

Scheme and Syllabus

B.Tech. Food Technology

Batch 2019 onwards



By
Department of Academics

IK Gujral Punjab Technical University

PROGRAMME EDUCATIONAL OBJECTIVES(PEOs)

- To provide quality education to the students to groom them in a way that they become capable and efficient techno managers in the area of Food Technology
- To impart the knowledge of basic principles and techniques with respect to various aspects of food
- To convert the students into industry professionals with high professional ethics and efficiency to meet the growing demands of modern Food Industries globally

Programme Outcomes (POs)

| | |
|-------------|--|
| P01 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. |
| P02 | Problem Analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| P03 | Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| P04 | Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| P05 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| P06 | The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| P07 | Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development. |
| P08 | Ethics: Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice. |
| P09 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| P10 | Communication: Communicate effectively on complex engineering activities with the engineering community and with society. Some of them are, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| P011 | Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| P012 | Lifelong Learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change. |

Programme Specific Outcomes (PSOs)

| | |
|---------------|---|
| PSO1: | Familiarize students with major and minor food components, analytical techniques, instrumentation and changes resulting from processing techniques for addressing technical and engineering challenges in raw and processed foods. |
| PSO2: | Understand the engineering and technology of handling, storage, processing, packaging, waste management, environmental impact and preservation of foods. |
| PSO 3: | Enhance capability of students to solve real problems related to food product development with regards to its overall quality, safety, society and environment. |
| PSO4: | Strengthen the foundation of students to build up career in industry, pursue higher studies in food as well as interdisciplinary areas and to build up the knowledge of current issues in addition to encouraging the students to start-up their own business ventures. |

I. K. G. Punjab Technical University
B.Tech. Food Technology

(w. e. f. session 2019-20)

General, Course structure & Theme & Semester-wise credit distribution

A. Definition of Credit:-

| | |
|------------------------------|-------------|
| 1 Hr. Lecture (L) per week | 1 credit |
| 1 Hr. Tutorial (T) per week | 1 credit |
| 1 Hr. Practical (P) per week | 0.5 credits |
| 2 Hours Practical(Lab)/week | 1 credit |

B. Range of credits:-

A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

AICTE Structure of Undergraduate Engineering program:-

For all semesters

| Sr. No. | Category | Suggested Breakup of Credits(Total 160) |
|---------|---|---|
| 1 | Humanities and Social Sciences including Management courses | 12* |
| 2 | Basic Science courses | 25* |
| 3 | Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc | 24* |
| 4 | Professional core courses | 48* |
| 5 | Professional Elective courses relevant to chosen specialization/branch | 18* |
| 6 | Open subjects – Electives from other technical and /or emerging subjects | 18* |
| 7 | Project work, seminar and internship in industry or elsewhere | 15* |
| 8 | Mandatory Courses [Induction training, Environmental Sciences, Indian Constitution, Essence of Indian Traditional Knowledge] | (non-credit) |
| | Total | 160* |

**Minor variation is allowed as per need of the respective disciplines.*

Course code and definition:-

| Course code | Definitions |
|--------------------|---|
| L | Lecture |
| T | Tutorial |
| P | Practical |
| C | Credits |
| BSC | Basic Science Courses |
| ESC | Engineering Science Courses |
| HSMC | Humanities and Social Sciences including Management courses |
| PCC | Professional Core Courses |
| PEC | Professional Elective Courses |
| OEC | Open Elective Courses |
| MC | Mandatory courses |
| PROJ. | Project |

I. K. G. Punjab Technical University
Choice Based Credit System Scheme and Syllabi
(w. e. f. session 2019-20)
B.TECH (FOOD TECHNOLOGY)

