CURRICULUM

OF

FOOD ENGINEERING

FOR

BS/BE/BSc

(Revised 2013)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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Composed by: Mr. Zulfiqar Ali, HEC, Islamabad

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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. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. 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).

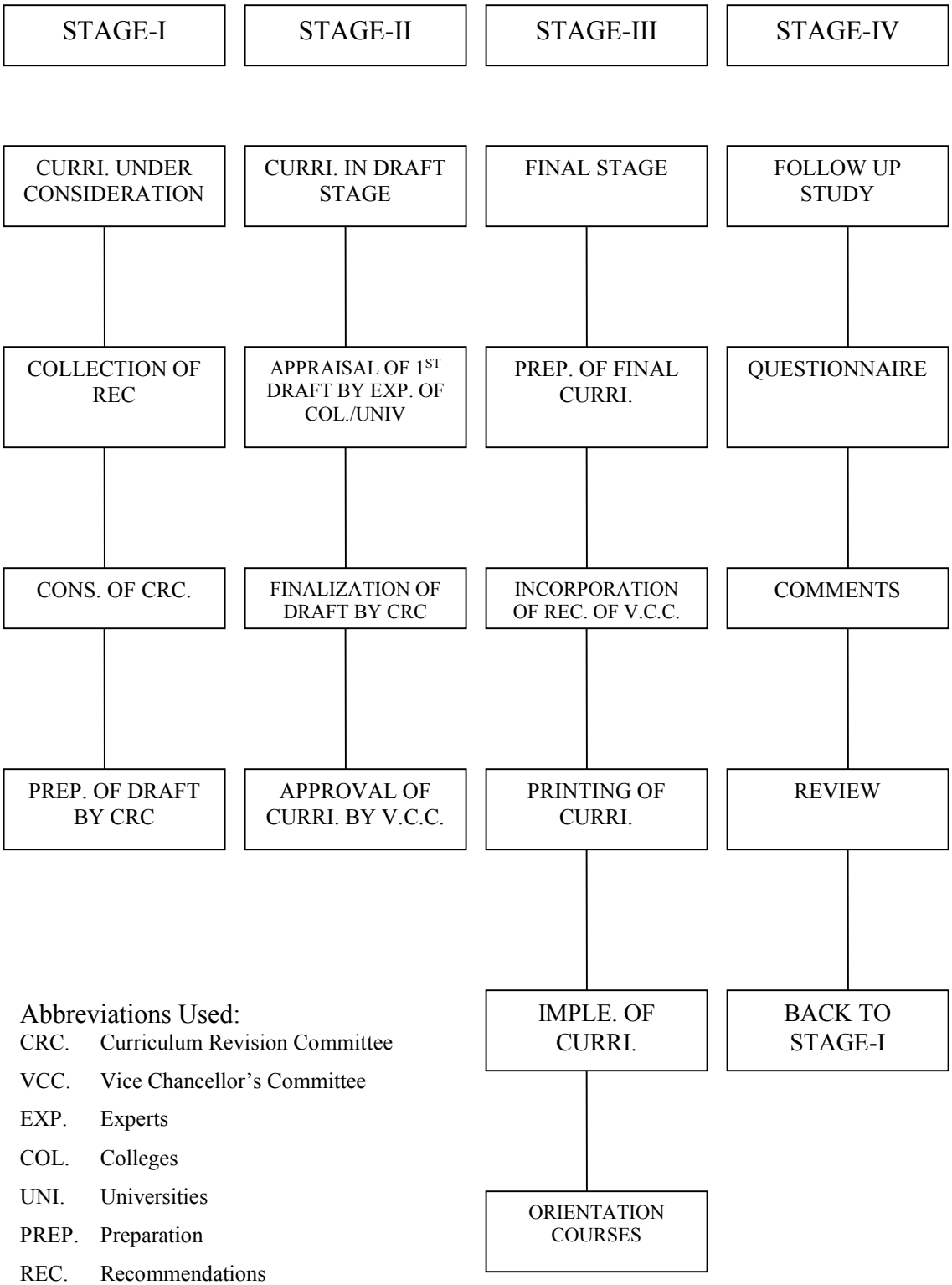
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector 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 international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

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 (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

CRC. Curriculum Revision Committee

VCC. Vice Chancellor's Committee

EXP. Experts

COL. Colleges

UNI. Universities

PREP. Preparation

REC. Recommendations

Introduction:

MINUTES OF THE FINAL MEETING OF NATIONAL CURRICULUM REVISION COMMITTEE IN FOOD ENGINEERING FROM JANUARY 29-31, 2013 AT HEC REGIONAL CENTER, LAHORE

The final meeting of National Curriculum Revision Committee in the discipline of Food Engineering was held on January 29-31, 2013 at HEC Regional Centre, Lahore to finalize the draft curriculum of Food Engineering, developed in its preliminary meeting held on September 04-06. Following attended the meeting:

1. **Engr. Prof. Dr. Muhammad Iqbal**, Convener
   Team Leader / Convener,
   Food Engineering Programme,
   Faculty of Agri. Engineering. & Technology,
   University of Agriculture, Faisalabad.

2. **Engr. Dr. Abdullah Khan Durrani** Member
   Professor,
   Institute of Chemical Engineering & Tech,
   University of Punjab, Lahore

3. **Engr. Dr. Kh. Altaf Hussain**, Member/Secretary
   Head Food Engineering Programme,
   Faculty of Agriculture Engineering & Technology,
   University of Agriculture, Faisalabad.

4. **Dr. Sagir Ahmed Sheikh,** Member
   Professor,
   Institute of Food Science & Technology,
   Sindh Agriculture University, Tajdojam.

5. **Dr. Farzana Yasmin**, Member
   Professor,
   Dept. of Biomedical Engineering,
   NED University of Engineering & Technology, Karachi.

6. **Dr. Jehan Ara**, Member
   Professor,
   Department of Food Science & Technology,
   University of Karachi, Karachi.

7. **Engr. Dr. Nasir M. Khan** Member
Additional Registrar (Accr.),
Pakistan Engineering Council (PEC),
Islamabad.

8. **Dr. Ijaz Ahmad,** Member
Principal Scientific Officer (PSO),
Dept. of Food & Biotechnology Research Centre (FBRC),
PCSIR, Ferozpur Road, Lahore.

9. **Dr. Mohammad Shoaib** Member
Senior Manager Quality Assurance (Retd),
Rafhan Maize Products, Abdullah Pur,
Faisalabad.

10. **Dr. Sarfraz Hussain**, Member
Associate Professor,
Institute of Food Science & Nutrition,
University of Sargodha,Sargodha.

11. **Dr. Nuzhat Huma,** Member
Associate Professor,
(In Place of Dr. Faqir Muhammad Anjum,)
Institute of Food Science & Technology,
University of Agriculture, Faisalabad

12. **Dr. Ihsan Mabood Qazi**, Member
(In Place of Prof. Dr. Javaidullah),
Assistant Professor,
Department of Food Science & Technology,
KPK Agricultural University, Peshawar.

2. The meeting started with the recitation from the Holy Quran by **Engr. Dr. Kh. Altaf Hussain**. After brief introduction of the participants **Mr. Farman Ullah Anjum**, Director General (Acad.), HEC welcomed the participants on behalf of the Chairman and Executive Director, HEC, and briefed the aims and objectives of the meeting with particular focus on the development of curriculum of new discipline of Food Engineering at undergraduate level. He thanked all the members of the committee for sparing their precious time to participate in the meeting, and added that their efforts will go long way in developing workable useful and comprehensive new degree program in Food Engineering and to make it compatible with international standards. **Mr. Muhammad Arif**, Dy. Director (Curriculum) then

requested Engr. **Prof. Dr. Muhammad Iqbal**, the Convener and **Engr. Dr. Kh. Altaf Hussain**, the Secretary of the Committee, to conduct proceedings of all technical sessions of meeting for three days.

3. **Engr. Prof. Dr. Muhammad Iqbal** welcomed the participants and apprised them that the Pakistan Engineering Council has accorded its approval for launching of Food Engineering programme in University of Agriculture, Faisalabad. The house was then opened to all participants to present their views/recommendations on the first draft prepared during the preliminary meeting in September 2012. The Committee discussed the recommendations given by each participant in detail and incorporated the necessary suggestions in the draft curriculum. The Committee taken into account the aspect of available facilities and faculty in the respective university, recommended to add some more foundation, breadth and depth courses. The individual university may choose optional courses out of the approved list according to faculty availability, suitability and needs and all the optional courses should be completed with regard to credit hours already approved in the final draft of the scheme of study. The Committee during its deliberation achieved the following objectives:

i. Finalized the curriculum in the discipline of Food Engineering so as to bring it at par with international standards.

ii. Updated the course contents and also improved the nomenclature of some courses.

iii. Incorporated latest reading & writing material against each course.

iv. Brought uniformity and developed minimum baseline courses in each and every course of study.

v. Made recommendations for promotion/development of the discipline.

4. After three day's long deliberation, the Committee unanimously approved the final curriculum of Food Engineering for BSC/BE/BS (4-year) degree programme. The Convener of the Committee thanked all members of the NCRC for their input in finalizing the curriculum keeping in view the requirement of the country and to make it more practical competitive and effective. The Committee highly appreciated the efforts made by the officers of HEC and all of other officials of HEC Regional Center Lahore for providing local hospitality.

5. Mr. Muhammad Arif thanked the Convener and all the members of the committee for sparing precious time and for their quality contribution towards preparation of the curriculum in the discipline of Food Engineering.

6. The meeting ended with the vote of thanks to the Chair as well as participants of the meeting.

CURRICULUM OF FOOD ENGINEERING FOR BS/BE/BSc (4-YEAR) DEGREE PROGRAMME

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.

Preamble

Food is the mainstay of all the developed and developing countries. Food handling is a significant feature in agriculture sector and skill in dealing with agricultural produces at and off-farm gate is an uphill task. The sensitivity of food requires engineering knowledge to carefully deal with such products. Food processing can be performed if professional engineers in the agricultural sector are available to keenly understand and manipulate with the tools of engineering.

Keeping in view, a degree programme in engineering has been designed in accordance with the basic guiding principles of the Accreditation Board of Engineering and Technology (ABET) in the USA to meet the current needs of value addition of farm products and self-employment prospects. Our neighbour countries namely; Turkey, Malaysia, Bangladesh etc. are successfully running the undergraduate programme in food engineering. Similarly Australia, USA, UK and Scandinavian countries are already producing food engineers and agricultural processing engineers.

In Pakistan, all types of seasons exist in various regions. The land potential to produce is very high and only thing we lag behind is the proper handling of harvested farm products. Therefore, scope of skilled professional in food engineering cannot be denied.

The surplus fruits, vegetables, cereal crops, dairy/poultry/aquatic products need specific hygienic handling/processing when mechanically produced and reduction in losses are the sole object of engaging engineering in food

products. Various studies in Pakistan reveal that 30-50% losses occur during and after harvesting and handling of different agricultural products, particularly perishables towards higher side of losses. The economic loss to farmer cannot be denied under such circumstances. The production potential of our farming system needs engineering approach to overcome prevailing vicious circle of poor food handling. Food Engineering is the answer to alter the existing circumstance in the agriculture sector. Marketable surplus can only be taken care of by mechanized processes and a multiplier for a growing economy in mechanized agriculture is food engineering. Time has come to initiate the new degree programme to meet the WTO standards in food products to compete the world market.

There is a strong demand for food engineering graduates in the food industry, which is the second largest industrial sector of Pakistan's economy. Food engineers help in developing new food products and conceive, design and operate food processes, equipments and plants for effective production of foods with minimal impact on the environment. Food engineers may work for food companies in research and development (R&D), equipment and facilities design, or management of production operations. Internships are usually available, and students are encouraged to make use of these opportunities.
Food engineering involves the application of engineering principles and concepts to the handling, storage, processing, packaging, and distribution of food and related products. In addition to engineering principles, the food engineering degree provides an understanding of the chemical, biochemical, microbiological, and physical characteristics of foods. Concepts of food refrigeration, freezing, extrusion, drying, packaging, handling, and other food operations are studied.

The food engineering curriculum provides a strong foundation in mathematical and physical, biological and food sciences, chemical and mechanical engineering. These courses will enable the students to familiarize with material and energy uses, methods for analyzing and designing processes, equipment and operations, methods for optimizing performance of operations in relevance to food and food systems.
Food engineers are key contributors in optimizing food quality and safety, and in maintaining high nutritional standards. In the development of food products like low-fat foods, food engineers design the conversion processes to assist in required quality food formulation.

There is a national demand to introduce newly emerging discipline of food engineering, thereby, fulfilling the necessity of value addition of agricultural products to compete the world market and provide technical skill to food industry. Additionally, food security and safety issues are also the concern to be addressed through this new programme.

STANDAR FORMAT FOR BS/BE/BSc IN FOOD ENGINEERING

BS/BE/BSc FOOD ENGINEERING

Duration: 4 years
Number of semesters: 8
Number of weeks per semester: 16 - 18
(minimum 16 weeks for teaching and 2 weeks for examinations)
Total number of credit hours: 136
Number of credit hours per semester: 16 - 18
Engineering Courses (Minimum): 69.12 percent
Non-Engineering Courses (Maximum): 30.88 per cent

Non-Engineering Domain

Knowledge Area	Sub Area	Name of Course	Lec CH	Lab CH	Credit Hour	Total Courses	Total Credits	% Area	% Overall
Humanities	English	English Composition & Comprehension	3	0	3	2	6	14.3	4.4
		Communication & Presentation Skills	2	1	3				
	Culture	Islamic Studies or ethics	2	0	2	2	4	9.52	2.94
		Pakistan Studies	2	0	2				
	Social Sciences	Sociology for Engineers	2	0	2	1	2	4.76	1.5
Management Sciences	- -	Engineering Economics & Management	3	0	3	1	3	7.14	2.2
Natural Sciences	Math	Linear Algebra & Calculus	3	0	3	3	9	21.43	6.62
		Differential Equations, Power Series, Laplace Transformation	3	0	3				
		Statistics & Probability	2	1	3				
	Physics	Applied Physics	2	1	3	1	3	7.14	2.2
	Chemistry	Food Chemistry	2	1	3	1	3	7.14	2.2
	Electives	Basic Agriculture for Engineers	2	1	3	4	12	28.57	8.82
		Post harvest handling of fruits and vegetables	2	1	3				
		Food Plant Layout and Sanitation	3	0	3				
		Food Industrial Waste Management	3	0	3				
Total: 42			36	6	42	15	42	100	30.88

* Math/Physics/Chemistry/Biology/Engineering Economics or related subject as appropriate for the programme; Lec CH: Lecture Credit Hours, Lab CH: Laboratory Credit Hours.

