of cereals.	Cognitive	2	1
3.	**Discuss** the process parameters of milling of different cereals.	Cognitive	2	1
4.	**Observe** the tools and machinery used in cereal milling	Cognitive	1	5
5.	**Practice** on equipment related to determination of quality parameters of cereals	Psychomotor	3	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☑7	Environment and Sustainability	☐
2 Problem Analysis:	☐8	Ethics	☐
3 Design/Development of Solutions	☐9	Individual and Team Work	☐
4 Investigation	☐10	Communication	☐
5 Modern Tool Usage	☑11	Project Management	☐
6 The Engineer and Society	☐12	Lifelong Learning	☐

Course Outline:

Theory

1. **Introduction**
   a. Evolution of flour milling process
   b. Recent developments in flour milling
   c. Definitions
   d. Types of cereals and their importance
2. **Wheat flour milling process**
   a. Types of mills
   b. Handling, storage, blending, cleaning, tempering and conditioning
   c. Mill's wheat-cleaning system

d. Air classification and fine grinding
e. Wheat impurities separation
f. Principles, methods and equipment

3. Process Control

a. Types of grinding machines
b. Different extraction rates of flour
c. Operations of roller mill
d. Grinding systems
e. Break, reduction and tailings
f. Principles and types of sifters
g. Purification process

4. Milling of different cereals

a. Milling of soft and durum wheat
b. Whole wheat products
c. Wet milling of corn: Production of starch, oil and gluten
d. Milling of rice
e. Flour handling and storage

5. Recent developments

a. Automation and its role within the milling industry
b. On-line process measurement
c. Recent developments in commercial milling

Practical:

1 Raw material analysis: Moisture, Gluten, ash, foreign materials
2 Effect of variety, ageing, tempering time and moisture content on flour yield and quality
3 Flour mill stream analysis: Color, moisture, protein, ash, pH and particle size
4 Flour performance test; Farinograph, mixograph, amylograph and falling number; Gluten washing tests, alkaline water retention capacity, Pelshenke value and SDS sedimentation test.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**

  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)
  Final Term (50%)

- **Laboratory (100%)**

Suggested Readings:

1. Champagne, E.T., 2004. *Rice Chemistry and Technology*. 3rd Ed. American Association of Cereal Chemists Inc., St. Paul, MN, USA.
2. Khan, K., and Shewry, P.R., 2009. *Wheat: Chemistry and Technology*. American Association of Cereal Chemists Inc., St. Paul., MN, USA.
3. Posner, E.S., and Hibbs, A.N., 2005. *Wheat Flour Milling.* 2nd Ed. American Association of Cereal Chemists Inc., St. Paul, MN, USA.
4. Serna-Saldivar, S.O., 2016. *Cereal Grains: Properties, Processing, and Nutritional Attributes*. CRC Press, Taylor & Francis Group, Boca Raton, FL, USA.
5. White, P. and L. Johnson. 2007. Corn: Chemistry and Technology. 2nd Ed. American Association of Cereal Chemists Inc., St. Paul, MN, USA.

FE/FD - Advances in Food Microbiology 3(3-0)

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

After this course and completion of an appropriate amount of independent study, students will be able to;

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the recent knowledge of food microbes	Cognitive	1	2
2.	**Explain** the phenomenon related to microbe application in food products	Cognitive	2	2
3.	**Discuss** the pathogenesis caused by food microbes	Cognitive	2	2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction**
   a. Overview of microorganisms and their growth in foods
   b. The Food preservation and biopreservation
   c. Antimicrobial resistance
   d. Biofilms formation
2. **Foodborne pathogens**
   a. Prevalence, virulence and pathogenesis of foodborne pathogens and their interaction with environment and the host
3. **Foodborne illness overview and new emerging foodborne pathogen**
   a. Major Food pathogens, origin, mechanism and control
   b. Listeria monocytogenes
   c. Escherichia coli
   d. Salmonella spp.
   e. Yersinia spp.
   f. Compylobacter jejuni
4. **Foodborne virus focusing on hepatitis A virus and norovirus**
   a. Foodborne virus and mycotoxins
   b. Prion diseases
5. Food Pathogen detection and control
   a. Detection of microorganism in foods
   b. Sampling plan and conventional detection methods
   c. Immunological methods and DNA based assay
   d. Phage based assay, molecular fingerprinting and biosensors in pathogen detection
6. **Our microbial organ and its role in health and diet induced disease**
   a. Probiotics, probiotics and functional foods

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%) Quiz (12%)
  Assignment (8%)
  Midterm(30%)
  Final Term (50%)

Suggested Readings:

1. Doyle, M.P. and Buchanan, R.L. eds., 2012. *Food microbiology: fundamentals and frontiers*. American Society for Microbiology Press.
2. Ray, B. and Bhunia, A., 2007. *Fundamental food microbiology*. CRC press.