| Semester | I | | II | | III | IV | V | VI | VII | VIII | Total |
|---|-------------|-------------|-------------|-------------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | A | B | A | B | | | | | | | |
| Humanities and Social Sciences including Management Courses (HSMC) | | 3 | 3 | | | | 2 | 2 | 3 | | 10 |
| Basic Sciences Courses (BSC) | 9.5 | 9.5 | 9.5 | 9.5 | 4 | | | 3 | | | 26 |
| Engineering Sciences Course (ESC) | 8 | 8 | 8 | 8 | 7 | 3 | | | | | 26 |
| Professional Core Course (PCC) | | | | | 7 | 17 | 16 | 9 | 6 | 4 | 59 |
| Professional Elective Course (PEC) | | | | | | | | 6 | 6 | 6 | 18 |
| Open Elective Course (OEC) | | | | | | | 3 | 3 | 3 | | 9 |
| Internship in Industry/ In-Plant Training/ Project-1and Project- 2/ Seminar | | | | | | | 2 | | 4+1 | 6 | 12 |
| Non Credit Mandatory Courses (MC) | 0 | 0 | 0 | 0 | 0 | | 0 | | | | |
| Total | 17.5 | 20.5 | 20.5 | 17.5 | 18 | 20 | 23 | 23 | 23 | 16 | 160 |

IMPORTANT NOTES:

1. The minimum credit requirement for B.Tech (Food Technology) is 160. Each semester will be of approximately 16- 23 credits and 24-31 contact hours per week.
2. Each theory examination will be of 3 hours duration and practical examination will be of 2 to 4 hours duration. One laboratory hour per week per semester will be assigned half credit. No elective course will be run unless the number of students registered for the elective course is five or more.
3. The student is required to register for one “Open Elective Course” paper in Semester 5th, 6th and 7th of his/her choice from any department, other than the parent department.
4. At the end of 2nd and 3rd year each student will undergo 4-6 and 6-8 weeks training/ internship in an industry /research institute/organization respectively and it will be evaluated in 5th semester and 7th semester.
5. Student will be required to submit an offer letter to the department for In-Plant Training at least 15 days before the commencement of 8th semester. During 8th semester a student may opt In-Plant Training of 4-6 of months or project along with subjects. The In-Plant Training and **Project** will be evaluated at the end of eight semester. Supervisor will get half credit per student per week for the Project.

SEMESTER III

| Category | Course Code | Course Title | Hours per week | | | Marks Distribution | | Total | Credits |
|----------|-----------------|--|----------------|----------|----------|-----------------------------|----------|-------|-----------|
| | | | L | T | P | Internal | External | | |
| MC | EVS 101-18 | Environmental Science | 2 | 0 | 0 | 100 | - | 100 | 0 |
| BSC | BTFT 211-19 | Introduction to Biology and Microbiology | 2 | 0 | 0 | 40 | 60 | 100 | 2 |
| BSC | BTFT 212-19 | Introduction to Biology and Microbiology Lab | 0 | 0 | 4 | 60 | 40 | 100 | 2 |
| PCC | BTFT PCC 213-19 | Food Composition and Analysis | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 214-19 | Food Composition and Analysis Lab | 0 | 0 | 4 | 60 | 40 | 100 | 2 |
| PCC | BTFT PCC 215-19 | Nutrition and Health | 2 | 0 | 0 | 40 | 60 | 100 | 2 |
| ESC | BTEC 216-19 | Engineering Properties of Food | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| ESC | BTEC 217-19 | Thermodynamics | 3 | 1 | 0 | 40 | 60 | 100 | 4 |
| | BMPD 301-18 | Mentoring & professional development | 0 | 0 | 2 | Satisfactory/Unsatisfactory | | | - |
| | | TOTAL | 15 | 1 | 8 | | | | 18 |

SEMESTER IV

| Category | Course Code | Course Title | Hours per week | | | Marks Distribution | | Total | Credits |
|----------|-----------------|---|----------------|----------|----------|-----------------------------|----------|-------|-----------|
| | | | L | T | P | Internal | External | | |
| PCC | BTFT PCC 221-19 | Food Biochemistry | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 222-19 | Principles and Methods of Food Processing | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 223-19 | Principles and Methods of Food Processing Lab | 0 | 0 | 4 | 60 | 40 | 100 | 2 |
| PCC | BTFT PCC 224-19 | Food Engineering | 3 | 1 | 0 | 40 | 60 | 100 | 4 |
| PCC | BTFT PCC 225-19 | Food Microbiology | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 226-19 | Food Microbiology Lab | 0 | 0 | 4 | 60 | 40 | 100 | 2 |
| ESC | BTEC 227-19 | Heat and Mass Transfer | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | BMPD 301-18 | Mentoring & professional development | 0 | 0 | 2 | Satisfactory/Unsatisfactory | | | - |
| | | TOTAL | 15 | 1 | 8 | | | | 20 |