BS/BE/BSc FOOD ENGINEERING

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 and Application in Engineering	2	1	3	2	6	6.38	4.44
	Design	Engineering Drawing , Graphics & CAD	1	2	3				
Engineering Foundation	--	Fluid Mechanics	2	1	3	8	24	25.53	17.65
		Metallurgy and Workshop Practices	2	1	3				
		Engineering Mechanics	2	1	3				
		Manufacturing Engineering	2	1	3				
		Engineering Thermodynamics	2	1	3				
		Heat and Mass Transfer	2	1	3				
		Instrumentations and Measurements	2	1	3				
		Industrial Engineering and Management	3	0	3				
Major Based Core (Breadth)		Physical Properties of Food Materials	2	1	3	11	33	35.1	24.26
		Material and Energy	3	0	3				
		Agricultural Process Engineering	2	1	3				
		Food Engineering Operations I	2	2	4				
		Post-Harvest Engineering	2	1	3				
		Energy Resources for Food Industry	2	1	3				
		Mechanics of Materials	2	1	3				
		Food regulations and legislations	2	0	2				
		Process Food Engineering	2	1	3				
		Food Microbiology	2	1	3				
		Engineering Numerical Analysis	2	1	3				
Major Based Core (Depth)		Food Engineering Operations II	1	2	3	7	**19**	20.21	13.97
		Food Product and Plant Design	2	0	2				
		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 or Machine Design	3	0	3				
Inter-Disciplinary Engineering	--	Machine Vision and Industrial Automation	2	1	3	2	6	6.38	4.415
		Fluid flow Systems	2	1	3				
Senior Design Project	--	Senior Design Project-I	0	2	2	2	**6**	6.38	4.41
		Senior Design Project-II	0	4	4				
Industrial Training (Summer)			0	0	0	0	0	0	0
Total Credit: 94			**62**	**32**	**94**	**32**	**4**	**100**	**69.12**

Scheme of Study of BS/BE/BSc Food Engineering

First Semester

Course Code	Title of the Course	Credit Hours
Major Courses		
	Metallurgy & Workshop Practices	3 (2-1)
	Fluid Mechanics	3 (2-1)
Minor Courses		
	Islamic Studies or Ethics (for non-Muslims)	2 (2-0)
	English Composition & Comprehension	3 (3-0)
	Linear Algebra & Calculus	3 (3-0)
	Applied Physics	3 (2-1)
	Total Credit hours	**17 (14-3)**

Second Semester

Major Courses		
	Manufacturing Engineering	3 (2-1)
	Engineering Numerical Analysis	3 (2-1)
	Engineering Mechanics	3 (2-1)
	Engineering drawing, Graphics, and CAD	3 (1-2)
Minor Courses		
	Basic Agriculture for Engineers	3 (2-1)
	Communication & Presentation Skills	3 (2-1)
	Total Credit hours	**18 (11-7)**

Third Semester

Major Courses		
	Engineering Thermodynamic	3 (2-1)
	Agricultural Processing Engineering	3 (2-1)
Minor Courses		
	Food Chemistry	3 (2-1)
	Computer Programming and Applications in Engineering	3 (2-1)
	Differential Equations, Power Series, Laplace Transform	3 (3-0)
	Sociology for Engineers	2 (2-0)
	Total Credit hours	**17 (13-4)**

Fourth semester

Major Courses		
	Instrumentation & Measurements	3 (2-1)
	Engineering Economics & Management	3 (3-0)
	Fluid flow systems	3 (2-1)
	Mechanics of Materials	3 (2-1)

Minor Courses		
	Pakistan Studies	2 (2-0)
	Statistics and Probability	3 (2-1)
	Total Credit hours	**17 (13-4)**

Fifth Semester

Course Code	Title of the Course	Credit Hours
Major Courses		
FE----	Physical Properties of Food Materials	3 (2-1)
FE---	Post-Harvest Engineering	3 (2-1)
FE---	Food Engineering Operation I	4 (2-2)
FE----	Heat and Mass Transfer	3 (2-1)
Minor Courses		
	Post harvest handling of fruits and vegetables	3 (2-1)
	Food regulations and legislations	2 (2-0)
	Total Credit Hours	**18 (12-6)**

Sixth Semester

Course Code	Title of the Course	Credit Hours
Major Courses		
FE----	Food Engineering Design	3 (3-0)
FE---	Food Process Engineering	3 (2-1)
FE---	Material and Energy Balance	3 (3-0)
FE---	Food Quality Control	2 (2-0)
Minor Courses		
	Food Processing & Preservation	3 (2-1)
	Food Microbiology	3 (2-1)
	Total Credit Hours	**17 (14-3)**

Seventh Semester

Course Code	Title of the Course	Credit Hours
Major Courses		
FE---	Food Engineering Operations II	3 (1-2)
FE---	Food Product and Plant Design	2 (2-0)
FE---	Food Packaging	3 (2-1)
FE---	Project & Report – I	2 (0-2)
FE---	Renewable Energy Resources for Food Industry	3 (2-1)
Minor Courses		
	Food Plant Layout and Sanitation	3 (3-0)
	Total Credit Hours	**16 (10-6)**

Eighth Semester

Course Code	Title of the Course	Credit Hours
Major Courses		
FE----	Machine Vision and Industrial Automation	3 (2-1)
FE---	Food Storage Engineering	3 (2-1)
	Industrial Engineering & Management	3 (3-0)
FE---	Project & Report – II	4 (0-4)
Minor Courses		
	Food Industrial Waste Management	3 (3-0)
	Total Credit Hours	**16 (10-6)**

FE = Food Engineering breadth and depth courses

Total Credit Hours for BS /BE/BSc Food Engineering = 136

Note:

1. **A supervised internship training is a mandatory requirement for partial fulfillment of Engineering Degree Program to be arranged by the Institution after Sixth / term (3-years). The evaluation of internship report through presentation shall be graded as Excellent, Good, or Satisfactory.**

2. **Final year Project and Report will be completed in the last two semesters**

LIST OF MAJOR COURSES
For BS/BE/BSc FOOD ENGINEERING

Course Code	Title of the Course	Credit Hours
FE-	Physical Properties of Food	3 (2-1)
FE-	Food Engineering Design / Machine Design	3 (3-0)
FE-	Post-Harvest Engineering	3 (2-1)
FE-	Food Process Engineering	3 (2-1)
FE-	Food Engineering Operation I	4 (2-2)
FE-	Material and Energy Balance	3 (3-0)
FE-	Heat and Mass Transfer	3 (2-1)
FE-	Food Quality Control	2 (2-0)
FE-	Food Engineering Operations II	3 (1-2)
FE-	Machine Vision and Industrial Automation	3 (2-1)
FE-	Food Product and Plant Design	2 (2-0)
FE-	Food Storage Engineering	3 (2-1)
FE-	Food Packaging	3 (2-1)
FE-	Renewable Energy Resources for Food Industry	3 (2-1)
	Metallurgy & Workshop Practices	3 (2-1)
	Manufacturing Engineering	3 (2-1)
	Engineering Thermodynamic	3 (2-1)
	Instrumentation & Measurements	3 (2-1)
	Agricultural Processing Engineering	3 (2-1)
	Engineering Economics & Management	3 (3-0)
	Industrial Engineering & Management	3 (3-0)
	Fluid Mechanics	3 (2-1)
	Engineering Numerical Analysis	3 (2-1)
	Fluid flow Systems	3 (2-1)
	Engineering Mechanics	3 (2-1)
	Engineering Drawing, Graphics, and CAD	3 (1-2)
	Mechanics of Materials	3 (2-1)
FE-	Project & Report – I	2 (0-2)
FE-	Project & Report – II	4 (0-4)

DETAILS OF COURSES

FE- Physical Properties of Food 3(2-1)

Characterization of food materials with regard to their functionality, rheological, thermal and electrical properties. Colloidal food systems and importance; functionality of food components; emulsifiers, stabilizers, texturizers, gelling and foaming agents, kinetic properties; characterization, porosity. Electron microscopy; Principles, scanning, transition, Colorimetry, tristimulus colorimetry, properties of colors, physiological basis of colors.

Practical:

Determination of; viscosity; Specific gravity of oils; Organic solvents, solutions, types of liquid mixtures; conductivities of different foods. Measurement of food textures and rheological properties.

Suggested Readings:

1. Arana, I. 2012. Physical Properties of Foods: Novel Measurement Techniques and Applications (Contemporary Food Engineering).
2. Figura, L. 2010. Food Physics: Physical Properties - Measurement and Applications; Publisher Springer Berlin Heidelberg, Germany.
3. 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.
4. Rivas, E. O., P. Juliano and H.Yan. 2010. Food Powders: Physical Properties, Processing, and Functionality (Food Engineering Series).
5. Sahin, S and S. G. Sumnu. 2010. Physical Properties of Foods (Food Science Text Series).

FE- Food Engineering Design / Machine Design 3(3-0)

Food Engineering Design:

Basic principles of designing a food factory, feasibility survey, preliminary and detailed cost estimation. Optimization of operating conditions and design of equipment used in food industry, special examples of designed food factories, (Students will perform literature and feasibility survey of assigned food factories, equipment design specific to assigned food factories, example of designed food factories, special topic of food factories design).

Suggested Readings:

1. Brennan, J. G., Butters, J. R., Cowell, N. D. and A. E. V Lilly. 1995. Food Engineering Operations. 3rd Ed., Elsevier Science B. V., Amsterdam - Lausanne - New York, USA.

2. Gomez, A. L. and G. V. Barbosa. 2005. Food Plant Design. *Universidad Politecnica de Cartagena, Spain,* CRC Press. *Washington State University, Pullman, USA Washington State University, Pullman,* USA.
3. Holah, J, BRI. Campden BRI, UK and H. L. M. Lelieveld. 2011. Hygienic design of food factories formerly Unilever R&D, Netherlands.
4. Peters, M. S. and Timmerhaus, K. D. T. 1991. Plant design and Economics for Chemical References: Engineers. 4th Ed., McGraw Hill Co. Ltd. New Delhi, India.
5. Robberts, T. C. 2013. Food Plant Engineering Systems, CRC Press, *University of Minnesota, Crookston, Minnesota,* USA.

Machine Design:

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

Suggested Readings:

1. Collins, J. A., H. R. Busby and G. H. Staab. 2009. Mechanical Design of Machine Elements and Machines.
2. Norton, R. L. 2005. Machine Design: An Integrated Approach (3rd ed.)
3. Shigley, J. C. Mischke and T. Brown. 2008. Standard Handbook of Machine Design.

FE- Post-Harvest Engineering 3(2-1)

Techniques in post-harvesting methods for grains, fruits, vegetables, and other food products. Pre-storage handling of food products - Physiological maturity, harvesting, threshing, handling, transportation techniques of grain, pulses, vegetable, fruit crops, and their harvesting recommendations, losses during harvesting, handling, transportation and their control methods. Post-harvest losses, forms, measurement of post-harvest losses, methods to control losses. Food quality; importance, grades factors and standards.

Practical:

Measurement of moisture content of various food products, Measurement of size, shape, density, specific gravity, porosity, angle of repose, coefficient of friction, hardness test; Thermal properties of biological materials; specific heat, thermal conductivity; Demonstration of separators, sorters, graders; field visits.

Suggested Readings:

1. Brennan, J. M. 2006. Food Processing Handbook. WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.
2. Jongen W. 2006. Fruits and Vegetable Processing-Improving Quality. CRC press, Wood head Publishing Limited, Cambridge, UK.
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 K. K. Singh. 2008. Unit operation of agricultural processing (4th Ed). Vikas Publishing House, New Delhi, India.
6. Singh, D. K. 2012. Post harvesting engineering, Oxford Book Co., UK.

FE- Food Process Engineering 3(2-1)

Principles of operations for the equipment used in processing industry and the response of biological materials to these operations. Non-linear curve fitting, energy associated with food freezing accounting for non-frozen water below the freezing point, flash evaporation, evaporated cooling, pumps, high pressure system applications, effective temperature measurements to account for radiation, simultaneous conduction, convection, heat transfer freezing time predictions, reaction kinetics including acquisition and analysis of reaction rate data and use in process optimization.

Practical:

Activities for sterilization of fluids containing particulates; Training in vapor induced puffing for producing crispy dried or baked food products; Training in application of supercritical fluids and extrusion to generate unique food ingredients; Food industrial visits.

Suggested Readings:

1. Bellinghouse, V. C. 2009. Food Processing: Methods, Techniques and Trends, Nova Science Pub Inc.
2. Doona, C. J. and F. E. Feeherry. 2007. High Pressure Processing of Foods. Blackwell Publishing and the Institute of Food Technologists, Blackwell Publishing Professional, 2121 State Avenue, Ames, Iowa 50014, USA.
3. Gaonkar, A. G. 1995. Food Processing, Recent developments. Elsevier Science B. V., Amsterdam - Lausanne - New York, USA.

4. J. Scott Smith, Y. H. Hui, 2008. Food Processing: Principles and Applications, John WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.

FE- Food Engineering Operations-I 4(2-2)

Material handling; handling and transportation freshly harvested and refrigerated perishable and non-perishable produce. Cleaning, sorting, grading, peeling, size reduction and mixing. Separation techniques; screening, filtration, centrifugal filtration, membrane filtration-MF, UF, NF, RO, IE., sedimentation, crystallization, centrifugation. Homogenization, Bleaching, blanching, deodorization, extraction, grinding. Conveying; Screws, vibrators, belt conveyors and elevators; fluidization and agitation, flow pattern and baffles.

Practical:

Demonstration of equipment and instruments used in food engineering operations. Evaluation of performance; Capacity; Efficiency and operating costs of individual food engineering units; Determination of optimum operating conditions.

Suggested Readings:

1. Brennan, J. M. 2006. Food Processing Handbook. WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.
2. Ibarz, A and G. V. Barbosa-Cánovas. 2007. Unit operations in food engineering. CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, USA.
3. Jun, S and J. M. Irudayaraj. 2009. Food Processing Operations Modeling (2nd ed.), Design and Analysis, CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, USA.
4. Saravacos, G. D. and Z. B. Maroulis. 2011. Food Process Engineering Operations. CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, USA.
5. Smith, P. G. 2011. Introduction to Food Process Engineering. Publisher Springer Berlin Heidelberg, Germany.

FE- Material and Energy Balance 3(3-0)

Systems of units, dimensions, basic principles of material balances for processes with and without chemical reaction, gases and vapors, saturation and humidity. Energy balance: Physical, chemical heat effects, enthalpy, latent heat, sensible heat, freezing drying, canning, other form of energy, use of steam tables. Simultaneous material and energy balances, engineering ethics, responsibilities, and heat safety considerations.

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.

FE- Heat and Mass Transfer 3(2-1)

Heat Transfer-Thermodynamics and heat transfer, engineering techniques in heat transfer, different forms of energy, heat transfer mechanisms; Principles of convective, conductive and radioactive heat transfer, shell balances concerning heat transfer, heat transfer coefficient correlations, boiling and condensation, thermal design of heat exchangers, transient heat transfer. Equations of change for isothermal systems, macroscopic balances for isothermal systems, analytical, approximate solutions to equations of heat, transfer, momentum, energy transport, interphase momentum, heat transfer. Empirical model the evaluation of heat transfer coefficients.

Mass Transfer - Introduction, analogy between heat and mass transfer, mass diffusion, boundary conditions, steady mass diffusion through a wall, transient mass diffusion, diffusion in moving medium, mass convection, simultaneous heat and mass transfer. Principles of diffusion, mass transfer in turbulent flow, mass transfer theories, general principles of stage wise and continuous contacting operations, applications to absorption and distillation.

Practical:

Method of heat transfer; Measurement of heat transfer by different methods; Study of boiling and convection heat transfer; types of heat exchangers, thermal processing; Experiments related to heat transfer from food products.

Suggested Readings:

1. Baehr, H. D. and K. Stephan. 2011. Heat and Mass Transfer. Print ISBN 978-3-642-20020-Online ISBN 978-3-642-20021-2 Publisher Springer Berlin Heidelberg, ISBN: 978-3-642-20020-5 (Print) 978-3-642-20021-2 (Online).
2. Çengel, Y. A, 2003, Heat Transfer-A Practical Approach (2nd ed). McGraw-Hill, USA.
3. Thrimulashwar, M. 2009. Fundamentals of Heat and Mass Transfer (2nd ed.). Pearson Education. ISBN 978-81-7758-519-3. Published Dorling Kindersley, Pvt., Ltd. India.