3. Doyle, M.P. and Buchanan, R.L. eds., 2012. *Food microbiology: fundamentals and frontiers*. American Society for Microbiology Press.
4. Ray, B. and Bhunia, A., 2007. *Fundamental food microbiology*. CRC press

FE/FD - Advances in Food Chemistry 3(2-1)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Identify** the structure of food constituents and relate the structure to the constituents function and importance in foods with respect to food quality, nutrition, safety, processing	Cognitive	1	4
2.	**Explain** how environmental factors such as temperature, pH, ionic characteristic and strength, bonding, light, etc. affect chemical changes in food systems and judge how to adjust these conditions to improve or minimize chemical and biochemical deterioration of food systems.	Cognitive	2	4
3.	**Analyze** chemistry and biochemistry principles into real-world food science and nutritional problems.	Cognitive	3	4

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☐7	Environment and Sustainability	☐
2 Problem Analysis:	☐8	Ethics	☐
3 Design/Development of Solutions	☐9	Individual and Team Work	☐
4 Investigation	☑10	Communication	☐
5 Modern Tool Usage	☐11	Project Management	☐
6 The Engineer and Society	☐12	Lifelong Learning	☐

Course Outline:

1. **Physico-chemical properties of food constituents and their practical importance in relation to their structure**
   a. Water
   b. Interaction of water with solutes and food components
2. **Proteins**
   a. Chemistry of bioactive proteins and peptides,
   b. properties of peptides,
   c. Structural modifications of proteins
   d. Chemistry of bioactive proteins and peptides, properties of peptides, Structural modifications of proteins
3. **Lipids**
   a. Chemical Reactions of Industrial importance
   b. Storage changes in fats and oils, oxidation mechanism of fats
   c. Effect of various metals, Ions, effects of moisture, surface area and antioxidants
   d. Effect of processing on the functional groups of fats and oils
   e. Emulsions
   f. Foamability
4. **Carbohydrate**
   a. Chemical changes in food carbohydrates during processing
   b. Dietary fibre,
   c. crude fibre and application of food carbohydrates
   d. Chemical reactions of industrial importance in carbohydrates
   e. Applications and preparations of sugars and polysaccharides
5. **Antioxidants**:
   a. Natural and synthetic
   b. Action mechanism
   c. Binding properties of vitamins with food
   d. Minerals in food processing
   e. Flavors and aroma compounds
   f. Carbonyl compounds
   g. Phenols
   h. Alcohol
   i. Esters
   j. Terpenes and their interactions with other food constituents
   k. Synthetic and natural aroma compounds
6. **Food contaminants and adulterants**:
   a. Toxic trace elements
   b. Toxic compounds of microbial origin
   c. Pesticides
   d. veterinary medicines and feed additives
   e. polychlorinated biphenyls
   f. Toxins generated during food processing

Practical:

1. Characterization of different food components from matrix
2. Chemical analyses for measurement of spoilage of fats and fatty food
3. Chemical analyses for measurement of spoilage of fats and fatty food
4. Determination of adulteration in fats and oils;
5. Determination of sugars
6. Determination of Vitamin C
7. Determination of iodine
8. Separation of natural food colors
9. Quantification of minerals in water
10. Extraction of pectin from fruit waste
11. Evaluation of antioxidative properties of vitamins
12. Estimation of starch
13. Estimation of cholesterol
14. Estimation of total dietary fiber
15. Estimation of, glucose
16. Estimation of pigments

Suggested Readings:

1. Yildiz, F., 2009. *Advances in food biochemistry*. CRC press.
2. Pratt, C.W. and Cornely, K., 2004. *Essential biochemistry*. Hoboken, NJ: Wiley.
3. Nip, W.K., Nollet, L.M., Paliyath, G. and Simpson, B.K., 2008. *Food biochemistry and food processing*. John Wiley & Sons.
4. Harlapur, M. and Shimbo, D., 2013. Lipoprotein. In *Encyclopedia of Behavioral Medicine* (pp. 1168-1169). Springer New York.
5. Nelson, D.L., Lehninger, A.L. and Cox, M.M., 2008. *Lehninger principles of biochemistry*. Macmillan.
6. Wenk, M.R. and Fernandis, A.Z., 2007. *A manual for biochemistry protocols* (Vol. 3). World Scientific.