SEMESTER V

| Category | Course Code | Course Title | Hours per week | | | Marks Distribution | | Total marks | Credits |
|------------------------|-----------------|---|----------------|---|---|--------------------|----------|-------------|---------|
| | | | L | T | P | Internal | External | | |
| HSM | HSMC301-19 | Economics for Engineers | 2 | 0 | 0 | 40 | 60 | 100 | 2 |
| MC | MC104-T-19 | Essence of Indian Traditional Knowledge | 3 | 0 | 0 | - | - | 0 | 0 |
| PCC | BTFT PCC 311-19 | Processing of Grains | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 312-19 | Processing of Grains Lab | 0 | 0 | 4 | 60 | 40 | 100 | 2 |
| PCC | BTFT PCC 313-19 | Fruits and Vegetables Processing | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 314-19 | Fruits and Vegetables Processing Lab | 0 | 0 | 4 | 60 | 40 | 100 | 2 |
| PCC | BTFT PCC 315-19 | Food Safety, Quality and Regulations | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 316-19 | Food Refrigeration and Cold Storage Construction | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| IPT | BTFT 317-19 | In Plant Training Seminar (4-6 weeks) | 0 | 0 | 4 | 60 | 40 | 100 | 2 |
| OPEN ELECTIVE COURSE-I | | Open Elective-I (from any other Department) | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| 23 | | | | | | | | | |
| Open Elective Course | BTFT 318-19 | Open Elective-I (for the students of other teaching department) Processing and preservation of food | 3 | 0 | 0 | 40 | 60 | 100 | 3 |

SEMESTER VI

| Category | Course Code | Course Title | Hours per week | | | Marks Distribution | | Total | Credits |
|-------------------------|-----------------|--|----------------|---|---|--------------------|----------|-------|-----------|
| | | | L | T | P | Internal | External | | |
| HSM | HSMC302-19 | Fundamentals of Management for Engineers | 2 | 0 | 0 | 40 | 60 | 100 | 2 |
| BSC | BTFT 320-19 | Statistics for Food Technologists | 2 | 1 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 321-19 | Technology of Milk and Milk Products | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 322-19 | Technology of Milk and Milk Products Lab | 0 | 0 | 4 | 60 | 40 | 100 | 2 |
| PCC | BTFT PCC 323-19 | Fermentation Technology | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 324-19 | Fermentation Technology Lab. | 0 | 0 | 2 | 60 | 40 | 100 | 1 |
| PEC | | Professional Elective – I | | | | | | | |
| PEC | PEFT 325.1-19 | Bioprocess Engineering | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PEC | PEFT 325.2-19 | Technology of Beverages | | | | | | | |
| PEC | PEFT 325.3-19 | Specialty Foods | | | | | | | |
| PEC | | Professional Elective – II | | | | | | | |
| PEC | PEFT 326.1-19 | Technology of Pulses and Oilseeds | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PEC | PEFT 326.2-19 | Technology of Spices and Herbs | | | | | | | |
| PEC | PEFT 326.3-19 | Dairy Process Engineering | | | | | | | |
| OPEN ELECTIVE COURSE-II | | Open Elective-II (from any other Department) | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | | | | | | | | | 23 |
| Open Elective Course | BTFT 327-19 | Open Elective-II (for the students of other teaching department) Food Safety, Quality and Regulations | 3 | 0 | 0 | 40 | 60 | 100 | 3 |