FE- Food Quality Control 2(2-0)

Principles of quality control: Attributes and their measurement, development of grades and standards of food products and food quality. Quality attributes: Influencing quality attributes in the Agri-food chain, quality management and organization, history of quality management, principles of the techno-managerial approach, concepts, systems and methods of quality design, quality control and quality improvement from a technological and managerial perspective. Food quality systems: GMP, HACCP, ISO, BRC, quality policy and strategy. Total Quality Management: Evaluation quality management, quality costs and auditing, specific aspects in different sectors.

Suggested Readings:

1. Clute, M. 2009. *Food* Industry *Quality Control* Systems. CRC Press
2. Mutlu, M. 2010 Biosensors in *Food* Processing, Safety, and *Quality Control*. CRC Press.
3. Pomeranz, Y and Melcoan C. E. 2002. Food Analysis: Theory and Practices. 3rd Ed., Kluwer.
4. Vasconcellos J. A. 2005. Quality assurance for the food Industry – A practical approach. Boca Raton, London, UK.

FE- Food Engineering Operations-II 3(1-2)

Heat exchanger; principles, types and their design. Unit processes; pasteurization, sterilization, cooling, freezing, drying, evaporating and concentration, distillation, Separators; calculation of number of plates required for binary separations. Lewis-Sorel, McCabe-Thiele methods. Column design; design, capacity and efficiency. Absorption; Extension of design techniques. Wetted wall columns and determination of transfer coefficients. Equipments for gas absorption.

Liquid-Liquid Extraction; Introduction, extraction Processes, extraction equipment.
Adsorption; The nature of adsorbents, Adsorption equilibria. Adsorption equipments and regeneration of spent adsorbents. Extrusion; introduction, importance, types, functions, dry, interrupted flight extruders/expanders, Single screw and Twin screw extruders: principles, applications, advantages, disadvantages. Textured vegetable proteins, breakfast cereals etc.

Practical:

Determination of heat transfer coefficients; Experiments related to size reduction, screen analysis of solid food; Dehydration of fruits, vegetables by using various drying techniques; Preservation of fruits and vegetables by the use of food additives and fermentations; Experiments on evaporation – multiple-effect evaporator, feeding of multiple-effect evaporators, advantages of multiple-effect evaporators, recompression and boiling evaluation,

evaporation of heat sensitive materials. Preparation of textured vegetable proteins, breakfast cereals. Effect of variation of ingredients, screw speed, temperature, etc. on the quality of end product.

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. Patel, K. D. 2009. Mechanical *Operations* Fundamental Principles and Applications. NiraliPrakashan.
5. Riaz, M. N (ed.). 2003. *Extruders in food applications.* Technomic Pub. Co. Inc., Lancaster, Pennsylvania, USA.
6. Singh, R. P., R. P. Singh, and D. R. Heldman. 2008. Introduction to Food Engineering, Food Science and Technology, International Series.

FE- Machine Vision and Industrial Automation 3(2-1)

Machine Automation: Introductions to programming controllers, Number system and codes, Logic concepts, processors, power supply, programming devices, memory system and I/O interaction, discrete input output system, analog input output system.

Programmable Logic Controllers (PLC), Programming Languages, ladder logic simulator, Programmable Logic Controllers startup and maintenance, system selection guidelines, Human Machine Interface (HMI), fundamentals of Supervisory Control and Data Acquisition (SCADA).

Machine Vision**:** Introduction to machine vision, Illumination and sensors; Illumination, image formation, camera sensors, camera interfaces and video standards, characteristics of camera sensors, commercially available camera sensors. Image acquisition and presentation; image acquisition hardware, speed considerations, inter-pixel distances. Fundamentals of digital image processing; point operations, geometric operations, mathematical morphology, Segmentation problem. Image Analyses, techniques for shape description, representation and information processing, organization of visual processes, visual representations, and visual processes. Industrial Automation and Its Components; Motor Control & Industrial Automation control circuits.

Practical:

Demonstration and selection of PLC. Basic task to ladder logic programming. Intermediate task to ladder logic programming. Advance task to ladder logic programming. Installation of program in PLC. Testing of program in PLC and

its reliability. Demonstration of different sensors and cameras used in machine vision. Demonstration to image processing software. A case study of image processing.

Suggested Readings:

1. Anonymous. 2007. Programming Manual. Mitsubishi Electric, Japan.
2. Dhillon, B. S. 2007. Applied Reliability and Quality: Fundamentals, Methods and Procedures . Publisher Springer Berlin Heidelberg, Germany.
3. Hornberg, A. 2006. Hand Book of Machine Vision, Litges & Dopf Buchbinderei. Latest Information and company manuals about PLC, HMI, SCADA and Machine Vision.
4. Pletney, V. N. 2007. Focus on *Food Engineering* Research and Developments. Nova Science Publishers.
5. Sun, D. W. 2011.Computer *Vision* Technology for *Food* Quality Evaluation. Food Science and Technology, International Series.
6. Vernon, D. 2002. Machine Vision. Prentice Hall Ltd., Ireland.

FE- Food Product and Plant Design 2(2-0)

Food product design; selection of novel products from food industry through market survey, food product development. Selection of the local preparation of the plant layout, material and energy balances. Design of the major units and sizing, auxiliary equipment including services, health and safety considerations, plant and product cost estimation. Plant design and layout; Objectives and functions, financial requirements, plant location, site selection, space requirement, building design and construction, floors, drains, walls, doors, windows, ceiling, ventilation, lighting, auxiliary facilities. Food plant equipments, layout of equipment, requirements, design, construction, and choice of materials. Use of computer for layout, environmental impact, material handling and equipment process flow chart.

Suggested Readings:

1. Antonio López Gómez, Gustavo V. Barbosa-Cánovas. 2007. Food plant design. Taylor & Francis inc.
2. Brennan, J. M. 2006. Food Processing Handbook. WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.
3. Clark, J. P. 2008. Practical *Design*, Construction and Operation of *Food* Facilities. Food Science and Technology, International Series.
4. Cramer, M. M. 2006. *Food Plant* Sanitation. CRC Press LLC International Standard Book, USA..
5. Lelieveld, H. L. M. 2003. Hygiene in *Food* Processing. CRC Press LLC International Standard Book, USA..
6. Maroulis, Z. B. and G. D. Saravacos. 2003 .*Food* Process *Design* . Taylor and Francis Group, Boca Raton, Florida, USA.

FE- Food Storage Engineering 3(2-1)

Cold Storages: Needs, types, design, and conditions; temperature, humidity controls, heat load, air conditioning, aeration etc. Storage of fresh and processed fruits, vegetables, principles of storage, mechanical refrigeration, controlled atmosphere storage (CA), vacuum storage, storage in polymeric films, transportation and marketing. Low temperature preservation: methods and equipments. Cold storage: requirements, insulation, air circulation, humidity, refrigeration load, automation of cold storages. Thermal properties of foods; refrigeration of fruits and vegetables, refrigeration of meat, milk and milk products, bakery products, poultry, eggs and aquatic foods and cool chain. Food freezing, storage, variably in storage conditions, maintenance and control of storage conditions.

Practical:

Measurement of bulk density of raw fruits, vegetables; Determination of physico-chemical properties of meat, milk, Determination of transpiration of fruits, vegetables, and other food products; Determination of refrigeration of fruits, vegetables, meat, milk, etc; Calculation of load of storage structures, mobile vans, CA compartmental storages; Determination of dehydration characteristics of fruits/ vegetables employing psyschrometry. Visit to food storage structures and food industries.

Suggested Readings:

1. Karel, M and D. Lund. 2003. Physical Principles Preservation of Food (2nd ed.). Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016, USA.
2. Khetarpaul 2005. Food Processing and Preservation. Daya Publishing House,
3. Salunkhe, D. K., Bolin, H. R. and Reddy, N. R. 1991. Storage, Processing and Nutritional Quality of Fruits and Vegetables; Fresh Fruits and Vegetables. CRC Press
4. Sivasankar, B. 2004. Food Processing and Preservation. PHI Learning Pvt. Ltd.,
5. Taub, I. A and Singh, R. P. 1997. Food Storage Stability. CRC Press.

FE- Food Packaging 3(2-1)

Introduction and importance of food packaging; evolution, functions and selection of packaging. Requirements and functions of containers. Heat and mass transfer aspects influencing effectiveness of packaging materials. Packaging materials, their properties and techniques for packing geometries. Type of containers: Primary and secondary containers, degree of rigidity, pre-formed and in-line forming, hermetic closure. Filling, Closing and Sealing Equipment: Operation and principles of simple gravity filler, vacuum gravity

filler, vacuum filler, counter pressure filler, piston filler, volumetric cup filler for solids and fully automated weight control system. Closing and Sealing Equipment: Principle, design, operation and handling of can-seaming machine, push on caps for glass containers and other sealer types, vertical form- fill- seal machine, vertical form-full-seal machine for sachets. Aseptic filling system: horizontal form-fill-seal machine for sachets, a thermoforming filling and sealing system, tetra brick aseptic packaging system. Modern packaging: Active, edible film, fiber, and Nano-composite packaging. Temperature control; self-heating and shrink wrapping machines.

Practical:

Identification of packaging materials used for various food products; Study of Package testing equipments and machineries; Study of food packaging machine parts, analysis of motion and displacement, velocity and acceleration of moving parts; Analysis of static and inertia of forces in machines; balancing of rotating and reciprocating mass; Study of principle, design, operation and handling of Horizontal form-fill-seal machine; Requirements of foods for specific packaging material; Canning in metal containers; Can testing; Determination of shelf-life in various packaging materials; Vapor permeability test. Determination of film thickness and preparation of edible films. Vacuum packing machines. Industrial visits of packaging industries.

Suggested Readings:

1. Anonymous. 2007. Handbook of packaging technology. Engineers India Research Institute Engineers India Research Institute, New Delhi, India.
2. Lee, D. S., K. M Yam, and L. Piergiovanni, 2008. Food packaging science and technology. CRC Press, Taylor and Francis Group, Boca Raton, Florida, USA.
3. Robertson, G. L. 2006. Food packaging: principles and practices. CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA.
4. Han, J. H. 2005. Innovations in Food Packaging. Elsevier Science B. V., Amsterdam - Lausanne - New York, USA.
5. Ahvenainen, R. 2003. Novel food packaging techniques, Published in North America by CRC Press LLC 2000 Corporate Blvd, NW, Boca Raton FL 33431, USA.
6. Robertson, G. L. 2012. Food Packaging: Principles and Practice, CRC Press. Taylor & Francis Group, Boca Raton, Florida, USA.
7. Wagner, J. R. 2009. Multilayer Flexible Packaging: Technology and Applications for the Food, Personal Care, and Over-the-Counter Pharmaceutical Industries. William Andrew.

FE-- Renewable Energy Resources for Food Industry 3(2-1)

Energy reclamation from agricultural crops/wastes: Energy and agricultural biomass production, bio-fuel, critical parameters of design, installation, operation and management of family and community biogas plants, vegetable oils as fuel. Classification and characterization of food stuffs, heat transfer phenomena, heat transfer and solid foods, heat transfer and liquid foods, thermal process equipment, examples on control and optimization of thermal process. Solar energy: Introduction, solar system, solar radiation, solar radiation at outer limit of atmosphere, estimation of solar radiation, direct and diffuse radiation, radiation measurement, solar radiation collectors, water and air heating, drying of agricultural products with solar radiation, space heating with solar energy, solar energy conservation. Energy Consumption in Farming: Energy for crop production, dairy farming, poultry farming, energy consumption for waste water treatment and solid wastes, energy conservation. Wind Power: Wind energy potential, vertical and horizontal axis wind mills, wind operated pumps and water lifts, other applications of wind power in agriculture. Energy and Environment: Greenhouse effect, energy dissipation through industrial and engine emissions and their impact on environment.

Practical:

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

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. McVeigh. 1987. Sun power; an introduction to the application of solar energy. Pergman Press, N. Y. USA.
5. Pimental, D. 1993. Hand book of energy utilization in Agriculture. CRC Press Inc. 2000 corporate. Blvd. Florida, USA.

6. Stout, B. A. 1990. Hand book of energy for world Agriculture. Elsevier Science B. V., Amsterdam - Lausanne - New York, USA.
7. Threlkeld, J. L. 1993. Thermal environmental engineering. Prentice Hall, Inc. Englewood Cliffs, N. Y. USA.

Metallurgy and Workshop Practices

3(2-1)

Production and properties of common engineering materials: Ferrous metals, iron ores, properties and uses of pig iron, cast iron, wrought iron, steel, standard processes of manufacturing of Iron and steel, open hearth process, basic oxygen processes, production of ingots. Composition/properties and uses of plastics, rubber, fibre glass and composite materials. Alloy steel and Irons: Effect of alloying elements, the AISI/SAE alloy steel and their identification, corrosion resistant steel, steel for high temperature services, alloy steel.

Non-ferrous metals: Properties and uses of copper, aluminum, zinc, tin, nickel, and lead. Non-ferrous alloys, copper alloys. Aluminum alloys, zinc base alloys, nickel base alloys. Lead-tin alloys, iron-carbon equilibrium diagram. Heat treatment: Heat treatment theory and process, heat treatment of steel, annealing, hardening, tempering, normalizing, surface hardening, quenching, heat treatment equipment. Welding: Definition, types of welding process, survey of welding equipment. Arc welding; Current rating, welding materials, arc welding processes, inspection and testing of welded joints. Gas welding; Welding flames and materials, cutting of metals, gas welding processes. Foundry: Definition, importance, advantages and disadvantages of foundry, casting, hand moulding tools, characteristics of moulding sand, foundry cores, properties of core and, crucibles, handling and care, copula furnace, construction, zone of copula and its advantages. Safety and First Aid: Safety in the shop, mechanical and other accidents, safety devices, safety methods, first aid equipment and methods, care and order in the workshop.

Practical:

Identification of tools and machines in the workshop. Identification of different metals by spark tests and advance methods. Demonstration of different heat treatment processes. Practice of arc welding. Practice of gas welding. Safety and first aid in the workshop related to electrical, mechanical and other accidents. Safety in the use of hand tools. Visits to local foundries.

Suggested Readings:

1. Abbaschian, R., L. Abbaschian, and R. E. Reed-Hill. 2008. Physical Metallurgy Principles. Cengage Learning.
2. Chapman, W. A. J. 2004. Workshop Technology Part-I. and II. Viva Books Private Ltd., India.

3. Havey, D. Miner. 1999. Exploring Pattern Making and Foundry. The MacMillan Co. N. Y., USA.
4. John, K C. 2011. Mechanical Workshop Practice. PHI Learning Pvt. Ltd.
5. Ostwald, P. H. and J. Munoz. 2002. Manufacturing Processes and systems. 9th edition John Wiley and Sons, New York. USA.
6. Sharma, S. 2010. Manufacturing Processes. I. K. International Pvt Ltd.

Manufacturing Engineering 3(2-1)

Turning and related operations: Lathe, construction, types of lathes, accessories, lathe operations, turret lathe; construction, types, turret lathe tooling, chip formation, mechanism of chip formation, cutting tool materials, tool failure and tool life. Shaping and planning: shaper; classifications, functions, shaper drive mechanism, shaper speeds and machining times, planning, construction and types, work set up, planer tools, metal bending and sheet rolling processes.