FE/FD - Advances in Meat Technology 3(2-1)

Contact Hours
Theory =32
Practical=48
Total =80

Credit Hours
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of meat processing technique	Cognitive	1	3
2.	**Explain** the on-line monitoring	Cognitive	2	3

	techniques for meat quality			
3.	**Discuss** the processing of functional meat products	Cognitive	2	3
4.	**Practice** on meat packaging systems	Psychomotor	3	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Contents:

1. **Emerging technologies in meat processing**
   a. Irradiation of meat and meat products
   b. High pressure processing of meat
   c. Electro-processing
   d. Use of infrared and light-based technologies for meat and meat products
   e. Ultrasound processing of meat
   f. Application of hydrodynamic shock wave processing in meat industry
   g. Robotics in meat processing
2. **Techniques for on-line monitoring of meat**
   a. Fourier transform infrared spectroscopy
   b. Fluorescence spectroscopy
   c. Raman scattering
   d. Hyperspectral imaging technique
3. **Approaches for the development of functional meat products**
   a. Processing of nitrite-free cured meat
   b. Nanotechnology in healthier meat processing
   c. Probiotic meat products
4. **Packaging of meat products**
   a. Modified atmosphere packaging
   b. Active packaging of meat products
5. **Meat authenticity and quality**
   a. Regulations and legislative issues
   b. Meat quality and safety

Practical:

1. Preparation of meat products: beef stews, sausages, meat balls, sliced dry beef, smoked meat, restructured meat products
2. Techniques to detect meat quality, authenticity and adulteration

3. Antioxidant assays of meat: FRAP (Fluorescence recovery after photobleaching), TBARS (Thiobarbituric acid reactive substances), peroxide value, total phenolic contents, total flavonoid contents
4. Determination of eating quality of meat: pH, color, texture, TVB-N (Total volatile basic nitrogen) value, water holding capacity, cooking loss, sensory evaluation
5. Visits to the meat/poultry processing industries/slaughterhouses

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Laboratory (100%)

Suggested Readings:

1. Cummins, E.J. and Lyng, J.G., 2016. *Emerging technologies in meat processing*. John Wiley & Sons, Ltd.
2. Grumezescu, A. ed., 2016. *Novel Approaches of Nanotechnology in Food* (Vol. 1). Academic Press.
3. Nollet, L.M. and Toldrá, F. eds., 2006. *Advanced technologies for meat processing*. CRC Press.
4. Toldrá, F. ed., 2010. *Handbook of meat processing*. John Wiley & Sons.
5. Warris, P.D., 2000. *Meat science. An introductory text*. New York: CABI Pub.

FE/FD - Nanotechnology in Food Engineering 3(3-0)

Contact Hours:	**Credit Hours:**
Theory =48	Theory =3.0
Practical =0	Practical =0
Total =48	Total =3.0

Learning Objectives:

Students get to know main physical and chemical theories on nanoparticle formation and particle formation processes including important technical products. The lecture i

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Develop an understanding of micro and nano scale food and bio materials	Cognitive	1	1
2.	Understand changes in properties of materials at nano scale	Cognitive	2	1,3
3.	Learn techniques to characterize the micro and nano structures of bioactive compounds and food matrices	Psychomotor	3	5

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☑	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

Includes modern physical characterization methods for nanoparticles as well as application examples for nanoparticles.

Course Contents:

1. An overview of the development and application of nanoscale materials in the food industry
2. Potential health risks of nanoparticles in foods, beverages and nutraceuticals
3. Detection and characterization of nanoparticles in food, beverages and nutraceuticals
4. Regulatory frameworks for the food nanotechnologies
5. Atomic force microscopy (AFM) and related tools for the imaging of foods and beverages on the nanoscale
6. Characterization of food materials in multiple length scales using small-angle X-ray scattering and nuclear magnetic resonance: principle and applications
7. Improving food sensory and nutritional quality through nanostructure engineering
8. Nano capsules as delivery systems in food
9. Fabrication, characterization and properties of food nano-emulsions

10. Nanotechnology-based approaches for rapid detection of chemical and biological contaminants in foods;
11. Fabrication, functionality and food industry applications of Electrospun fibers
12. Nano-composites for food and beverage packaging materials
13. Nano- and micro- engineered membranes: Principles and applications in the food and beverages industries
14. Visits (3) to Nanotechnology Labs

Suggested Readings:

1. Nanotechnology in the Food, Beverage and Nutraceutical Industries (Woodhead Publishing Series in Food Science, Technology and Nutrition) 1st Edition by Qingrong Huang (Editor)
2. Nanotechnology in Agriculture and Food Science (Applications of Nanotechnology) 1st Edition by Monique A. V. Axelos (Editor) Marcel Van de Voorde (Editor).
3. Nanotechnology and Functional Foods: Effective Delivery of Bioactive Ingredients (Institute of Food Technologists Series) Jul 7, 2015 by Cristina Sabliov and Hongda Chen.
4. Nanotechnology and Food Industry Francisco Javier Gutiérrez, Mª Luisa Mussons, Paloma Gatón and Ruth Rojo Centro Tecnológico CARTIF. Parque Tecnológico de Boecillo, Valladolid España InTech Europe University Campus STeP Ri Slavka Krautzeka 83/A 51000 Rijeka, Croatia Phone: +385 (51) 770 447 Fax: +385 (51) 686 166 www.intechopen.com.