SEMESTER VII

| Category | Course Code | Course Title | Hours per week | | | Mark distribution | | Total | Credits |
|--------------------------|--------------------|---|----------------|----------|-----------|-------------------|-----------|------------|-----------|
| | | | L | T | P | Internal | External | | |
| HSMC | HSMC401-19 | Personality Development | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFTPCC 411-19 | Instrumental Analysis of Foods | 2 | 0 | 0 | 40 | 60 | 100 | 2 |
| PCC | BTFT PCC 412-19 | Instrumental Analysis of Foods Lab. | 0 | 0 | 2 | 60 | 40 | 100 | 1 |
| PCC | BTFT PCC 413-19 | Waste Management and Effluent Treatment | 2 | 0 | 0 | 40 | 60 | 100 | 2 |
| PCC | BTFT PCC 414-19 | Waste Management and Effluent Treatment Lab. | 0 | 0 | 2 | 60 | 40 | 100 | 1 |
| PEC | | Professional Elective- III | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | PEFT415.1-19 | Food Plant Design and Layout | | | | | | | |
| | PEFT415.2-19 | Food and Agri Business Management | | | | | | | |
| | PEFT415.3-19 | Food Flavours and Colours | | | | | | | |
| PEC | | Professional Elective-IV | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | PEFT416.1-19 | Technology of Frozen Foods | | | | | | | |
| | PEFT416.2-19 | Meat, Fish and Poultry Processing | | | | | | | |
| | PEFT416.3-19 | Food Product Development and Sensory Evaluation | | | | | | | |
| IPT | BTFT 417-19 | In-Plant Training (6-8 weeks) | 0 | 0 | 6 | 60 | 40 | 100 | 4 |
| Project | PRFT-1 | Project-1 | 0 | 0 | 2 | 60 | 40 | 100 | 1 |
| OPEN ELECTIVE COURSE-III | | Open Elective –III (from any other department) | 3 | 0 | 0 | | | | 3 |
| | | | 16 | 0 | 12 | | | | 22 |
| Open Elective Course | BTFT418-19 | Open Elective –III (for the students of other teaching department) Instrumental Analysis of Foods | 3 | 0 | 0 | 40 | 60 | 100 | 3 |

SEMESTER VIII

| Category | Course Code | Course Title | Hours per week | | | Marks Distribution | | Total | Credits |
|----------------|--------------------|--|---------------------|----------|-----------|--------------------|----------|-------|---------|
| | | | L | T | P | Internal | External | | |
| PCC | BTFT PCC 421-19 | Food Packaging | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| PCC | BTFT PCC 422-19 | Food Packaging Lab. | 0 | 0 | 2 | 60 | 40 | 100 | 1 |
| PEC | | Professional Elective –V | | | | | | | |
| | PEFT423.1-19 | Baking and Confectionary Technology | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | PEFT423.2-19 | Technology of Fats and Oils | | | | | | | |
| | PEFT423.3-19 | Snack Food Technology | | | | | | | |
| PEC | | Professional Elective –VI | | | | | | | |
| | PEFT424.1-19 | Introduction to Food Additives | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | PEFT424.2-19 | Technology of Traditional Foods | | | | | | | |
| | PEFT424.3-19 | Functional Foods and Nutraceuticals | | | | | | | |
| Project | PRFT- 2 | Project 2 (6-8 weeks) | 0 | 0 | 12 | 60 | 40 | 100 | 6 |
| 16 | | | | | | | | | |
| IPT | BTFT426-19 | In Plant Training Seminar+ Report+ Viva | (4-6 Months) | | | 60 | 40 | 100 | 10 |
| Project | PR FT- 2 | Project 2 | (6-8 weeks) | | | 60 | 40 | 100 | 6 |
| 16 | | | | | | | | | |

SEMESTER

THIRD

| | | |
|-----------|---|--|
| RBT Level | Course Outcomes: After the completion of the course, the students will be able to: | |
| L1 | CO1 | Describe the basic organization of organisms and subsequent building to a living being. |
| L2 | CO2 | Explain the machinery of the cell functions that is ultimately responsible for various daily activities. |
| L3 | CO3 | Demonstrate the minimum nutritional requirements of microorganisms and the factors affecting their growth. |
| L4 | CO4 | Differentiate the mechanism of metabolism of various type of nutrients. |
| L5 | CO5 | Appraise the role of microorganisms in different fields. |

UNIT-I

Basic Cell Biology: Introduction: Methods of Science-Living Organisms: Five kingdom classification, Cells and Cell theory, Cell Structure, Function and chemical constituents of living cell and cell division.

UNIT-II

Nutrient Metabolism: structure and function of protein, carbohydrate (TCA, Pyruvate cycle etc.), fat and enzymes. Mineral nutrition: Essential minerals, macro and micro nutrients and their role, Nitrogen metabolism.

UNIT-III

The nutritional requirements and types of microorganisms (Carbon, Hydrogen, nitrogen, phosphorus, Oxygen and growth factors); Microbial Growth curve, Measurement of Growth; Factors effecting growth. Microbiology of carbon, nitrogen, phosphorus and sulphur transformations.