Drilling and reaming: Drilling; types and sizes, drill chucks. Counter boring, counter sinking, reaming, drilling machine types, and estimating drilling time. Milling: Definition, milling operations, milling cutters, milling machines types, size, accessories, dividing head, estimating milling time. Gear manufacturing: Gear terminology, gear types, basic methods for machining gears. Computer-aided manufacturing (CAM) and computer – integrated manufacturing (CIM) Systems: Machine tools control, numerical control system, computerized numerical control system (CNC) programming for numerical control. Automatic machines, transfer machines, computer aided- manufacturing (CAM), computer simulation of manufacturing process and system. Automated assembly use of mechanical hands/Industrial Robots, concept of computer-integrated automation system (unmanned factory).

Practical:

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

Suggested Readings:

1. Chapman, W. A. J. 2004. Workshop Technology Part-I. and II. Viva Books Private Ltd., India.
2. Kalpakjin, S. and Schmid, R. S. 2004. Manufacturing engineering and technology. 4th Ed. Tata McGraw-Hill Co. Ltd., New Delhi, India.
3. Ostwald, P. H. and J. Munoz. 2002. Manufacturing Processes and systems. 9th Edition, John Wiley and Sons, New York. USA.

4. Pang, P. N. T. 2004. Essentials of *Manufacturing Engineering* Management. Universe, Inc.
5. Qin, Y. 2010. Micro-manufacturing *Engineering* and Technology. Elsevier Science B. V., Amsterdam - Lausanne - New York, USA.
6. Rao, P. N. 2005. CAD/CAM – Principles and applications. 2nd ed. Tata McGraw Hill Co. Ltd. New Delhi, India.

Engineering Thermodynamics 3(2-1)

Heating and expansion of gases; Units of heat, gases and vapors, constant volume and constant pressure, P-V diagram, specific heat of gases, internal energy of gas, law of conservation of energy, methods of heating and expanding gases and vapors, work done by gas in expanding.

Laws of perfect gases: The two laws of thermodynamics, the heating of gases, equations for different types of heating methods. Air cycles: Cycles of operation, air standard efficiency of a cycle, reversible process, reversible cycles, reversibility and efficiency, Carnot cycle, Otto cycle, diesel cycle, mean effective pressure. Entropy of gases: Entropy and heat, T-S diagrams, Carnot, Otto, diesel and dual combustion cycles on T-S diagrams. Air compressors: functions, compressor types, reciprocating and rotary compressors, single and multistage compressors, cylinder clearance, work done, compressor efficiency. Compound expansion: advantages of compound expansion, tandem type of two- cylinder compound engine, receiver type compound engine; combined indicator diagram for compound engine. Fuels: Combustion of fuels, properties of fuels – viscosity, pour point, flash point, calorific value, API gravity, conversion of volumetric analysis, analysis by weight, weight of carbon in burnt gases, weight of air required for complete combustion of fuel, weight of flue gases per pound of fuel burnt, weight of excess air supplied, method of analyzing flue gases, heat carried away by flue gases, volumetric analysis of a gas, air fuel ratio for I.C. Engine. Refrigeration: Co efficient of performance, units of refrigeration, air compression refrigeration, vapor compression refrigeration, refrigeration cycles, rating, quality of refrigerant and general considerations, components of refrigeration system, heat pumps.

Practical:

Study of working principles of two stroke and four stroke engines using models. Demonstration of Joule's law. Study of rotary and reciprocating air compressors and their characteristic curves. Study of PV diagram of diesel/gasoline engines. Analysis of engine flue gases for CO, CO2, NO2, etc. Determination of energy content of different fuels using calorimeter. Study of heat transfer using refrigeration and air conditioning cycle. Measurement of fuel viscosity using viscometer. Determination of flash point and fire point of different petroleum products.

Suggested Readings:

1. Eastop, T. D. 2004. Applied thermodynamics for engineering and technologists (5th ed.) Pearson Education Singapore.
2. Jones, J. B. and Hawkais, G. A. 2002. Engineering Thermodynamics. John Willey and Sons, Inc. N.Y., USA.
3. Lewitt E. H. 2002. Thermodynamics applied to heat engines, Isaac Pitman and Sons, London.
4. Sontagg, R. E. and G. J. Van Wylen. 2010. Fundamentals of thermodynamics (7th ed.), John Willey and Sons, Inc. New York, USA.
5. Muthuraman, S. 2011. Engineering Thermodynamics: Study of Thermodynamic Properties and Applications. VDM Publishing.
6. Mishra, D. P. 2012. Engineering Thermodynamics. CENGAGE Learning.
7. Chattopadhyay, P. 2011. Engineering Thermodynamics (Revised 1st ed.). Oxford University Press, UK.

Instrumentation and Measurements 3(2-1)

Basic terminology and concepts related to instruments, instrument behavior application of instrumentation, functional elements of instruments, basic terms related to instrumentation, such as threshold, resolution, accuracy, precision, sensitivity, response and error of instrument, uncertainty analysis, and least square techniques, static and dynamic characteristics of instrumentation, signal conditioning and recording devices. Principles and theory of electrical instruments: potentiometer, wheat stone bridge, strain analysis; strain measurement; strain gauges, types and their applications.

Displacement, velocity and acceleration measurement: sensors and transducers, displacement measurement sensors; potentiometer, LVDT, capacitance sensors, piezoelectric sensors, velocity and acceleration sensors. Force and Torque Measurements: Force Measurements; Load cells. Torque measurements; torque cells. Pressure Measurement: Gauge, vacuum and absolute pressure, pressure measuring devices. Measurement of Temperature: Resistance thermometers, thermocouples and radiation methods. Fundamentals of mechatronics: Introduction to electronics and sensors used in agricultural machinery, interfacing the machine and computers for response, controls and data logging, computer simulation of mechanical system.

Practical:

Measurement of Displacement by LVDT and Potentiometer; Measurement of wind velocity. Measurement of Force by Strain Gauges; Calibration of pressure gauges with dead weight tester; Measurement of Temperature by thermocouples; Computer inter-facing for the depth and draft controls of tractors; Visit to Mechatronics labs BSc. of different institutions; Study of depth sensors in Agricultural Machinery

Suggested Readings:

1. Bakshi, U. A. and A. V. Bakshi. 2009. Instrumentation Engineering. Technical Publications.
2. Bakshi, U. A. and A. V. Bakshi. 2010. Measurements and Instrumentation. Technical Publications.
3. Dally, J. W., W. F. Riley and K. G. McConnel. 2003. Instrumentation for engineering measurements, 2nd Ed. John Wiley and Sons, Inc. Singapore
4. Figliola, R. S. and D. E. Beasley. 2004. Theory and design for mechanical measurements. (3rd ed.). John Willey and Sons (Asia) Pvt., Inc. Singapore
5. Kishore. 2009. Electronic Measurements and Instrumentation. Pearson Education India.
6. Mahalik, N. P. 2003. Mechatronics, principles, concepts and applications. Tata McGraw-Hill, New Delhi, India.
7. Shetty, D. and R. A. Kolk. 2001. Mechatronics System Design. Vikas Publishing House, Pvt., Ltd. New Delhi, India.

Agricultural Processing Engineering 3(2-1)

Introduction: industrial processes, value addition, structure and composition of food grains and fruits, engineering properties of agricultural materials - physical, mechanical and thermal properties. Pumps: types of pumps used in the industries, pump selection, pump laws and performance, viscosity effects. Fans: Classification as to type and design of fans, fan theory, fan performance, factors affecting fan selection, general performance and laws, fans in series and parallel, compression effect. Material handling and transportation equipment: Belt conveyors, chain conveyors, bucket elevators, pneumatic conveyors, gravity conveyors, augers, and trailer/ trucks. Cleaning, Sorting and grading: Grade factors, washing types and methods of washing, sorting fruits and vegetables, types of sorters, cleaning and sorting, grading, nuts and seeds, types of grain cleaners/sorters, aerodynamics of small particle, types of separators, machine vision and its applications in grading. Size reduction: Size reduction and screen analysis of solid foods. Types of size reduction mills; fineness modulus, value of ground feed, size relationships, energy requirements, size reduction procedures, reducing devices, performance and characteristics of size reduction devices, mixing and types of mixers. Drying: Drying and dehydration, moisture content determinations; primary methods, equilibrium moisture content, drying processes, constant rate period, falling rate period, falling rate drying mechanism, dynamics of equilibrium moisture content, effect of temperature upon the rate of drying, effect of air rate upon the rate of drying, heat and mass balance limitation of the drying equipment, calculations, types of driers, psychometric chart.

Practical:

Determination of internal friction and angle of repose. Measurement of bulk density of grains; Measurement of grain moisture content by oven method and moisture meter; Selection of fans for aeration of bin. Calculation of Fineness modulus of wheat flour; Demonstration of sieves used for cleaning/grading; Carrying out screen analysis of milling/grinding equipment; Study of Psychometric chart to calculate heat transfer during aeration/drying; Study of dehydration characteristics of fruits/vegetable by moisture content vs. time curve and drying rate vs moisture content curve; Visit to cold storage facilities; Study tour to visit agricultural processing units and plants.

Suggested Readings:

1. Dabhi, M. N. and N. K. Dhamsaniya. 2008. Agricultural Process Engineering. Agrotech Publishing Academy, India.
2. Hanlon, J. F. 1992. Handbook of packaging engineering. 2nd Ed. John Willey and Sons, N. Y., USA.
3. Henderson, S. M. 2010. Agricultural Process Engineering. The AVI Publishing Company, Inc. Westport, Connecticut. USA.
4. Myler, H. R. 1999. Fundamentals of machine vision. Prentice Hall of India, New Delhi.
5. Pandey, H. H. K. Sharma, R. C. Chauhan, B. C. Sarkar and M. B. Bera. 2004. Experiments in food process engineering. CB.SC. Publishers and distributers, New Delhi, India
6. Sahay, K. M. and K. K. Singh. 2002. Unit operation of agricultural processing (2nd ed). Vikas Publishing House, New Delhi, India.
7. Toledo, R. T. 2006. Fundamentals of Food *Process Engineering.* Food Science Text Series.

Engineering Economics and Management 3(3-0)

Management Fundamentals: Management, Administration, Leadership, Relationship Vs Task Management, Project and Program, Project Life Cycle, Trade Off. Line/Project Organization, Functional Organization, Matrix and Mixed Organization. Role and Responsibilities, Career Path, Special Demands on the Project Manager, Common Characteristics of a most effective Team, Selection of a Project Manager. Project Scheduling and Control: Network Techniques, PERT, CPM & GRANT Charts, Use of Project management Software's, Crashing of a Project, Physical Assets Control, Human Resource Control, Financial Control. Marketing Management: Selling versus Marketing, Role of a company: Leader, Follower, Challenger, Basics of Marketing, Place, Price and Promotion. Role of a company in Market Place. Economics and Accounting: Budgeting Methods, Cost Estimation, Assets, Liabilities, Capital and Revenue Expenditure, Depreciation, Depletion, Amortization, Owner's Equity Debentures, Loan Financing, Accounting, Qaurds, Ledgers, Profit and loss statement.

Suggested Readings:

1. Anonymous. 2002. The Certified Quality Auditors HACCP Handbook. ASQ Food, Drug and Cosmetic Division. ASQ Quality Press, Milwaukee Wisconsin, USA.
2. Mishra, R. 2008. Industrial Economics and Management Principles. Firewall Media.
3. Swamy, N. 2007. Engineering Economics & Management, Dynaram Publications, India.

Industrial Engineering and Management 3(3-0)

Introduction: Industrialization and industrial policies of Pakistan; Classification of agro-based industries, management, operations research, system engineering, statistics, ergonomics, manufacturing engineering, ISO and WTO regulations. Production System Design: Mill and Plant Layout; Line Diagrams; Flow Diagrams, Work measurement, General Terminologies used in physical measurements. Product System control: Inventory control, production control, production planning, quality control, statistical process control charts, sampling plan, Total Quality Management.

Industrial Management: Definition of Management; Functions of Management: Personal Management; human resource development, Policy Formulation and decision Making. Materials Purchase and Stores. Management. Cost Management. Production Routing, Scheduling and Dispatch Management.

Operations Research: introduction, linear programming, graphical and algebraic method, transportation algorithm, assignment algorithm, queuing theory and simulation. Engineering Economy: Pricing, costing, interest calculation, present worth, future worth, annual rate of return, annual cost method, return on investment, payback method, cost control engineering. Industrial Safety Engineering: Safety Measures, Accidents Causes, Job Safety Analysis. Machine Guards and Safety Equipment; Control of Noise, Contaminants and Radiation/heat etc. Health hazards and Safety Management. Health and Safety Policies. Industrial Environmental Communication and Pollution: Industrial Environmental Education; Factors Affecting Environment of different industries; Environmental Planning, Monitoring and Control Strategies of Recycling Materials for Ecological balance. What is Pollution; Sources of Pollution, e.g. Natural Sources, Industrial Sources, Point Sources and Non-Point Sources. Industrial Revolution and its Impact on Soil, Water, Air and human health. Effect of Unplanned Technological growth on Environmental Pollution.

Suggested Readings:

1. Hicks. P. 1994. Industrial engineering and management (2nd ed.). McGraw-Hill International Edition. N. Y.

2. Kumar, B. 2001. Industrial Engineering, Khanna Publishers, Nath Market, Delhi, India.
3. Patil, S. B. 2008. *Industrial Engineering and Management*. Technical Publications PUNE.
4. Reddy, C. N. M. *2007.* Industrial Engineering and Management. *New age International Publi*shers, India.
5. Telsang, M. 2004. Industrial engineering and production management. Tata McGraw-Hill. N. Delhi.

Fluid Mechanics 3(2-1)

Fundamentals of Fluid Mechanics: Definition and branches of fluid mechanics, distinction between solid and fluids, Properties of fluids: density, viscosity, surface tension, specific weight, specific gravity, etc., bulk modules of elasticity, compressibility of fluids. Fluid statics: Pressure variations in a fluid, pressure measuring devices, gauges and manometers, buoyancy and stability of submerged and floating bodies, forces on plane and curved surfaces, center of pressure. Fluid kinematics: Types of flow, dimensions of flow, streamlines, path lines, flow patterns for different references, continuity equation, source flow, sink flow, flow nets, uses and limitations of flow net. Pipe flow: pipe flow equations, head losses in pipes flow; friction losses due to ends, elbows, reducers, etc; pressure distribution along pipe line; laminar and turbulent flow in pipes, major and minor energy losses in pipes, branching pipes, flow distribution in pipes place in series and in parallel; pipe network analysis. Energy Consideration in Steady flow: General equations of steady flow, heads, Bernoulli's equation and its Practical applications, hydraulic and energy grade lines, power consideration in fluid flow, cavitations, head losses, solution of flow problems. Momentum and forces in fluid flow: Impulse-momentum principle and application, force exerted on a stationary and moving bodies (flat and curved), relation between absolute and relative velocities, reaction of a jet, jet propulsion, torque in rotating machines. Fluid Flow Measurements: Orifices, weirs, notches and venture meter, pitot tube, coefficient of contraction, velocity and discharge, derivation of their discharge formulae and their applications.

Practical:

Demonstration of various parts of hydraulic bench. Experimental study of laminar and turbulent flow. Experimental study of tube gauges and dead weight pressure gauges. Calibration of orifices by various methods. Calibration of Venturimeter. Calibration of rectangular and triangular notch. Verification of Bernoulli's theorem. Determination of meta-centric height. Viscosity of a given fluid by viscometer. Drag on a small sphere.