FE/FD - Experimental Statistics 3(3-0)

Contact Hours	**Credit Hours**
Theory =48	Theory =3.0
Practical =0	Practical =0
Total =48	Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of experimental statistics	Cognitive	1	2
2.	Explain Statistical significance tests experimental designs	Cognitive	2	2
3.	**Practice** on various statistical design of experiments	Psychomotor	3	2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Theory:

1. **Statistical significance tests**
   a. Simple correlation coefficients
   b. Multiple correlation coefficients
   c. Partial correlation coefficients
   d. Rank correlation coefficient.
2. **Linear regression**
   a. Inference regarding simple linear regression parameters
   b. Prediction and its inference in simple linear regression
   c. Intrinsically linear regression models
3. **Multiple Linear and quadratic regression**
   a. Relative importance of regressors
   b. Basic principles of experimental design
4. **Experimental Designs**
   a. Basic experimental designs (CRD, RCBD),
   b. Pairwise comparison tests
   c. contrast and orthogonal polynomials
   d. Two and three factor factorial experiments
   e. Graphic interpretation of factorial results with interaction and main effect plots. Split plot design, Nested designs.

Suggested Readings:

1. Gomez, K.A. and Gomez, A.A., 1984. Statistical procedures for Agricultural research. Wiley Interscience Publications.
2. Mead, R., Curnow, R.N., Hasted, A.M. and Curnow, R.M, 2002. Statistical Methods in Agriculture and Experimental Biology (3rd ed.). Chapman & Hall.
3. Montgomery D.C., 2012. Design and analysis of experiments. 8th edition. John Wiley and Sons, N.Y.
4. Muhammad, F., 2015. Statistical Methods and Data Analysis. Kitab Markaz, Bhawana Bazaar, Faisalabad.

FE/FD - Advanced Food Biochemistry 3(3-0)

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =3.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Identify** the major and minor constituents of food and the chemical reactions in which they participate.	Cognitive	1	4
2.	**Explain** the principles involved in the processing of the major types of food products.	Cognitive	2	4
3.	**Analyze** the unit operations and be able to understand their working principles and equipment used in food processing facilities.	Cognitive	3	4

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☐7	Environment and Sustainability	☐
2 Problem Analysis:	☐8	Ethics	☐
3 Design/Development of Solutions	☐9	Individual and Team Work	☐
4 Investigation	☑10	Communication	☐
5 Modern Tool Usage	☐11	Project Management	☐
6 The Engineer and Society	☐12	Lifelong Learning	☐

THEORY:

1. **Water**
   a. Water and its relation to food:
   b. Properties of water,
   c. Structure of water,
   d. Water activity
2. **Carbohydrates:**
   a. Classification,
   b. Structure,
   c. Physical

d. Chemical properties,
e. Caramelization,
f. Maillard reaction,
g. Dietary fiber.

3. Lipids:

a. Classification,
b. Structure,
c. Fatty acids,
d. Properties,
e. Rancidity,
f. Emulsifiers.
g. Proteins,
h. Classification of protein
i. Functions of protein

4. **Vitamins and mineral elements**:

a. Introduction
b. Structure,
c. Functional properties,
d. Stability.

5. Enzymes:

a. Introduction to enzymes, and its classification
b. Enzyme kinetics,
c. specific application in the food industry.

6. Lipids:

a. Introduction and classifications of lipids,
b. functions and health properties of fats and oils in foods.

7. Nucleic acid biochemistry:

a. Nucleic acid structure,
b. RNA and DNA,
c. The genome,
d. DNA synthesis,
e. RNA synthesis,
f. Protein synthesis,
g. Applications in food science and technology.

8. **Recombinant DNA and Biotechnology:**

a. Overview,
b. Restriction and endonucleases,
c. DNA cloning,
d. Polymerase chain reaction (PCR).

Suggested Readings:

1. Yildiz, F., 2009. *Advances in food biochemistry*. CRC press.
2. Eskin, N.M. and Shahidi, F., 2012. *Biochemistry of foods*. Academic Press.
3. Nip, W.K., Nollet, L.M., Paliyath, G. and Simpson, B.K., 2008. *Food biochemistry and food processing*. John Wiley & Sons.

4. Voet, D., Voet, J.G. and Pratt, C.W., 2013. *Fundamentals of biochemistry: life at the molecular level* (No. 577.1 VOE).