UNIT-IV

Role of microorganisms in organic matter degradation, maintenance of soil fertility and pest control; Microbiology of soil. Microbiology of air. Microbiology of water. Importance of bacteria, yeast, molds in food industry; Overview of Microorganisms associated with different fermented foods; Role of microorganisms in food borne infections and intoxications.

Recommended Readings:

1. ThyagaRajan S, Selvamurugan N, Rajesh M P, Nazeer R A, Thilagaraj R W, S. Barathi, and M. K. Jaganathan (2012) “*Biology for Engineers,*” Tata McGraw-Hill.
2. Weaver R (2012) “*Molecular Biology,*” McGraw-Hill (5th Ed).
3. Stainier R.Y. Ingraham J. L., Wheelis M. L. & Painter P. R. (2003) *General Microbiology.*
4. Tauro P. Kapoor K. K. & Yadav K. S. (1996) *Introduction to Microbiology. New Age International Pvt. Ltd. New Delhi.*
5. William Carroll Frazier (1967) *Food Microbiology.*

Mapping of Course Outcome (CO) and Program Outcome (PO)

| Course Code: BTFT 211-19 | | Course Title: Introduction to Biology and Microbiology | | | | | | | | | | | | | | | |
|---|-----------------------------|---|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------------|------|------|------|------|
| (1/2/3 indicates strength of the correlation) 3-Strong, 2-Medium, 1-Weak | | | | | | | | | | | | | | | | | |
| | Program Outcome (PO) | | | | | | | | | | | | PSO | | | | |
| | | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | PSO4 |
| Course Outcome (CO) | CO 1 | | 2 | 1 | | | | | | | | | | 2 | | 3 | |
| | CO 2 | | | | 1 | 1 | | | | | | 1 | | 1 | 2 | 3 | |
| | CO 3 | | 2 | | | 2 | | | | | | 1 | | 1 | 2 | 1 | |
| | CO 4 | | 1 | 1 | | | | | | | | | | | 2 | | 2 |
| | CO 5 | | 1 | 2 | | | | | | | | 1 | | | 1 | | 3 |

| | | |
|-----------|---|--|
| RBT Level | Course Outcomes: After the completion of the course, the students will be able to: | |
| L1 | CO1 | Describe the preparation of standard solutions and buffers. |
| L2 | CO2 | Estimate the various components of cells using different techniques. |
| L3 | CO3 | Operate simple & micropipettes and microscope. |
| L4 | CO4 | Examine the cell structure using different instruments. |
| L5 | CO5 | Evaluate the quantity of microorganisms using different methods. |

To learn use of microscope and principles of fixation and staining, Preparation of Normal, molar and standard solutions, phosphate buffers, serial dilutions, Use of micropipettes, Separation of amino acids and chloroplast pigments by paper chromatography, Perform gram staining of bacteria, Study the cytochemical distribution of nucleic acids and mucopolysaccharides in cells/tissues from permanent slides, Perform quantitative estimation of protein using the Lowry's method and determine the concentration of the unknown sample using the standard curve plotted, Separate and quantify sugars by thin layer chromatography, Raise the culture of E. coli and estimate the culture density by turbidity method and draw a growth curve from the available data, Isolation of genomic DNA from E.coli.

Mapping of Course Outcome (CO) and Program Outcome (PO)**Course Code: BTFT 212-19****Course Title: Introduction to Biology and Microbiology Lab****(1/2/3 indicates strength of the correlation) 3-Strong, 2-Medium, 1-Weak**

| | Program Outcome (PO) | | | | | | | | | | | | PSO | | | | |
|----------------------------|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|
| | | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | PSO4 |
| Course Outcome (CO) | CO 1 | | 2 | 1 | | | | | | | | | 1 | 2 | | 3 | 3 |
| | CO 2 | | | | 1 | 1 | | | | | | 1 | 2 | 1 | 2 | 3 | 2 |
| | CO 3 | | 2 | | | 2 | | | | | | 1 | | 1 | 2 | 1 | 1 |
| | CO 4 | | 1 | 1 | | | | | | | | | 2 | | 2 | | 2 |
| | CO 5 | | 1 | 2 | | | | | | | | 1 | 1 | | 1 | | 3 |