Suggested Readings:

1. Çengel, Y. A. 2010. Fluid Mechanics. Tata McGraw-Hill Education, India.

2. Daughterty, R. I., J. B., Franzini, and E. J. Finnemore. 1995. Fluid Mechanics with Engineering Application, McGraw Hill Book Co. Singapore.
3. Franzini, J. B. and Finnemore, E. J. 2003. Fluid Mechanics with Engineering Application. McGraw-Hill Book Co., Singapore.
4. Jain, A. K. 1990. Fluid Mechanics: A Text-Book for Engineering Students. Khana Publishers, New Delhi, India.
5. Streeter, V. L. 1988. Fluid Mechanics. McGraw-Hill Inc., New York. Potter, M. C., C. David and B. H. Ramadan. 2011. Mechanics of Fluids. Si Version. Cengage Learning.

Engineering Numerical Analysis 3(2-1)

Finite difference, Forward, backward and central difference and its operators form, Interpolation and extrapolation; Linear and higher order interpolating polynomials, Newton's Gregory forward and backward difference interpolation formulas and its utilization as extrapolation, Lagrange interpolation and extrapolation, Numerical differentiation based on differences, Numerical integration; Trapezoidal and Simpson' approximations, Trapezoidal and Simpson's extrapolations by Romberg integration process, Numerical Solution of non-linear equations; Bracketing and iteration methods and its applications as multiple root methods, Direct solution of the system of linear equations; Gauss-elimination, Direct and indirect factorization, symmetric factorization, tridiagonal factorization, Iterative methods like Jacob's iteration and Gauss-Seidel iteration, Numerical solution of initial value problems; Single-Step methods like Euler's method, Euler's modified method, Runge-Kutta method and its comparison with Taylor's series expansion, Multi-steps methods like Adams Bashforth and Modulation two and three step methods, Higher order differential equations, system of differential equations, Numerical solution of linear and nonlinear boundary value problems.

Practical:

Numerical solution techniques will be elaborated and demonstrated.

Suggested Readings:

1. Bhat, R. B. and S. Chakraverty. 2004. Numerical Analysis in Engineering. Alpha Science International.
2. Moin, P. 2010. Fundamentals of Engineering Numerical Analysis. Cambridge University Press.
3. Sastry, S. S. 2005.Introductory Methods of Numerical Analysis. PHI Learning Pvt. Ltd.

Fluid Flow Systems 3(2-1)

Pumps: Purposes, pump components, pump classification centrifugal, jet, positive displacement, turbine pumps, submersible pumps, propeller and mixed flow pumps and gas or air lift pumps; types of impellers (open, semi-closed, closed), terminology in pumping systems-specific speed, priming, pumping energy, total dynamic head pump problems and their remedies.

Characteristic curves: TDH-Q curve, cavitations; net positive suction head; umps location, affinity laws, pump testing, maintenance of pumps, system head curves and its components for pumps selection, pumps in parallel, pumps in series. Pumping system head and power requirements; Suction lift, well draw down, friction head loss, operating head seasonal variation in system head curve, pumps selection, prime mover electric, diesel and their selection, feasibility of prime mover selection, determining pumping head, brake horsepower; water horse power; input horse power; pumping plant efficiency.

Practical:

Study of components of various pumps; study of pump characteristics; determination of pumps efficiency; determining operating conditions and input horse power for pumps installed in parallel; determining operating condition and input horse power for pumps installed in series; laboratory study of losses in pipe flow; visit to study the pumping system and pipe flow of a selected industry.

Suggested Readings:

1. Ahmad, N. 1995. Groundwater Resources of Pakistan, Shahzad Nazir Publisher, Gulberg-III, Lahore, Pakistan.
2. Ahmad, N. 1995. Tubewell Theory and Practices, Shahzad Nazir Publishers, Gulberg-III, Lahore, Pakistan.
3. Saleh, J. 2002. Fluid Flow Handbook. McGraw-Hill Professional, USA.
4. Tranini, J. B. and E. J. Fennimove. 2003. Fluid Mechanics with Engineering Applications, McGraw-Hill Book Co., Singapore.

Engineering Mechanics 3(2-1)

Concept of measurement of mass, force, time and space, Systems of units, Fundamentals & Derived units, Conversion of units, required Accuracy of results, General Principles of Statics, Vector addition, Subtraction and Products, Resultant of Distributed (Linear & Non-linear) force Systems, General conditions of equilibrium of Co-planer forces, Laws of Triangle, Parallelogram and Polygon of forces, Types of beams, Supports and Loads, Simple cases of Axial forces, Shear forces and Bending Moment diagrams,

Problem involving friction on Flat surfaces, Geometrical Properties of Plane Areas, Work, Energy, Power, Impulse, Momentum, Conservation of Momentum and Energy, Rectilinear and Curvilinear motions, Tangential and Normal Components of Acceleration, Simple Harmonic motion

Practical:

To verify the law of polygon of forces, the law of parallelogram of forces, the principles of moments, the co-efficient of friction between surfaces. Special numerical problems and assignments. Moment of inertia of fly wheel mounted on wall and a wooden block by suspension. Efficiency of various models of machines. Modulus of rigidity of metal bar by static and dynamic methods. Special numerical problems and assignments.

Suggested Readings:

1. Bansal R. K., 2004 Engineering Mechanics and strength of materials, Mehar Offset press, New Delhi, India.
2. Khurmi R. S. 2006. Strength of Materials, Rajandar Ravindra Printers (Pvt) Ltd., New Delhi India.
3. Kumar, K. L., 2006. Engineering Mechanics 3rd edition, Tata McGraw-Hill Publishing Company Ltd. New Delhi India.
4. Meriam, J. L. and L. G. Kraige. 2005. Engineering Mechanics. Vol. I, Statics. John Wily and Sons, Co., New York.
5. Mukherjee, S. and A. R. 2011. Elements of Engineering Mechanics. PHI Learning Pvt. Ltd., India.
6. Singal, S. 2009. Engineering Mechanics. I. K. International (Pvt) Ltd., India.
7. Singer, F. L. 2000. Engineering Mechanics. Harper and Row Publishers, New York, USA.

Engineering Drawing, Graphics, and CAD 3(1-2)

Introduction to engineering drawing, various types of lines, basic geometrical constructions, conic sections, theory of orthographic projection, dimensioning & lettering, Introduction to tolerance, projections off points, projections of straight lines, Projections of planes and solids in simple position, sectioning of solids, Isometric projections, development of surfaces.

Drawing Sketches. Working with drawing Aids. Basic Dimensioning and Tolerancing. Model Space view ports, Paper space view ports and Layouts. Plotting Drawing. Hatching Drawing. Working with Blocks. Working with Advanced Drawing Options. Technical Drawing with AutoCAD. Isometric Drawing. The User Coordinate System. Getting Started with 3D. Creating Solid Models. AutoCAD on the Internet.

Practical:

Introduction to drawing instruments and their use, various scales, practice of orthographic projection missing lines in orthographic projection, Drawing three views of different objects, Practice of Dimensioning and Lettering, Practice of Sectioning, Conversion of orthographic projection into isometric view, Creating drawings of Engineering Fasteners like Rivets, Cotters Joints, threads etc. Drawing and working problems on AutoCAD Mechanical Power Pack Package.

Suggested Readings:

1. Autocad. 2004. Autocad Mechanical Power Pack, Autodesk New York, USA.
2. Auto CAD. 2005. A problem –Solving Approach Autodesk Press Sham Tickoo.
3. David A. and D. P. Madsen. 2011. Engineering Drawing and Design. Delmar Cengage Learning.
4. French, T. E. and Vierch, C. J. 2000. A Manual of Engineering Drawing, McGraw Hill Book Co. New York, USA.
5. James, H. Earle. 1992. Engineering Design Graphics, Addison-Wisley Publishing Co. Reoding Massachusetts.
6. Lang, K. L and A. J. Kalameja. 2011. AutoCAD 2012 Tutor for Engineering Graphics. Delmar Cengage Learning.
7. Parkinson A. C. 1998. A First year Engineering Drawing, Sir Isaac Pitman and Sons Ltd., England.

Mechanics of Materials 3(2-1)

Stress and strains: Stress at a point, components of stress, analysis of plane stress, principle stresses, maximum shear stress, Mohr's circle. Axial loading: Stress due to axial forces, strain, properties of material under axial loading. Bending: Bending stress in beams, shear and bending moment diagrams. Combined loading: Stresses due to axial, bending and torsional loading.

Deflection: Moment curvature relationship, deflection of beams by the method of double integration. Deflection of beams: Double integration method with singularity function, area moment method, torsion: shearing stress and angle of twist, hollow and circular shafts.

Buckling; pin ended column, eccentrically loaded column, initially curved column, critical loads and critical stresses. Curved beans, stresses in curved bars, cylinder and spheres: stresses in thin and thick walled cylinders, Fatigue loading analysis and design.

Practical:

Practical exercises related to axial loaded, bending torsions and deflection of beams. Buckling curved bars, strain gauges and fatigue loading, special numerical problems and assignments.

Suggested Readings:

1. Gere, J. M. and B. J. Goodno. 2012. Mechanics of Materials. Cengage Learning.
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 J. W. Mcnabb. 2001. Engineering Mechanics of Materials. Mac-Millan Publishing Co. New York.
5. Sarkar B. K. 2006. Strength of Materials, Tata McGraw-Hill Publishing Pvt. Ltd. New, Delhi.

FE- Project & Report-I 2(0-2)

Introduction to technical report writing, important components of technical writing, selection/preparation of research topic, objectives, review of literature, methodology, data processing, results, conclusions, summery, abstract, presentation of (data collected in the field/laboratory) results in the form of graphs, tables, figures, and photographs, references and appendices, report writing, presentation methods and skills.

FE- Project & Report–II 4(0-4)

Introduction to project planning and location, plant design and development, project analysis and evaluation, project simulation and thesis writing.

LIST OF MINOR COURSES
For BS/BE/BSc FOOD ENGINEERING

Course No.	Title of the Course	Credit Hours
1	Islamic Studies or Ethics (for foreign student)	2 (2-0)
2	English Composition & Comprehension	3 (3-0)
3	Linear Algebra & Calculus	3 (3-0)
4	Applied Physics	3 (2-1)
5	Basic Agriculture for Engineers	3 (2-1)
6	Communication and Presentation Skills	3 (2-1)
7	Food Chemistry	3 (2-1)
8	Computer Programming and Applications in Engineering	3 (2-1)
9	Differential Equations, Series, Laplace Transform	3 (3-0)
10	Sociology for Engineers	2 (2-0)
11	Pakistan Studies	2 (2-0)
12	Statistics & Probability	3 (2-1)
13	Post-harvest handling of Fruits and Vegetables	3 (2-1)
14	Food Processing and Preservation	3 (2-1)
15	Food Plant Layout and Sanitation	3 (3-0)
16	Food regulations and legislations	2 (2-0)
17	Food Industrial Waste Management	3 (3-0)
18	Food Microbiology	3 (2-1)

Islamic Studies or **Ethics for Non-Muslims** **2(2-0)**

Annexure – A

English – I **3(3-0)**
(Functional English)

Annexure – B

English – II **3 (2-1)**
(Communication Skill)

English – III
(Technical Writing & Presentation Skills)

Linear Algebra and Calculus **3(3-0)**

Basic set theory: Complex numbers: Cartesian and polar form, De Moivre's theorem, roots, exponential, trigonometric, hyperbolic and logarithmic functions', complex powers. Matrices, determinants and system of linear equations. Vector spaces: Definitions, linear dependence and independence of vectors, some theorems on linear dependence, linear transformation, bases.

Suggested Readings:

1. Kreyszig, E. 2000. Advanced Engineering Mathematics, Ed. 8th, John Wiley and Sons, New York.
2. Yusuf, S. M. and M. Amin. 2002. Mathematical Methods, Ilmi Kitab Khana, Kabir Street Urdu Bazar, Lahore.

Applied Physics 3(2-1)

Electricity and Magnetism: Voltage, current, resistance, power, single phase and 3-phase A.C. supply. Series and parallel circuits. Vector addition and subtraction of A.C. voltages. A.C/D.C. motors: Concept of rotating fields, polyphase induction motor, lap and wave winding of single phase and three phase motors, torque and starting characteristics, measuring instruments, transformers. A.C. power generators. Electrical distribution and wiring for farm buildings. Electric controls, motor controls, and protection. Selection of farm motors, applications of electricity at farm.

Electronics: Semi-conductors, PN-junction; Transistor; its characteristics and uses; Amplifiers; Power supplies; Magnetism: Electro-Megnetic induction and radiation; Radioactivity: Radio isotopes; Biological effects of radiation; Laser: Introduction, generation and uses of Laser. Fiber optics– characteristics.

Practical:

Construction of wiring systems, fuses, switches of various types insulators. Circuits design and drawing of a typical farm electrical system. Selection of motor for various farm equipment such as forage cutter, feed-grinders, and shop tools. Practice on repair and adjustment of electric motors, switches, fuses, transmission wiring controls. Study of 3 phase induction motor. Study of star and delta connections. Study of semi conductor, triode, diode valve and transistors. Use of AVO meter, CRO, plani meter. Fabrication of full wave rectifier and inductance study of its wave-shape. Measurement of self inductance and mutual inductance.

Suggested Readings:

1. Theraja, B. L. 2004. A Text-Book of Electrical Technology. S. Chand & Co. Ltd. New Delhi, India.
2. Fitzgeraid, A. E. 1994. Basic Electrical Engineering. McGraw-Hill, New York.
3. Hammond, P. 1979. Electromagnetism of Engineers. Pergamon Press, New York, USA.

Basic Agriculture for Engineers 3(2-1)

Agriculture-history, importance and branches, allied sciences, impact of climate of Pakistan on crop production. Area under crop production, Basic inputs of agriculture for crop production viz; biological, hydrological, chemical, and mechanical inputs. Land resources and their utilization in Pakistan. Principles of crop production. Tillage: its objectives and types. Cropping systems and crop rotations, Irrigation systems. Production technology of major and minor crops. Classification of field crops w.r.t their food value. Techniques and practices for enhancing crop productivity.

Practical:

Identification of various soil types; Demonstration of various irrigation methods; Demonstration and use of tillage implements, seedbed preparation and intercultural operations; Identification of various crops and their seeds w.r.t food value; Demonstration of improved sowing methods; Visits to grain storage facilities and progressive farms; Raising nursery for transplanting seedlings of non-traditional / regional crops; study of medicinal crops and organic farming.

Suggested Readings:

1. Arnon, I. 1992. Agriculture in Dry Lands-Principles and Practices. Elsevier Sci. Pub., London.
2. Chaudhri, D. P. and K. A. Dasgupta. 1985. Agriculture and the Development Process: A study of Punjab, Cromm Helm Ltd., London.

3. Cheema, Z. A. and M. Farooq. 2007. Agriculture in Pakistan. Allied Book Centre, Urdu Bazar Lahore, Pakistan.
4. Cooper, E. L. 1990. Agriscience: Fundamentals and Applications, Delmar Publisher, New York.
5. Khan, S. R. A. 2001. Crop Management in Pakistan with Focus on Soil and Water. Directorate of Agri. Information, Punjab, Lahore.
6. Nazir, M. S. 1994. Crop Production. Ed. E. Bashir & R. Bantel, National Book Foundation, Islamabad.
7. Somani, L. L. 1993. Recent Advances in Dry Land Agriculture. Part-2, Scientific Publishers, Jodhpur.