FE/FD - Safety and Quality in the food Processing 3(3-0)

Contact Hours:
Theory =48
Practical=0
Total =48

Credit Hours:
Theory =3.0
Practical=0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy Level	PLO
1.	**Acquire** food safety and quality knowledge related to food engineering and processing	Cognitive	1	1
2.	**Analyze**complex problems associated with food manufacture.	Cognitive	2	2
3.	**Explain** the safety and quality requirements of food processing systems	Cognitive	2	3
4.	Design a hazard analysis critical control point plan (HACCP) and a defect analysis control plan (DACP) for safe and quality food production.	Psychomotor	3	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1 Engineering Knowledge	☑7	Environment and Sustainability	☐
2 Problem Analysis:	☑8	Ethics	☐
3 Design/Development of Solutions	☑9	Individual and Team Work	☐
4 Investigation	☐10	Communication	☐
5 Modern Tool Usage	☐11	Project Management	☐
6 The Engineer and Society	☐12	Lifelong Learning	☐

Course Outline:

1. Introduction

a. History and overview of food safety and quality management
b. Definitions
c. Scope
d. Types of food safety hazards

2. **Food Safety**
    a. Infectious and microbial agents
    b. Types of infectious versus, bacteria and protozoans
    c. Food born toxic agents
    d. Physical toxin, Microbial toxin, Plant and animal toxin, Residual toxin.
3. **Adulterants**
    a. Food additives
    b. Packaging materials
    c. Toxicants induced during food processing
    d. Toxicants induced from industrial waste
    e. Toxicological studies
4. **Risk management**
    a. Risk assessment
    b. Hazard analysis of foods
    c. Risk analysis and food safety
5. **Quality control Systems**
    a. Codex standards
    b. Quality & food safety management system, Certification from 3rd party
    c. Pre requisite program, GMP and GFSI
    d. Recognized food safety management system: FSSC-22000, BRC and HACCP, IFS, Global GAP and EUGAP, ISO 9001 and ISO 17025
    e. Traceability system, Halal standard & certification, Biosecurity programs
    f. Statistical Process Control

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  Quiz and Assignments (10%)
  Midterm (30%)
  Final Term (60%)

Suggested Readings:

1. Ali, I., 2014. *Food Quality Assurance: Principles and Practices*. 2nd Ed. CRC Press, USA.
2. Motarjemi, Y., and Lelieveld, H., 2013. *Food Safety Management: A Practical Guide for the Food Industry*. Elsevier Science, USA.
3. Knechtges, P.L., 2011. *Food Safety: Theory and Practice.* Jones & Bartlett Learning, USA.
4. Medina, D.A., and Laine, A.M., 2011. *Food Quality: Control, Analysis and Consumer Concerns*. Nova publishers, USA.
5. Awan, J.A., and Anjum, F.M., 2010. *Food Toxicology*. Unitech Communications, Faisalabad-Pakistan.

6. Clute, M., 2008. *Food Industry Quality Control Systems.* Culinary and Hospitality Industry Publication Services, USA.
7. Evans, J.R., 2005. *Total Quality: Management, Organization and Strategy*. Westport Pub. Co., New York.
8. Hoyle, D., 2001. *ISO 9000: Quality System Handbook,* 4th ed. Butterworth-Heineman, Oxford, UK.
9. Blanchfield, J.R., 1998. *Good Manufacturing Practice*. Institute of Food Science and Technology, London, UK.
10. McDonald, D.J., and Engel, D., 2009. *A Guide to HACCP*. Highfield Pub. Sprotborough, UK

FE/FD - Polymer Engineering 3(3+0)

Contact Hours		**Credit Hours**
Theory	=48	Theory =3.0
Practical	=0	Practical =0
Total	=48	Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Apply** and integrate knowledge from each of the four primary elements of Materials Science and Engineering (structure, properties, processing and performance) to solve problems related to materials selection and design	Cognitive	3	1
2.	**Describe** material related conditions for forming of polymer materials and have insight regarding the most important polymer-based processing techniques.	Cognitive	2	2
3.	**Discuss** the applications of common polymeric materials relevant to food engineering.	Cognitive	2	3
4.	**Describe** the role of rubber-toughening in improving the mechanical properties of polymers	Cognitive	2	2
5.	**Indicate** how the properties of polymeric materials can be exploited by a product designer	Cognitive	2	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☑	7	Environment and Sustainability	☐
2	Problem Analysis	☑	8	Ethics	☐
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline

1. **Properties of polymeric materials**
   a. Review of structure and properties of polymeric materials
   b. their deformation and failure mechanisms
   c. the design and fabrication of polymeric end items
   d. The molecular and crystallographic structures of polymers related to the elastic
   e. viscoelastic
   f. yield and fracture properties
   g. Polymeric solids and reinforced polymer composites
2. **Fabrication techniques**
   a. extrusion
   b. injection moulding
   c. reaction injection molding
   d. thermoforming, and blow molding
   e. Configuration of Polymer chains
3. **Deformation**
   a. Viscoelasticity and rubber elasticity
   b. Deformation mechanisms in glassy amorphous polymers
   c. Toughening mechanisms in polymers
   d. Materials selection
   e. manufacturing engineering
   f. properties, and applications of polymers
4. **Rubber**
   a. classes of dry rubber compounds
   b. vulcanization process
   c. Compounding of rubbers
   d. such as carbon blacks
   e. politicizes and age resisters
   f. characterization of rubbers
   g. silicon rubber

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
  - Quiz (12%)
  - Assignment (8%)
  - Midterm(30%)
  - Final Term (50%)
- **Laboratory (0%)**

Suggested Readings :

1. Brinson H.F. and Brinson L. C. 2015. Polymer Engineering Science and Viscoelasticity: An Introduction 2nd Ed. Springer.
2. Thakur V.K., and Thakur M.K., 2015. Handbook of Sustainable Polymers: Processing and Applications CRC Press.
3. David I.B., 2002. An Introduction to Polymer Physics Cambridge University Press.
4. Sperling L.H., 2006. Introduction to Physical Polymer Science 4th Ed. John Wiley & Sons.
5. Ram A., 1997. Fundamentals of Polymer Engineering Springer .
6. Stevens M.P., 1998. Polymer Chemistry An Introduction 3rd Edition Oxford University Press.

FE/FD - Advanced Reaction Engineering 3(3+0)

Contact Hours		**Credit Hours**
Theory	=48	Theory =3.0
Practical	=0	Practical =0
Total	=48	Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	A working **knowledge** of modeling and simulation approaches to understand the properties of chemical reactions at a molecular level.	Cognitive	1	1

2.	Ability to **transform** a chemical engineering problem into a mathematical representation; broad understanding of the available numerical tools and methods to **solve** the problem, their scope and limitations.	Cognitive	3	2
3.	An **understanding** of the basic design approaches to advanced energy efficient separation processes.	Cognitive	2	1
4.	Ability to **transfer** and **operate** engineering principles in application to other fields.	Cognitive	5	3

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs

1	Engineering Knowledge	☑ 7	Environment and Sustainability	☐
2	Problem Analysis:	☑ 8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☐
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	☐ 11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Reactors**
   a. Isothermal Reactors
   b. Non-Isothermal Reactor
   c. Batch, Tubular and Stirred Tank Reactors
   d. Stable Operating Conditions in Stirred Tank Reactor
   e. Non-Ideal Reactors
   f. Residence Time Distribution
   g. Conversion Models in Non-Isothermal Reactors
2. **Catalysis**
   a. Catalysis and Adsorption
   b. Solid Catalysts
   c. Preparation and Classification of Catalysts
   d. Surface Area, Density and Void Volume of Catalysts
   e. Rate Equation of Fluid-Solid Catalytic Reactions
   f. External Transport Processes in Heterogeneous Reactions
   g. Fixed Bed and Fluidized Bed Reactors
   h. Internal Transport Processes

i. Reaction and Diffusion in Porous Catalysts
j. Effectiveness Factors
k. Interpretation of Experimental Data from Laboratory Reactors
l. Design of Heterogeneous Reactors

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Readings:

1. Fogler H.S., 2016. Elements of Chemical Reaction Engineering 5th Ed. Prentice Hall.
2. Tapio O. S., Jyri P.M. and Warna J.P. 2010. Chemical Reaction Engineering and Reactor Technology CRC Press.
3. Octave Levenspiel ,"Chemical Reaction Engineering" 3rd Edition, Wiley & Sons, 1999.
4. Charles. G. Hill "An Introduction to Chemical Engineering Kinetics & Reactor Design "Wiley & Sons 1997.

FE/FD - Process Safety Management 3(3-0)

Contact Hour		**Credit Hours**
Theory	=48	Theory =3.0
Practical	=0	Practical =0
Total	=48	Total =3.0

COURSE LEARNING OUTCOMES

Upon successful completion of the course, the student will be able to

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Identify** the process hazards through process hazards analysis and incorporation elements of safety on all aspects of the design.	Cognitive	2	1
2.	**Discuss** the relationship of process safety to an organization's overall accident prevention efforts	Cognitive	2	2
3.	**Identify** the 14 elements required by the PSM Standard.	Cognitive	2	1
4.	**Explain** the various methodologies used to develop a process hazard analysis	Cognitive	2	3