Course Title: Food Composition and Analysis

Hours per week: 3+0+0

Credits: 3

| | | |
|-----------|---|---|
| RBT Level | Course Outcomes: After the completion of the course, the students will be able to: | |
| L1 | CO1 | Draw the chemical structure of carbohydrates, proteins and fats |
| L2 | CO2 | Explain the properties and functions of food macromolecules and some micronutrients. |
| L3 | CO3 | Employ different methods for quantitative and quantitative analysis of different food. |
| L4 | CO4 | Compare various enzymes with respect to their rate of action and site for working. |
| L5 | CO5 | Select the appropriate method for food analysis by applying food composition knowledge. |

UNIT-I

Carbohydrates: Introduction, General Properties, Monosaccharides, Oligosaccharides, Polysaccharides, Nutritional Value of Carbohydrates, Commercial Sugar and Sugar Products, Qualitative Analysis and Quantitative Analysis.

UNIT-II

Lipids: Introduction, Simple Lipids and their Constituents, Compound Lipids, Derived Lipids, Nutritional Value of Fats and Fat Products, Commercial Fats and Fat Products, Deterioration of Fats, Analysis.

UNIT-III

Protein: Introduction, Amino Acid and the Peptide Bond, Classification Of Proteins, Structure of Proteins, Molecular Weight and Isoelectric Point of Proteins ,Analysis of Proteins; Vitamins and Minerals: Nomenclature, classification and analysis Introduction, Enzymes: Introduction, Nomenclature and Classification, Food Enzymes.

UNIT-IV

Weighing Devices, Visible and Ultraviolet Spectrophotometry, Thin-Layer Chromatography, pH, Sampling, Moisture, Crude Fat, Crude Protein, Crude Fiber.

Recommended Readings:

1. Wang, D. (2012). *Food Chemistry*: Nova Science Publishers.
2. Chopra, H. K. & Panesar, P. S. (2010). *Food chemistry*: Alpha Science International Ltd, Oxford, U.K.
3. Coultate, T. P. (2009). *Food: The Chemistry of Its Components* (5 ed.): American Chemical Society.
4. Newton, D.E. (2009). *Food Chemistry*: Facts On File, Incorporated.
5. Damodaran, S., Parkin, K. L., & Fennema, O. R. (2007). *Fennema's Food Chemistry*: CRC Press, Taylor and Francis group.

Mapping of Course Outcome (CO) and Program Outcome (PO)

| Course Code: BTFT 213-19 | | Course Title: Food Composition and Analysis | | | | | | | | | | | | | | | | |
|---|-----------------------------|--|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------------|------|------|------|------|---|
| (1/2/3 indicates strength of the correlation) 3-Strong, 2-Medium, 1-Weak | | | | | | | | | | | | | | | | | | |
| | Program Outcome (PO) | | | | | | | | | | | | PSO | | | | | |
| | | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | PSO4 | |
| Course Outcome (CO) | CO 1 | 2 | 1 | | | | | | 2 | | | | 1 | 2 | 1 | 2 | 2 | 3 |
| | CO 2 | | 2 | | | | | | | | | | 1 | 1 | 1 | 2 | 1 | 1 |
| | CO 3 | | 1 | 2 | | | | | 1 | | | | 2 | 1 | | 1 | 2 | 2 |
| | CO 4 | | | | | | | | 1 | | | | 2 | | 2 | 1 | | |
| | CO 5 | 3 | 2 | | | | | | | | | | | 1 | | | 2 | 3 |

Course Title: Food Composition and Analysis Lab.

Hours per week: 0 + 0 +4

Credits: 2

| | | |
|-----------|---|--|
| RBT Level | Course Outcomes: After the completion of the course, the students will be able to: | |
| L1 | CO1 | Describe the different methods of food sampling. |
| L2 | CO2 | Explain the different methods used for food analysis. |
| L3 | CO3 | Apply the qualitative and quantitative methods of food analysis. |
| L4 | CO4 | Examine the results of food analysis and use it for further data analysis. |
| L5 | CO5 | Judge the composition of different food materials. |

Methods of sampling for food analysis. Moisture analysis – oven drying method / moisture meter. Qualitative test for carbohydrates – Molisch test, Barfoed test, Benedict test. Determination of total carbohydrates, various types of starches, soluble sugars and reducing sugars. Methods of protein analysis – Kjeldahl method / Biuret method. Determination of total fats and oils – solvent extraction method. Determination of free fatty acids value, saponification value and iodine value in food samples. Mineral analysis by atomic absorption spectrophotometer and flame photometer. Chromatographic methods for separations and quantification of various vitamins. Determination of total phenols and tannins by colorimetric method. Some important chemical test and analysis for food additives and flavour components.