Communication and Presentation Skills 3(2-1)

Definition, types and functions of communication; effective communication and its barriers; verbal communication skills; speaking, speech making, listening, reading and writing. Preparing and delivering a speech, development of effective reading skills, art of effective writing, writing scientific and popular articles. Listening: the process, types, barriers and strategies for effective listening; non-verbal communications; characteristics, functions and types; leadership; concept, techniques, functions and characteristics; development of effective leadership skills.

Practical:

Communication & Presentation Skills labs related to speaking, speech making, listening, reading and writing.

Suggested Readings:

1. Calvert, P. (Ed.). 1990. The communication's Hand Book: Techniques and Technology. Maupin House, USA.
2. Devito, J. A. 1997. Human Communication: The Basic Course. Addison Wesley Longman, Inc., New York, USA.
3. Gronbeck, B. E., R. E. McKerrow, D. Ehninger and A. H. Monroe. 1974. Principles and Types of Speech Communication. Harper Collins College Publishers, New York.
4. Kossen, S. 1994. The Human Side of Organizations. Harper Collins College Publishers, New York, USA.
5. Roy, E. and S. Roy. 1993. Guide to Basic Writing. Prentice Hall. Englewood Cliffs. New York, USA.

Food Chemistry 3(2-1)

Brief review of organic chemistry; Structure and component of food components: Carbohydrates, proteins, lipids, water, vitamins, minerals, enzymes, phenolic compounds and pigments. Food Additives: Preservatives, colorants, antioxidants, sweeteners, emulsifiers and their role in food industries. Toxicological concepts: Contaminants and evaluation of metals,

pesticides, antibiotics mycotoxins, polycyclic aromatic hydrocarbons and toxic compounds naturally found in foods. Nutritional value of food: Calorific value and pH of food.

Practical:

Proximate analysis of moisture, ash, fibre, fat, peroxide value, acidity, pH, protein and carbohydrate. Use of analytical instrumentation like HPLC, polarimeter, conductivity meter and spectroscopic techniques. Familiarities with sensory evaluation and shelf life estimation of perishable food.

Suggested Readings:

1. David L. Nelson and Michael M. Cox Lehninger. 2005. Principles of Biochemistry; 4th ed.
2. Freeman and Comp. Fennama O.R. 1996, Food Chemistry, Marcel and Dekker, New York.
3. Berlitz H. D. & Grosh W. 1999. Food Chemistry, Publisher Springer Berlin Heidelberg, Germany.
4. Brody T. 1999, Nutritional Biochemistry, Academic Press.
5. Shi J. 2002, Functional Foods: Biochemical & Processing Aspects, CRC Press
6. Principles of Biochemistry; David L. Nelson and Michael M. Cox Lehninger, 4th ed. 2005.
7. Freeman and Fennama O. R. 1996, Food Chemistry, Marcel and Dekker, New York.

Computer Programming and Applications in Engineering 3(2-1)

Introduction: Computer components, operating system, software & applications, Programming: Introduction, programming languages, flowchart, programming structure, introduction to C++, application of C++ to solve engineering problems, modeling and simulation.

Practical:

Demonstration of computer components and Windows installation. Exercise on the use of word processing, spreadsheet and engineering graphics. Programming of engineering problems with C++.

Suggested Readings:

1. Perry, G. and M. Johnsons. 1992. Turbo C++ by Examples. Prentice Hall Computer Publishing, New York, USA.
2. Shelly and Cashman. 1996. Using Computer, a Gateway to Information. Boyd and Fraser Publishing Company, USA.

Differential Equations, Power Series, Laplace Transform 3(3-0)

Ordinary Differential Equation: Basic concepts of ordinary differential equation, General and particular solution, Initial and boundary condition, Linear and nonlinear differential equations, Solution of first order differential equation by separable variables and its application in our daily life situations, Techniques like change in variables homogeneous, non-homogeneous, exact, non-exact, linear and non-linear Bernoulli could be used in case of complications. Solution of second order differential equations by theory of operators and its application as forced and free oscillations, the extension of second order solution criteria to high order differential equations, solution of the system of differential equations by theory of operators and its application in daily life situations.

Partial Differential Equations: Basic Concepts, linear and non-linear P. D equations, Quasi linear and Quasi non-linear P. D equations, homogenous and non-homogenous P. D equations, solutions of P. D equations, boundary and initial conditions as dirichlet conditions, Neumann's condition, Robbin's/mixed condition, classification of P. D equations as Elliptic conditions, Parabolic and hyperbolic. Analytic Solution by separation of Variables of the Steady State, two dimensional heat equation/Laplace equation and un-steady one dimensional heat equation/Diffusion equation with homogenous and non-homogenous boundary conditions. D'Alembert's solution of two dimensional wave equation homogenous and non-homogenous boundary conditions. Fourier Series: Periodic waveforms and their Fourier representations, calculating a Fourier series, Fourier series of odd and even functions, Half range Fourier series, Fourier series solution for the above P. D equations.

Suggested Readings:

1. Kreyszig, E. 1999. Advanced Engineering Mathematics. John Wiley and Sons, New York, USA.
2. Yousaf, S. M. 1998. Mathematical Methods, Ilmi Kitab Khana Kabir Street, Urdu Bazar, Lahore, Pakistan.
3. Sharma, G. S., K. L. Auhuja and I. J. S. Sarna.1988. Advanced Mathematics for Engineers and Scientists. Tata McGraw-Hill Co., India.

Sociology for Engineers 2(2-0)

Studying the Group Dynamics; Types of Social Groups, Primary and Secondary groups, In-groups and Out-groups, Reference Group; Group Dynamics; Group Size, Leadership, Social Loafing, Social Dilemmas, Groupthink, Conformity. Types of Disputes: Dispute Resolution Techniques; Participatory Irrigation Management; Organizational Techniques for Sustainable Social Organizations: A Case Study; Community Development: A Case Study of AKRSP.

Suggested Readings:

1. Bhatti, M. A., M. A. Cheema and G. V. Skogerboe. 1999. Maintenance and Operational Activities in the Command Area of Shahpur and Mirwal Small Dam. Pakistan National Programme International Irrigation Management Institute Lahore. Report No. R-78.
2. James, W. and V. Zanden. 1988. The Social Experience: An Introduction to Sociology. Random House, New York.
3. Starkloff, R., D. J. Bandaragoda, M. A. Cheema and M. A. Bhatti. 1999. Social Organization for Improved System Management and Sustainable Irrigation Agriculture in Mirwal and Shahpur Small Dams. Pakistan National Program International Irrigation Management Lahore. Report No. R-80.
4. Charles D Fledderman, Engineering Ethics, Prentice Hall, New Mexico, 1999.

Pakistan Studies 2(2-0)

Annexure - C

Statistics and Probability 3(2-1)

Statistics: Mean value, Measures of central tendency, Measures of variation, Standard deviation, Expected value of a random variable, Standard deviation of a random variable, The Poisson distribution, The uniform distribution, The exponential distribution, The normal distribution, The standard normal, The standard normal distribution. Probability**:** Sets, Application of Venn Diagrams, Introducing probability, Mutually exclusive events, The addition law of probability, Complementary events, Concepts from communication theory, Problems related to engineering, Conditional probability, The multiplication law, Independent events, Baye's formula, Permutations and combinations, Multiplication principle, Problems related to engineering, science and management, Applications of counting, Bernoulli trials, Binomial probability, Markov chains, Probability distribution, Expected value, Decision making, Problems related to engineering and management.

Practical:

Simple, Multiple and Component bar diagram. Historigram, Frequency polygon, Frequency curve, c.f. curve, cumulative percentage curve and locate Quantiles. Problem assignments relating probability. Fitting a Binomial distribution. Fitting a Poison distribution. Fitting a Normal distribution. Sampling distribution of difference between two means. Application/use of t-test for Null hypothesis. Test of significance of association of attributes by x^2-test (chi-square test). Testing goodness of fit. Calculating a simple, partial and a multiple correlation and their tests of significance. Fitting a simple linear regression equation and its test of significance by Analysis of Variance (F-test) and t-test. Analysis of variance of data from C. R. D., R. C. B. D. and L. S. design.

Suggested Readings:

1. Choudhry, S. M. and S. Kamal. 1998. Introduction to Statistical Theory Part I & II; Ilmi Kitab Khana, Kabir Street, Urdu Bazar, Lahore, Pakistan.
2. Erwin Kreyszig, Advanced Engineering Mathematics 8th Edition, John Wiley & Sons Publication.
3. Lind, D., W. Marchal, and S. Wathen. 2011. Basic Statistics for Business and Economics with Formula Card (7th ed.). The McGraw-Hill/Irwin Series Operations and Decision Sciences, McGraw-Hill Co., India.
4. Miller I. and J. E. Freund. 1985. Probability and Statistics for Engineers. Prentice Hall, Inc., Englewood Cliffs, New Jersey, USA.
5. Muhammad, F. 1999. Statistical Methods and data analysis; Kitab Markaz, Bhowana Bazar, Faisalabad, Pakistan.
6. Ronald E. Walpole. 1982. Introduction to Statistics; McMillan publishing Co., Inc. New York. USA.
7. Taylor, L. D. 1974. Probability and Mathematical Statistics. Harper & Row, Publishers New York, USA.
8. Walpole R. E. 1982. Introduction to Statistics, McMillan publishing Co, Inc. New York.

Post-harvest handling of Fruits and Vegetables 3(2-1)

Importance of postharvest science and technology; fruits and vegetable classification; maturity indices, quality standards, harvest and postharvest handling, pack house operations and transport of important fruits and vegetables.

Practical:

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

Suggested Readings:

1. Florkowski, W. J. and R. L Shewfelt, B. Brueckner, and S. E. Prussia. 2009. Postharvest Handling; A Systems Approach (2nd Ed.). Academic Press.
2. Kader, A. A. 2002. Postharvest Technology of Horticulture Crop (3rd Ed.). University of California. Agriculture and natural Resources. California, USA.
3. Kader, A. A. 2002. Postharvest Technology of Horticulture Crop (3rd Ed.). University of California. Agriculture and natural Resources. California, USA.
4. Kitinoja, L. and A. A. Kader. 2003. Small-Scale postharvest handling practices. A manual for Horticultural Crops (4th Ed.). University of California, Davis, Postharvest Technology Research and Information Centre.
5. Kitinoja, L. and A. A. Kader. 2003. Small-Scale postharvest handling practices. A manual for Horticultural Crops (4th Ed.). University of California, Davis, Postharvest Technology Research and Information Centre.

Food Processing and Preservation 3(2-1)

Preparatory operations: cleaning, sorting, grading, size reduction, blanching, sulphiting. Heat processing: methods – thermisation, pasteurization, HTST, commercial sterilization, UHT. Canning: unit operations. Retort operation: equipment. Ohmic heating: Principles, processes and equipment design. Effect of heat processing: nutrients, microorganisms. Low temperature preservation: refrigeration: methods and equipments. Use of chemical additives: contaminants, adulterants, additives. Food additives: classification, criteria for selection, GRAS additives, permissible limits, food safety, E-numbers. Preservation by fermentation technology: principles, objectives, types - alcoholic, acetic and lactic fermentations. Fermented foods: bread, wine, vinegar, yoghurt, sausages, pickles. Food irradiation: principles, applications, equipments, safety aspect, effect on food properties, detection methods.

Practical:

Bottling/canning of selected fruits, vegetables. Cold storage of fruits and vegetables. Freezing of fruits and vegetables. Dehydration of fruits and vegetables. Use of chemicals in preservation of food products. Production of vinegar, yoghurt and pickles. Evaluation of bottled, frozen and dehydrated products. Visit to food industries. Ohmic heating procedure for food quality test.

Suggested Readings:

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

Food Plant Layout and Sanitation 3(3-0)

Food processing industry: introduction, investment. Plant location and layout: significance, location analysis, selection criteria - freedom from pollution, availability of potable water, raw material, labor and energy supply, communication facilities, facilities for waste disposal. Plant cleaning: soil types, methods, detergents, water conditioners. Sanitizing: chemical, heat, irradiation. Cleaning methods – CIP, dismantling cleaning. Pests: types, inspection, control. Waste management: fluid and solid wastes. HACCP: introduction, requirements.

Suggested Readings:

1. Arvanitoyannis, I. S. 2008. Waste management for the food industries. Elsevier Academic Press, New York, USA.
2. Farber, J. M. and E. C. D. Todd. 2000. Safe handling of foods. Marcel and Dekker, New York, USA.
3. Leliveld, H. L. M., M. A. Mostert, and J. Holah. 2005. Handbook of hygiene control in food industry. Woodhead Publishing Ltd., Abington Hall, Abington, Cambridge, UK.

Food Regulations and Legislations 2(2-0)

Pakistan Standards: Standards and Quality Control Authority: functions, authorities. Pure Food Rules: Background, definitions, significant features, enforcement, amendments; Food inspector and public analyst: qualifications, duties, powers. Food Adulteration: Adulterants, health hazards, methods of detection. Food Labelling: Perspectives on nutrition labelling; Islamic food laws and regulations: sources, principles, lawful foods, unlawful foods; Consumer laws in Pakistan. International Food Laws: Introduction, The World Trade Organization (WTO) - the agreement on the application of sanitary and phytosanitary measures; GATT; Codex Alimentarius: general, procedural manual, standards, codes, legal force.

Suggested Readings:

1. Janjua Z I. 1987. Food laws manual. Law Times Pub., Lahore, Pakistan.
2. Rees N and D. Watson. 2000. International standards for food safety. Kluwer Sci. Pub, New York, USA.

Food Industrial Waste Management 3(3-0)

Food industrial wastes: types; sources and characteristics of food processing wastes. Waste disposal and physical, chemical and biological treatments. BOD, COD, Bio processing in food waste treatment. Management of waste by products: sugar, fruits and vegetable, meat, fish, oil and fat, dairy and cereals. Recovery of materials from effluents by different systems. Utilization of food industry wastes. ISO Environmental Standards.

Suggested Readings:

1. Arvanitoyannis, L. S. 2008. Waste management for the food industries. Elsevier Academic Press, Oxford, USA.
2. Lawrence, K. W. and M. U. S. Wang. 1992. Hand Book of Industrial Waste Treatment. Harcep Dekker, Inc., New York, USA.
3. Lee, B. H. 1996. Fundamentals of food biotechnology. VCH Pub. Inc., New York, USA.
4. Waldron, K. 2008. Handbook of waste management and co-product recovery in food processing. CRC press, New York, USA.

Food Microbiology 3(2-1)

History, branches, scope and significance of microorganism. Overview of eukaryotic and prokaryotic cell, characteristic of Microorganism, nomenclature, culture media, Growth curve. Introduction to microorganism important in food industry and their effects in food products (food born diseases). Measures to control growth of such organism in food. Cleaning, disinfection, sanitation. Combined methods, preventive measures; GMP, GHP, SSOP, HACCP. Beneficial microorganism in food industries. Structure of Nucleic acid, DNA replication, protein synthesis, gene transfer. Spoilage of various foods causes of spoilage, types of spoilage. Examination: Sampling, microbial test procedures, indicator organisms, food poisoning organisms, food spoilage organisms.

Practical:

Microscopic study of food pathogens, familiarities with washing, cleaning, sterilization and inoculation using instrumentation like autoclave, laminar flow, incubators and drying oven.