5.	**Describe** the components necessary for an effective emergency response plan	Cognitive	2	9

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs

1	Engineering Knowledge	☑ 7	Environment and Sustainability	☐
2	Problem Analysis:	☑ 8	Ethics	☐
3	Design/Development of Solutions	☑ 9	Individual and Team Work	☑
4	Investigation	☐ 10	Communication	☐
5	Modern Tool Usage	☐ 11	Project Management	☐
6	The Engineer and Society	☐ 12	Lifelong Learning	☐

Course Outline:

1. **Risk**
   a. Risk perception
   b. Acceptable risk
   c. risk rating and ranking
   d. Risk matrix
   e. Chemical process accidents
   f. On-site risk
   g. Fatal Accident Rate (FAR)
   h. Off-site risk
   i. Individual and societal risks
   j. Quantitative risk assessment methods
2. **Standards and Regulations**
   a. Impact of standards and regulations
   b. OSHA
   c. Process safety management standard PSM
   d. Risk Management Professional (RMP) background based case studies
   e. Introduction to the 14 Elements
   f. OSHA PSM Requirement – Process Hazard Analysis (PHA)
   g. Difference between PSM and OSHA Regulations
3. **Toxicological Studies**
   a. Routes of entry
   b. Causes and Effects
   c. Models of doses
   d. Response curves
   e. Threshold limit values
   f. Liquid discharge
   g. Vapour discharge

h. Flashing liquids
i. Pool evaporation Design basis, Dispersion models, Weather effects Release mitigations

4. HAZOP studies

a. Deviations from normal operation
b. Hazard and Operability Studies
c. Permit to work systems (PTWs)
d. Event tree analysis, Fault tree analysis
e. Bow tie analysis
f. Investigation methodologies
g. Determining Root Causes, Structured Approach Developing Effective Recommendations
h. Learning from accidents, Investigation process and reporting

5. Fire Triangle

a. Flammability characteristics of liquids and vapours
b. Ignition
c. Fire effects
d. Explosion mechanism
e. Fixed and portable fire extinguishers
f. Fire- Water System Design

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
  - Quiz (12%)
  - Assignment (8%)
  - Midterm(30%)
  - Final Term (50%)
- **Laboratory (0%)**

Suggested Readings:

1. David Y.W. 2017. Safety Professional's Reference and Study Guide, 2nd Ed.CRC Press.
2. Nicholas J. Bahr “System Safety Engineering and Risk Assessment: A Practical Approach”, 2nd edition, Taylor & Francis Group 2014.
3. Daniel A. Crowl, Joseph F. Louvar “Chemical Process Safety”, 3rd edition, Prentice Hall International,2011.

FE/FD - Functional Foods 3(3+0)

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

After this course and completion of an appropriate amount of independent study, students will be able to;

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the fundamental knowledge of functional foods	Cognitive	1	3
2.	**Design** functional foods for various health benefits	Cognitive	2	3
3.	**Discuss** the regulations pertaining functional foods	Cognitive	2	8

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☑
3	Design/Development of Solutions	☑	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Introduction**
   a. Functional foods history
   b. Global market share and Pakistani market
   c. Functional foods terminology
      I. Nutraceuticals
      II. Probiotics, prebiotics
      III. Antioxidnats
      IV. Anticarcinogens
      V. Food fibre

2. **Types of functional foods**
   a. Antioxidants
   b. Anticarcinogens
   c. Probiotics as functional ingredient
      I. Prerequisite to be probiotic

II. Sources and applications

d. Prebiotics and synbiotic foods

3. Health claims of functional foods

a. Functional foods and cardiovascular disease
b. Obesity
c. Mental health
d. Cancer and others

4. Functional food products

a. Animal based functional foods
b. Plant based functional foods
c. Functional food products in the region and global market

5. Regulations of functional foods

a. Regulatory requirements for probiotics
b. Regulatory requirements for other nutraceuticals

6. Recent trends in the field

Suggested Readings:

1. Functional Foods, Editor: Maria Saarela, 2nd Edition, WoodHead Publishing, 2011
2. Functional Food Ingredients and Nutraceuticals: Processing Technologies, John Shi, Second Edition, CRC, 2015

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
  - Quiz (12%)
  - Assignment (8%)
  - Midterm(30%)
  - Final Term (50%)

Suggested readings:

1- Guo, M., 2013. *Functional foods: principles and technology*. Elsevier.
2- Martirosyan, D.M. ed., 2014. *Introduction to Functional Food Science: Textbook*. Functional Food Center
3- Martirosyan, D.M., 2011. Functional foods and chronic diseases: science and practice. *Dallas, USA: Food Science Publisher*, pp.1-287.
4- Lee, Y.K. and Salminen, S., 2009. *Handbook of probiotics and prebiotics*. John Wiley & Sons.
5- Tannock, G.W. ed., 2005. *Probiotics and prebiotics: scientific aspects*. Horizon Scientific Press.