Mapping of Course Outcome (CO) and Program Outcome (PO)**Course Code: BTFT 214-19****Course Title: Food Composition and Analysis Lab.****(1/2/3 indicates strength of the correlation) 3-Strong, 2-Medium, 1-Weak**

| | Program Outcome (PO) | | | | | | | | | | | | PSO | | | | |
|----------------------------|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|
| | | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | PSO4 |
| Course Outcome (CO) | CO 1 | 2 | 1 | | | | | | 2 | | | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO 2 | | | 1 | | 2 | | | | | | 2 | 2 | 1 | 2 | 1 | 2 |
| | CO 3 | | 1 | 2 | | | | 1 | | | | 2 | 1 | 2 | | 2 | 1 |
| | CO 4 | | | | | 2 | | 1 | | | | 1 | | 2 | 1 | | |
| | CO 5 | 3 | 2 | | | | | | | | | | 1 | | | 2 | 3 |

| | | |
|-----------|---|--|
| RBT Level | Course Outcomes: After the completion of the course, the students will be able to: | |
| L1 | CO1 | Define the terms and concepts related to food and nutrition. |
| L2 | CO2 | Explain and classify the requirement and source of nutrients essential for human health |
| L3 | CO3 | Discuss the role of nutrition in infections and diseases. |
| L5 | CO4 | Distinguish the role of nutrition education and different organizations for improving health of the masses nationwide. |
| L6 | CO5 | Design and formulate balanced diet plans for different vulnerable groups according to RDAs. |

UNIT-I

Scope, concepts and importance of nutrition; definition of various terms related to nutrition, human digestive system, Malnutrition and its types, epidemiology of under nutrition and over nutrition, nutrition infection and immunity

UNIT-II

Nutrients: Classification, functions, sources, requirement and deficiency of proteins, carbohydrates, lipids, vitamins and minerals. Importance of dietary Fiber and water in human health, Energy - definition, units of measurement of energy, basal metabolic rate (BMR), specific dynamic action (SDA) of foods, factors affecting BMR and respiratory quotient (RQ)

UNIT-III

Recommended Dietary Allowance (RDA) for reference man and woman, concept of Balanced diets, diets for different age groups, Nutrition - role of nutrition in pregnancy and lactation, infant nutrition, childhood nutrition, geriatric nutrition; Nutrition of special groups: (space & sports)

UNIT-IV

Importance of Nutrition Education, Role of different national and international organizations in maintaining health and nutritional status, nutritional policies like food for work, mid-day meals, integrated child development services (ICDS) vitamin A and Iron, prophylaxis, measures; Existing food fads and fallacies & how to overcome

Recommended Readings:

1. Joshi S. A., (1992) *Nutrition and Dietetics* Tata Mc Grow- Hill publishing Company Ltd., New Delhi
2. M. Swaminathan, Vol I & II *Foods and Nutrition* NIN Publications
3. Manay S., and Shadksharawamis N., *Food: Facts and Principles*, New Age International Pvt. Ltd., New Delhi.
4. Mann J., and Truswell S., (2007) *Essentials of Human Nutrition 3rd Ed.* Oxford University Press, 2007.
5. Khanna (1997) *Textbook of Nutrition and Dietetics*, Phoenix Publisher House Pvt. Ltd., New Delhi.
6. Eastwood M. S., (2003) *Principles of Human Nutrition 2 ed*, Blackwell Publishers.