Suggested Readings:

1. Adams M. R. and M. O. Moss. 2005. Food Microbiology (Second Edition). Thomas Graham House, Science Park, Milton Road, Cambridge CB4 OWF, UK.
2. Bibek R. 2004, Fundamental Food Microbiology III Edition, CRC Press LLC

3. Hogg, S. 2005. Essential Microbiology. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, UK.
4. Jay, J. M., M. J. Loessner and D. A. Golden. 2010. Modern Food Microbiology (Food Science Text Series). Springer Science + Business Media, Inc., Spring Street, New York, NY 10013, USA.
5. Montville, T. J. and K. R. Matthews. 2008. Food Microbiology: An Introduction. Amazone Company.
6. Ray, B and A. Bhljnia. 2008. Fundamentals of food Microbiology (4th Ed). CRC Press Taylor & Frands Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Ratan, FL 33487-2742.

Islamic Studies

Annexure - A

OPTIONS FOR FOUNDATION AND BREADTH AND DEPTH COURSES

Note: All the optional courses should be compatible with regard to credit hours approved in the scheme of studies

A. Options for Foundation Courses

Foundation 1 (Base) Basic Agriculture for Engineers 3(2-1)

Agriculture-history, importance and branches, allied sciences, impact of climate of Pakistan on crop production. Area under crop production, Basic inputs of agriculture for crop production viz; biological, hydrological, chemical, and mechanical inputs. Land resources and their utilization in Pakistan. Principles of crop production. Tillage: its objectives and types. Cropping systems and crop rotations, Irrigation systems. Production technology of major and minor crops. Classification of field crops w.r.t their food value. Techniques and practices for enhancing crop productivity.

Practical:

Identification of various soil types; Demonstration of various irrigation methods; Demonstration and use of tillage implements, seedbed preparation and intercultural operations; Identification of various crops and their seeds w.r.t food value; Demonstration of improved sowing methods; Visits to grain storage facilities and progressive farms; Raising nursery for transplanting seedlings of non-traditional / regional crops; study of medicinal crops and organic farming.

Suggested Readings:

1. Arnon, I. 1992. Agriculture in Dry Lands-Principles and Practices. Elsevier Sci. Pub., London.
2. Chaudhri, D. P. and K. A. Dasgupta. 1985. Agriculture and the Development Process: A study of Punjab, Cromm Helm Ltd., London.
3. Cheema, Z. A. and M. Farooq. 2007. Agriculture in Pakistan. Allied Book Centre, Urdu Bazar Lahore, Pakistan.
4. Cooper, E. L. 1990. Agriscience: Fundamentals and Applications, Delmar Publisher, New York.
5. Khan, S. R. A. 2001. Crop Management in Pakistan with Focus on Soil and Water. Directorate of Agri. Information, Punjab, Lahore.
6. Nazir, M. S. 1994. Crop Production. Ed. E. Bashir & R. Bantel, National Book Foundation, Islamabad.
7. Somani, L. L. 1993. Recent Advances in Dry Land Agriculture. Part-2, Scientific Publishers, Jodhpur.

Foundation 2 (Base) Metallurgy & Workshop Practices

Production and properties of common engineering materials: Ferrous metals, iron ores, properties and uses of pig iron, cast iron, wrought iron, steel, standard processes of manufacturing of Iron and steel, open hearth process, basic oxygen processes, production of ingots. Composition/properties and uses of plastics, rubber, fibre glass and composite materials. Alloy steel and Irons: Effect of alloying elements, the AISI/SAE alloy steel and their identification, corrosion resistant steel, steel for high temperature services, alloy steel. Non-ferrous metals: Properties and uses of copper, aluminum, zinc, tin, nickel, and lead. Non-ferrous alloys, copper alloys. Aluminum alloys, zinc base alloys, nickel base alloys. Lead-tin alloys, iron-carbon equilibrium diagram. Heat treatment: Heat treatment theory and process, heat treatment of steel, annealing, hardening, tempering, normalizing, surface hardening, quenching, heat treatment equipment. Welding: Definition, types of welding process, survey of welding equipment. Arc welding; Current rating, welding materials, arc welding processes, inspection and testing of welded joints. Gas welding; Welding flames and materials, cutting of metals, gas welding processes.

Foundry: Definition, importance, advantages and disadvantages of foundry, casting, hand moulding tools, characteristics of moulding sand, foundry cores, properties of core and, crucibles, handling and care, copula furnace, construction, zone of copula and its advantages. Safety and First Aid: Safety in the shop, mechanical and other accidents, safety devices, safety methods, first aid equipment and methods, care and order in the workshop.

Practical:

Identification of tools and machines in the workshop. Identification of different metals by spark tests and advance methods. Demonstration of different heat

treatment processes. Practice of arc welding. Practice of gas welding. Safety and first aid in the workshop related to electrical, mechanical and other accidents. Safety in the use of hand tools. Visits to local foundries.

Suggested Readings:

1. Chapman, W. A. J. 2004. Workshop Technology Part-I.and II. Viva Books Private Ltd., India.
2. Rao. P. N. 2002. Manufacturing Technology: metal cutting and machine tools. Tata McGraw-Hill Co. Ltd. New Delhi, India
3. Ostwald, P. H. and J. Munoz. 2002. Manufacturing Processes and systems. 9th edition John Wiley and Sons, New York. USA.
4. Havey, D. Miner. 1999. Exploring Pattern Making and Foundry. The MacMillan Co. N. Y., USA.

Foundation 3 (Base) Fluid Flow Systems

Pumps: Purposes, pump components, pump classification centrifugal, jet, positive displacement, turbine pumps, submersible pumps, propeller and mixed flow pumps and gas or air lift pumps; types of impellers (open, semi-closed, closed), terminology in pumping systems-specific speed, priming, pumping energy, total dynamic head pump problems and their remedies.

Characteristic curves: TDH-Q curve, cavitations; net positive suction head; umps location, affinity laws, pump testing, maintenance of pumps, system head curves and its components for pumps selection, pumps in parallel, pumps in series.

Pumping system head and power requirements; Suction lift, well draw down, friction head loss, operating head seasonal variation in system head curve, pumps selection, prime mover electric, diesel and their selection, feasibility of prime mover selection, determining pumping head, brake horsepower; water horse power; input horse power; pumping plant efficiency.

Practical:

Study of components of various pumps; study of pump characteristics; determination of pumps efficiency; determining operating conditions and input horse power for pumps installed in parallel; determining operating condition and input horse power for pumps installed in series; laboratory study of losses in pipe flow; visit to study the pumping system and pipe flow of a selected industry.

Suggested Readings:

1. Ahmad, N. 1995. Groundwater Resources of Pakistan, Shahzad Nazir Publisher, Gulberg-III, Lahore

2. Ahmad, N. 1995. Tubewell Theory and Practices, Shahzad Nazir Pubishers, Gulberg-III, Lahore.
3. Tranini, J. B. and E. J. Fennimove. 2003. Fluid Mechanics with Engineering Applications, McGraw-Hill Book Co., Singapore.

Foundation 4 (Base) Food Toxicology

Toxicology: basic concepts, toxicants, Toxicity: curve, factors influencing. Dose response relationship. Intrinsic and extrinsic toxicants: overview. Toxicological testing methods: acute, subacute and chronic toxicity. Toxicants in the body: absorption, translocation and excretion.

Food Safety: characterization, risk assessment. Food hazards: physical, chemical and biological. Systems for food safety surveillance: GAP, GMP, HACCP, CIP, SSOP related standards over view. Organic solvent, Lubricant and Cleaning agents' safety evaluation.

Suggested Readings:

1. Sharma PD.1997. Toxicology. Rastogi publication, Meerut, India.
2. Lu FC and kacew S.2002.Lu's basic Toxicology .4th ed. Taylor & Francis Inc. New York. NY.
3. Blanchfied JR.1998.Good Manufacturing Practices. Institute of Food Science & Technology, London.

Foundation 5 (Base) Introduction to Food Engineering

Development of food engineering and its scope, Importance of chemistry and biological science in food engineering, Industries based on Raw materials; Heat processing of food, processing of baked and snacked food, honey, syrups, confectionery, beverages, milk and fish, freezing and cold storage of food, microwave heating; Personal cleanliness, buildings and facilities; Food processing from harvest to preservation, packaging and distribution.

Suggested Readings:

1. Heldman, D. R. 2007. Handbook of food engineering (2nd ed.) 6000 Broken sound Parkway NW, Suit 300, Boca Raton, FL 33487-2742.
2. Singh R. P. and D. R. Heldman. 2009. Introduction to Food Engineering (4th ed.) Academic Press is an imprint of Elsevier, 30 Corporate Drive, Suite 400, Burlington, MA 01803, USA.
3. Yanniotis, S. 2008. Solving Problems in Food Engineering. ISBN: 978-0-387-73513-9 eISBN: 978-0-387-73514-6, Library of Congress Control Number: 2007939831. Yanniotis, S. 2008. Solving Problems in Food Engineering. Springer Science+Business Media, LLC., 233 Spring Street, New York, NY10013, USA.

Foundation 6 (Base) Electrical Technologies for Food Engineers

Electric Circuits; Kirchoff's Laws, Superposition theorem, Substitution theorem. Thevenin's theorem, Norton's theorem, Rosen's theorem of star / mesh transformation, Transformers, generators and their accessories; Voltage and current relations, Balanced and unbalanced load analysis; Elementary concept of armature reaction and commutation, Cross and demagnetizing ampere turns; Motors, Induction Motors, Rotating field theory, Principle of working, Slip and its effect on motor current quantities, Losses, efficiency and performance curves, Starting, Full load and maximum torque relations, Torque slip characteristics; Construction, working principles, Emf equation, Electrical circuits; Voltage and current ratios of single and three phase converters, Mercury arc Rectifiers, Construction, Operation, Voltage and current ratios of single phase and three phase rectifiers.

Suggested Readings:

1. Baksh, T. A. 2009. Electrical Technology (4th ed.) Technical Publications Punes
2. Thereja, B. L. 2006. A textbook of Electrical Technology (1st ed.. S. Chand Publisher.

B. Options for Breadth Courses

Elective 1 (Breadth) Machine Vision and Industrial Automation

Machine Automation: Introductions to programming controllers, Number system and codes, Logic concepts, processors, power supply, programming devices, memory system and I/O interaction, discrete input output system, analog input output system. Programmable Logic Controllers (PLC), Programming Languages, ladder logic simulator, Programmable Logic Controllers startup and maintenance, system selection guidelines, Human Machine Interface (HMI), fundamentals of Supervisory Control and Data Acquisition (SCADA).

Machine Vision**:** Introduction to machine vision, Illumination and sensors; Illumination, image formation, camera sensors, camera interfaces and video standards, characteristics of camera sensors, commercially available camera sensors. Image acquisition and presentation; image acquisition hardware, speed considerations, inter-pixel distances.

Fundamentals of digital image processing; point operations, geometric operations, mathematical morphology, Segmentation problem. Image Analyses, techniques for shape description, representation and information processing, organization of visual processes, visual representations, and

visual processes. Industrial Automation and Its Components; Motor Control & Industrial Automation control circuits.

Practical:

Demonstration and selection of PLC. Basic task to ladder logic programming. Intermediate task to ladder logic programming. Advance task to ladder logic programming. Installation of program in PLC. Testing of program in PLC and its reliability. Demonstration of different sensors and cameras used in machine vision. Demonstration to image processing software. A case study of image processing.

Suggested Readings:

1. Dhillon, B. S. 2007. Applied Reliability and Quality: Fundamentals, Methods and Procedures.
2. Hornberg, A. 2006. Hand Book of Machine Vision, Litges & Dopf Buchbinderei. Latest Information and company manuals about PLC, HMI, SCADA and Machine Vision.
3. Mitsubishi. 2007. Programming Manual. Mitsubishi Electric, Japan.
4. Pletney, V. N. 2007. Focus on *Food Engineering* Research and Developments. Nova Science Publishers.
5. Sun, D. W. 2011.Computer *Vision* Technology for *Food* Quality Evaluation. Food Science and Technology, International Series.
6. Vernon, D. 2002. Machine Vision. Prentice Hall Ltd., Ireland.

Elective 2 (Breadth) Renewable Energy Resources for Food Industry

Energy reclamation from agricultural crops/wastes: Energy and agricultural biomass production, bio-fuel, critical parameters of design, installation, operation and management of family and community biogas plants, vegetable oils as fuel. Classification and characterization of food stuffs, heat transfer phenomena, heat transfer and solid foods, heat transfer and liquid foods, thermal process equipment, examples on control and optimization of thermal process. Solar energy: Introduction, solar system, solar radiation, solar radiation at outer limit of atmosphere, estimation of solar radiation, direct and diffuse radiation, radiation measurement, solar radiation collectors, water and air heating, drying of agricultural products with solar radiation, space heating with solar energy, solar energy conservation.

Energy Consumption in Farming: Energy for crop production, dairy farming, poultry farming, energy consumption for waste water treatment and solid wastes, energy conservation. Wind Power: Wind energy potential, vertical and horizontal axis wind mills, wind operated pumps and water lifts, other applications of wind power in agriculture. Energy and Environment:

Greenhouse effect, energy dissipation through industrial and engine emissions and their impact on environment.

Practical:

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

Suggested Readings:

1. Hobs, P. N. 1981. Methane production from agricultural and domestic wastes. Applied Sci. Publishers Ltd, London, U. K. Jewell, W. J. 1996. Energy, agriculture, and waste management. Ann Arbor Science. Publisher Inc. Ann Arbor, Michigan, USA.
2. McVeigh. 1987. Sun power; an introduction to the application of solar energy. Programme Press, N. Y. USA.
3. Pimental, D. 1993. Hand book of energy utilization in Agriculture. CRC Press Inc. 2000 corporate. Blvd. Florida, USA.
4. Stout, B. A. 1990. Hand book of energy for world Agriculture. Elsevier Science B. V., Amsterdam - Lausanne - New York - Oxford - Shannon – Tokyo.
5. Threlkeld, J. L. 1993. Thermal environmental engineering. Prentice Hall, Inc. Englewood Cliffs, N. Y. USA.

Elective 3 (Breadth) Engineering Economics & Management

Management Fundamentals: Management, Administration, Leadership, Relationship Vs Task Management, Project and Program, Project Life Cycle, Trade Off. Line/Project Organization, Functional Organization, Matrix and Mixed Organization. Role and Responsibilities, Career Path, Special Demands on the Project Manager, Common Characteristics of a most effective Team, Selection of a Project Manager. Project Scheduling and Control: Network Techniques, PERT, CPM & GRANT Charts, Use of Project management Software's, Crashing of a Project, Physical Assets Control, Human Resource Control, Financial Control.
Marketing Management: Selling versus Marketing, Role of a company: Leader, Follower, Challenger, Basics of Marketing, Place, Price and Promotion. Role of a company in Market Place. Economics and Accounting: Budgeting Methods, Cost Estimation, Assets, Liabilities, Capital and Revenue Expenditure, Depreciation, Depletion, Amortization, Owner's Equity

Debentures, Loan Financing, Accounting, Quards Ledgers, Profit and loss statement.

Suggested Readings:

1. Anonymous. 2002. The Certified Quality Auditors HACCP Handbook. ASQ Food, Drug and Cosmetic Division. ASQ Quality Press, Milwaukee Wisconsin, USA.
2. Hand Outs on Engineering Economy and ISO 9000.
3. Meredith, J. R. and S. J. Mantel. (2000) Project Management, McGraw-Hill Co. Ltd. New Delhi, India.
4. Narasimha Swamy, N. (2007) Engineering Economics & Management, Dynaram Publications, India

Elective 4 (Breadth) Food Biotechnology

Biotechnology: Introduction, history. Microbial metabolism. Developments in metabolic and biochemical engineering: metabolites, range of fermentation process, components of fermentation process .Isolation and preservation of industrially important microorganisms. Industrial fermentation: media, design and types of fomenters, process variable in fermentation, recovery, purification of fermentation products . Production of organic acids, enzymes, amino acids, single cell proteins, carotenoids and fermented food products. Microbial genetics: conjugation social aspects of food biotechnology. Recycling of agriculture waste: renewable energy generation. Genetic concept of replication, translation and transcription in production of GMO food ingredients: advantages and disadvantages perception.