FE/FD - Environmental Impact Assessment 3(2-1)

Contact Hours:		**Credit Hours:**
Theory	=32	Theory =2.0
Practical	=48	Practical =1.0
Total	=80	Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of basic concepts of environmental audit, risk management and EMS	Cognitive	1	7
3.	**Understand** the processes involved in environmental management food components at micro scale	Cognitive	2	7
5.	**Observe** the environmental issues to analyze them	Psychomotor	3	2

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs)

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☑
2	Problem Analysis:	☑	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Environment and Environmental Issues**
   a. Country Profile
   b. Concepts of Sustainable Development
   c. Basic Environmental Economics
2. **Environmental Organizations**
   a. Environmental Legislations NEQs
   b. Pollution Charges
   c. Cleaner Production
3. **Components for Environmental Assessment**
   a. Screening
   b. Scoping
   c. Baseline Study

d. Mitigation
e. Monitoring

4. **Environmental Impact Methodology**
   a. Environmental Management Plan
   b. Environmental Impact Statements
   c. Life Cycle Assessment (LCA)
   d. Environmental Auditing
   e. Risk Analysis
   f. EMS and ISO-14001
5. **Environmental management in the food industry**,
   a. Contributions on training,
   b. Eco-labeling
   c. Establishing management systems

Practical:

1. Case studies related to EIA conduction of different Projects
2. (Seven Food Industries)
3. ISO-14000 certification within industries (Seven Food Industries)
4. Field visits and Practical Assignments (Two Food Industries)

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment

- **Theory (100%)**
  Quiz / Assignments (10%)
  Mid Term (30%)
  Final Term (60%)
- **Laboratory (100%)**

Text and Reference Books:

1. Charles, H. E.. Environmental Impact Assessments. Taylor & Francis, New York, 2011.USA.
2. Wright, B. Environmental Sciences: Towards a Sustainable Future. 11th Ed,2011. Pearson Education Inc. New York, USA
3. Nathe, E.. Environmental Management in Practice Vol. I, II, III.1998 Rutledge Publisher, London, UK.
4. PEPA Guidelines by PEPA M. O. E. Government of Pakistan (latest edition)
5. Sonesson, U., J. Berlin and F. Ziegler Environmental assessment and management in the food industry: Life Cycle Assessment and related approaches, 2010.Elsevier.

FE/FD - Solid Waste Management 3(3+0)
Solid Waste Management

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0
Total =3.0

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge about terminologies relevant to solid waste and the well-established processes for treatment	Cognitive	1	7
2.	**Determine** the problems deriving from waste management within the current social status.	Cognitive	2	7
3.	**Evaluate** methods and processes for waste management, aiming at complying with the existing legislation, but also, aiming at the prospect of the way towards a zero waste society	Cognitive	3	2,7

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	□ 7	Environment and Sustainability	☑
2	Problem Analysis:	☑ 8	Ethics	□
3	Design/Development of Solutions	□ 9	Individual and Team Work	□
4	Investigation	□ 10	Communication	□
5	Modern Tool Usage	□ 11	Project Management	□
6	The Engineer and Society	□ 12	Lifelong Learning	□

Course Outline

1. **Introduction to Waste Management**
   a. Regulatory aspects of integrated solid waste management
   b. Characterization
   c. Properties of Municipal Solid Waste (MSW)

2. **Municipal wastewater sludge utilization**
    a. Hazardous waste found in MSW
    b. Collection
    c. Transport of solid waste
    d. Separation
    e. Processing
    f. Combustion
    g. Composting
    h. Recycling of waste material
3. **Landfill method of solid waste disposal**
    a. Guidelines for design,
    b. Construction,
    c. Operation,
    d. Monitoring,
    e. Remedial actions, and closure of landfills
4. **Current issues and innovative approaches to manage solid waste.**

Suggested Teaching Methodology

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
    Quiz and
    Assignments(10%)
    Mid Term (30%)
    Final Term (60%)

Suggested Readings:

1. Worrell, W.A. and Vesilind, P.A., 2011. *Solid Waste Engineering, SI Version*. Cengage Learning.
2. Wang, L.K., Hung, Y.T., Shammas, N.K., Wang, M.H.S. and Chen, J.P., 2017. *Handbook of Advanced Industrial and Hazardous Wastes Management*. CRC Press.
3. Asnani, P.U., 2006. Solid waste management. *India infrastructure report*, *570*.
4. Cheremisinoff, N.P., 2003. *Handbook of solid waste management and waste minimization technologies*. Butterworth-Heinemann.