Practical:

Isolation, purification and maintenance of yeast and bacterial cultures. Aerobic and anaerobic fermentation and production of various fermented food products.

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. Shetty, K., Paliyath, G, Pometto, A. and Levin, RE.2005. Food biotechnology .Marcel Dekker Inc., New York, USA.
3. Borem, A., Santos, F. R. and Bowen, D. E.2004. Understanding Biotechnology. Pearson Education Inc., New Jersey, USA.

Elective 5 (Breadth) Food Biochemistry

Brief review of organic chemistry; overview of cellular structures and processes; acids, bases and buffers; amino acids and peptide bonds; protein structure and function; enzymes; biochemical basis of diseases; use of biochemical measurements for diagnosis. Thermodynamics of biological processes; adenosine triphosphate (ATP) and phosphoryl group transfers; oxidation-reduction reactions; ATP synthesis via oxidative phosphorylation in mitochondria. Carbohydrate structure, glycoconjugates: proteoglycans, glycoproteins and glycolipids; digestion of carbohydrates; glycogen structure and metabolism; glycolysis; gluconeogenesis; the pentose phosphate pathway; regulation of glycolysis and gluconeogenesis; the citric acid cycle.

Lipids and membranes; digestion of triacylglycerol; fatty acid and triacylglycerol synthesis; triacylglycerol storage in adipose tissues; cholesterol and bile salt metabolism; blood lipoproteins; fatty acid oxidation; ketone body synthesis and utilization; phospholipid and sphingolipid metabolism. Protein digestion and amino acid absorption; the urea cycle; synthesis and degradation of amino acids; role of various tissues in amino acid metabolism; molecules derived from amino acids. Nucleic acid structure: RNA and DNA; the genome; DNA synthesis (replication); RNA synthesis (transcription); protein synthesis (translation); regulation of gene expression; recombinant DNA and biotechnology.

Suggested Readings:

1. Garrett, R. H and C. M. Grisham. 2008. Biochemistry (4th Ed.). Brooks/Cole, Cengage Learning
2. Hui, Y. H., Wai-Kit Nip, Leo M. L. Nollet and G. Paliyath. 2006. Food Biochemistry and Food Processing.
3. Nelson, D. L and M.M. Cox. 2005. Lehninger Principles of Biochemistry (4th ed.), Freeman and Comp.
4. Pamela C. and C. Lippincott. 2005. Biochemistry (3rd ed.). Lippincott's Illustrated Review, Williams & Wilkins.
5. Voet, D. V and J. G. Voet 2010. Biochemistry (4th ed.) VP & Publisher Kaye Pace

Elective 6 (Breadth) Food Enzymology

Chemical and biological reactions, reaction types, determination of reaction rate constants, factors effecting reaction kinetics, microbial death and enzyme kinetics, semi-continuous and continuous fermentation systems, design of a bioreactor, biomass formation kinetics, substrate consumption kinetics, inhibition kinetics, determination of oxygen transfer coefficient and specific oxygen consumption rate, determination of yield and productivity values in bioprocesses; Factors affecting reaction rates in foods, calculation of kinetic parameters for reactions in foods, effects of temperature on

reaction rates in foods; Kinetics of biomass production, substrate utilization and product formation in cell cultures, kinetics of microbial death and enzyme inactivation. Reaction rates; theories about reaction rates; factors affecting reaction rates in foods; calculation of kinetic parameters for reactions in foods; effects of temperature on reaction rates in foods; Kinetics of biological reactions; Kinetics of biomass production; substrate utilization and product formation in cell cultures; Kinetics of microbial death and enzyme inactivation.

Suggested Readings:

1. Kolev, D. 2013.Enzymology. Amazon.com Textbooks Store
2. Whitaker, J. R. 2003. Handbook of Food Enzymology, Publisher-Marcel Dekker, New York, USA.
3. Whitaker, J. R., G. J Alphons, and D. W. S. Wong. 2002. Handbook of Food Enzymology, Food Science and Technology.

C. Options for Depth Courses

Elective 1 (Depth) Food Processing and Preservation 3(2-1)

Preparatory operations: cleaning, sorting, grading, size reduction, blanching, sulphiting. Heat processing: methods – thermisation, pasteurization, HTST, commercial sterilization, UHT. Canning: unit operations. Retort operation: equipment. Effect of heat processing: nutrients, microorganisms. Low temperature preservation: refrigeration: methods and equipments.
Use of chemical additives: contaminants, adulterants, additives. Food additives: classification, criteria for selection, GRAS additives, permissible limits, food safety, E-numbers. Preservation by fermentation technology: principles, objectives, types - alcoholic, acetic and lactic fermentations. Fermented foods: bread, wine, vinegar, yoghurt, sausages, pickles. Food irradiation: principles, applications, equipments, safety aspect, effect on food properties, detection methods.

Practicals

Bottling/canning of selected fruits, vegetables. Cold storage of fruits and vegetables. Freezing of fruits and vegetables. Dehydration of fruits and vegetables. Use of chemicals in preservation of
food products. Production of vinegar, yoghurt and pickles. Evaluation of bottled, frozen and dehydrated products. Visit to food industries.

Suggested Readings

1. Brennan, JG. 2006. Food processing handbook. Wiley-VCH Verlag GmbH & Co. KGaA, 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.

Electives 2 (Depth) Sugar & Confectionery Technologies

Composition and properties Sugarcane and sugar beet and honey, Sugar of Molasses: production, quality; Indigenous technology for small scale sugar production: *gur, khund, shaker*; Raw sugar manufacturing: unit operations, Bagging, storage; Factors affecting sugar processing; Quality criteria: raw and refined sugar; Specialty sugar products: brown or soft sugar, liquid sugar; Sugar industry by-products and their uses; Caloric and non-caloric sweeteners; Nutritional Value, Sweetening Power, Processing, Toxicology and Safety. Packaging, By-products and their Utilization. Quality Control. Non- Nutritive Sweeteners; Significance, classification, industries in Pakistan. Ingredients, manufacturing - high boiled sweets, caramel, toffee, fudge, gums; Need, ingredients, manufacture; Chewing gum technology; Chocolate confectionery; History, manufacture - potato, nuts, cereal, meat and fish based; Puffed and baked snacks; Ingredients, formulations, applications; Quality control; Packaging;

Suggested Readings:

1. Delgado, A.V. 2001. Sugar Processing and By-Products of the Sugar Industry,
2. William, W.P. 2000. The Science of Sugar Confectionery, RSC

Elective 3 (Depth) Process Control in Food Industry

Importance; introduction to process control principles; definition of control objectives; Basics of mathematical modelling; process control elements; definition of open and closed loop systems; transfer functions and block diagrams; Types and selection of control schemes; Process control of selected food engineering operations; Bioreactors, blanching, pasteurization and sterilization, drying, freezing, evaporation and concentration, baking and extrusion.

Suggested Readings:

1. Koughner and Couple. Process Modelling and Control (7th ed.)
2. Luyben, W. and L. L. Michael. 1997. Essentials of Process Control. McGray Hill, Inc., USA.

NCRC Recommendations for Food Engineering Under-graduate Program

The degree nomenclature of Food Engineering Program will be BSc/BE/BS Food Engineering.

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. The food Engineering program may be registered as a separate engineering profession with PEC.
3. The PEC is required to legislate for induction of food engineering graduates in the food industries of Pakistan.
4. 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 at federal and provincial levels.
5. The HEC need to facilitate the required necessary funding to the universities offering food engineering program.
6. 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.
7. The Federal and Provincial Food Control Authorities be approached by HEC and PEC for employment of graduates of food engineering.
8. For any institution seeking eligibility for F.Sc. pre medical students, it will be mandatory to launch zero semesters in addition to four year degree program in food engineering to cover the deficiency of Pre-Engineering courses.
9. All the optional courses should be compatible with regard to credit hours approved in the scheme of studies
10. Facilities of training abroad to the faculty members in food engineering program be provided by HEC on priority basis.
11. Preference be given by HEC to offer scholarships to the deserving graduates for higher studies abroad.
12. 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.
13. Faculty should manage to attend national/international conferences/expo with the financial support from HEC related to the field of Food Engineering.

Objectives:

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
Effectively practice Food Process Engineering for the design and operation of systems for processing of biological materials with Controlled Atmosphere (CA) practices and also to develop products for the food industries.			√	√				√	√	√
Have demonstrated proficiency in fundamental engineering skills and technical knowledge as well as professional and personal skills appropriate for their profession.	√		√		√		√			
Are prepared for future challenges and opportunities in the areas of food engineering and value addition/food security through the discovery and applications of technical knowhow.		√		√				√		√

Subjects outcomes:

Course title	PO1	PO2	PO3	PO3	PO4	PO5
	An ability to apply knowledge of mathematics, science, and engineering	An ability to design and conduct experiments, as well as to analyze and interpret data	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	An ability to function on multidisciplinary teams	An ability to identify, formulate, and solve engineering problems	An understanding of professional and ethical responsibility

PO6	PO7	PO8	PO9	PO10
An ability to communicate effectively	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	A recognition of the need for, and an ability to engage in life-long learning	An understanding of biological and food process engineering principles	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Non-Engineering Domain											
Islamic Studies or Ethics (for foreign student)			√			√			√		
English Composition & Comprehension	√			√		√	√		√		
Linear Algebra & Calculus	√		√		√						√
Applied Physics	√	√	√					√			√
Basic Agriculture for Engineers	√	√	√		√					√	
Communication & Presentation Skills				√		√	√				
Food Chemistry	√	√	√		√					√	√
Computer Programming and Applications in Engineering	√	√	√	√	√		√				√
Differential Equations, Series, Laplace Transform	√		√		√						√
Sociology for Engineers			√			√	√		√		
Pakistan Studies			√			√			√		
Statistics & Probability	√	√	√		√		√	√			√
Post-harvest handling of Fruits and Vegetables	√			√	√					√	
Food Processing and Preservation	√			√	√			√		√	√
Food Plant Layout and Sanitation	√		√		√					√	√
Food Regulation and Legislation	√		√	√	√	√					
Food Industrial Waste Management	√	√	√					√			
Food Microbiology	√	√						√			√
Engineering Domain											
Metallurgy & Workshop Practices			√		√						√
Manufacturing Engineering		√	√	√	√						√
Engineering Thermodynamic	√		√		√		√	√		√	
Instrumentation and Measurements			√		√						√
Agricultural Processing			√	√						√	√

Engineering											
Engineering Economics & Management			√			√	√	√	√		
Industrial Engineering & Management		√	√	√	√				√		√
Fluid Mechanics	√	√			√						
Engg. Numerical Analysis	√	√	√		√			√			√
Fluid flow systems		√			√			√			
Engineering Mechanics	√		√		√				√		√
Engineering Drawing Graphics and CAD	√	√	√	√			√	√			√
Mechanics of Materials			√					√			
Major Based Core											
Physical Properties of Food			√		√		√			√	
Food Engineering Design		√	√		√						√
Material and Energy Balance					√			√		√	√
Principles of Food Process Engineering			√		√			√			
Food Engineering Operations-I			√	√			√	√	√	√	√
Heat and Mass Transfer					√				√	√	√
Food Engineering Operations II			√	√	√		√	√		√	√
Machine Vision and Industrial Automation			√		√			√	√		√
Food Quality Control			√	√		√					
Food Storage Engineering		√		√						√	√
Food Product and Plant Design		√	√		√			√			√
Post-Harvest Engineering			√	√		√				√	√
Food Packaging			√	√						√	√
Renewable Energy Resources for Food Industry			√		√			√			
Project & Report I-II	√	√	√	√	√	√	√	√	√	√	√

COMPULSORY COURSES

Annexure - A

Islamic Studies

Aims:

1 To provide Basic information about Islamic Studies
2 To enhance understanding of the students regarding Islamic Civilization
3 To improve Students skill to perform prayers and other worships
4 To enhance the skill of the students for understanding of issues related to faith and religious life**.**

Contents:

Introduction to Quranic Studies

- Basic Concepts of Quran
- History of Quran
- Uloom-ul -Quran

Study of Selected Text of Holy Quran

- Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
- Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
- Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
- Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
- Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holy Quran

- Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6, 21, 40, 56, 57, 58.)
- Verses of Surah Al-Hashar (18,19, 20) Related to thinking, Day of Judgment
- Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

- Life of Muhammad Bin Abdullah (Before Prophet Hood)
- Life of Holy Prophet (S.A.W) in Makkah
- Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

- Life of Holy Prophet (S.A.W) in Madina
- Important Events of Life Holy Prophet in Madina
- Important Lessons Derived from the life of Holy Prophet in Madina

Introduction to Sunnah

- Basic Concepts of Hadith
- History of Hadith
- Kinds of Hadith
- Uloom-ul-Hadith
- Sunnah & Hadith
- Legal Position of Sunnah

Introduction to Islamic Law & Jurisprudence

- Basic Concepts of Islamic Law & Jurisprudence
- History & Importance of Islamic Law & Jurisprudence
- Sources of Islamic Law & Jurisprudence
- Nature of Differences in Islamic Law
- Islam and Sectarianism

Islamic Culture & Civilization

- Basic Concepts of Islamic Culture & Civilization
- Historical Development of Islamic Culture & Civilization
- Characteristics of Islamic Culture & Civilization
- Islamic Culture & Civilization and Contemporary Issues

Islam & Science

- Basic Concepts of Islam & Science
- Contributions of Muslims in the Development of Science
- Quranic & Science

Islamic Economic System

- Basic Concepts of Islamic Economic System
- Means of Distribution of wealth in Islamic Economics
- Islamic Concept of Riba
- Islamic Ways of Trade & Commerce

Political System of Islam

- Basic Concepts of Islamic Political System
- Islamic Concept of Sovereignty
- Basic Institutions of Govt. in Islam

Islamic History

- Period of khlaft-e-rashida
- Period of Umayyads
- Period of Abbasids

Social System of Islam

- Basic concepts of social system of Islam
- Elements of family

- Ethical values of Islam

Recommended Readings:

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 Jurisprudence 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)

Annexure - B

English I
(Functional English)

Objectives: Enhance language skills and develop critical thinking.

Course Contents:

Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension

Answers to questions on a given text

Discussion

General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening

To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Introduction

Note: Extensive reading is required for vocabulary building

Recommended Books:

1. **Functional English**

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492

2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

English II
(Communication Skills)

Objectives: Enable the students to meet their real life communication needs.

Course Contents:

Paragraph writing
Practice in writing a good, unified and coherent paragraph

Essay writing
Introduction

CV and job application

Translation skills
Urdu to English

Study skills
Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills
Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills
Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books:

Communication Skills

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing

1. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading

1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
2. Reading and Study Skills by John Langan
3. Study Skills by Riachard Yorky.

English III

(Technical Writing and Presentation Skills)

Objectives: Enhance language skills and develop critical thinking

Course Contents:

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended books:

Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing
   1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).

   2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
   3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills
c) Reading
   The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

Pakistan Studies
(Compulsory)

Introduction/Objectives:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

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

Recommended Books:

1. Burki, Shahid Javed. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.

4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
5. Wilcox, Wayne.*The Emergence of Banglades.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.