Mapping of Course Outcome (CO) and Program Outcome (PO):

| Course Code: BTFT 215-19 | | Course Title: Nutrition and Health | | | | | | | | | | | | | | | |
|--|----------------------|------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|
| (1/2/3 indicates strength of the correlation) 3-Strong, 2-Medium, 1-Weak | | | | | | | | | | | | | | | | | |
| | Program Outcome (PO) | | | | | | | | | | | | PSO | | | | |
| | | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | PSO4 |
| Course Outcome (CO) | CO 1 | 2 | 1 | | | | | | 2 | | | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO 2 | | | 1 | | 2 | | | | | | 2 | 2 | 1 | 2 | 1 | 2 |
| | CO 3 | | 1 | 2 | | | | 1 | | | | 2 | 1 | 2 | | 2 | 1 |
| | CO 4 | | | | | 2 | | 1 | | | | 1 | | 2 | 1 | | |
| | CO 5 | 3 | 2 | | | | | | | | | | 1 | | | 2 | 3 |

Course Code: BTFT 216-19

Course Title: Engineering Properties of Foods

Hours per week:3+0+0

Credits: 3

| | | |
|-----------|---|---|
| RBT Level | Course Outcomes: After the completion of the course, the students will be able to: | |
| L1 | CO1 | Describe various physical and rheological properties of food and biomaterials. |
| L1 | CO2 | Describe thermal properties and flow behaviour of foods. |
| L2 | CO3 | Explain psychrometrics, dielectric, surface and colorimetric properties of foods. |
| L5 | CO4 | Judge the processing technique to be adopted for various foods according to their properties. |
| L6 | CO5 | Design the various equipments by considering the various properties of foods. |

UNIT-I

Mass, volume, area related properties of foods and their measurement techniques; Rheological properties of food: stress, strain, Hooke's law, elasticity, Plasticity, ductility; flow behavior: Newtonian and Non Newtonian fluid, Time dependent and independent flow behavior.

UNIT-II

Thermal properties of food: specific heat capacity, thermal conductivity, enthalpy, thermal diffusivity, experimental approach to measure thermal properties; Thermodynamic properties of food: Thermodynamic food-water system, sorption energy, significance of thermal properties; Psychrometrics: Properties of dry air, composition of air, specific heat of dry air, enthalpy of dry air, properties of water-vapour, properties of air-vapour mixtures, psychometric chart, application of psychometric chart in food processing.

UNIT-III

Dielectric properties of food: principle, measurement, frequency and temperature dependence, composition dependence of dielectric properties; assessment of food quality by using dielectric properties, effects of processing and storage on dielectric properties of foods.

UNIT-IV

Surface properties: surface tension, fundamental consideration, Gibbs adsorption equation and contact angle measurement techniques; colorimetric properties of food: measurement of colour, colour spectrum etc.

Recommended Readings:

1. Rao M. A., Rizvi S. S. H., Datta A. K. & Jasim A. (2014) *Engineering properties of foods*, 4th edition, CRC Press.
2. Lewis M. J. (1990) *Physical Properties of Foods and Food Processing Systems*. Woodhead Publishing.
3. Devahastin S. (2011) *Physicochemical aspects of food engineering and processing*, CRC Publication.
4. Singh R. P. & Heldman D. R. (2009) *Introduction to Food Engineering 4th edition*, Academic Press.

Mapping of Course Outcome (CO) and Program Outcome (PO)

| Course Code: BTFT216-19 | | Course Title: Engineering Properties of Foods | | | | | | | | | | | | | | | |
|-------------------------|---------------------|--|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|
| | | (1/2/3 indicates strength of the correlation) 3-Strong, 2-Medium, 1-Weak | | | | | | | | | | | | | | | |
| | Course Outcome (CO) | Program Outcome (PO) | | | | | | | | | | | | PSO | | | |
| | | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | PSO4 |
| | CO 1 | 3 | 2 | | | 3 | 2 | 1 | | | 1 | 2 | 3 | 3 | 3 | 2 | 2 |
| | CO 2 | 2 | 2 | | | 1 | 1 | 2 | 2 | | | | 3 | 3 | 3 | 3 | 2 |
| | CO 3 | 3 | 2 | 2 | 2 | | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| | CO 4 | 3 | 3 | | 3 | 2 | 1 | 1 | | | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| | CO 5 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

| RBT Level | Course Outcomes: After the completion of the course, the students will be able to: | |
|-----------|---|--|
| L1 | CO1 | Describe basic concepts of engineering thermodynamics and the practical application of thermodynamic laws. |
| L3 | CO2 | Illustrate the implementation of 1st law of thermodynamics for different flow processes and apply the basic concepts of heat engine, heat pump and refrigerator used in engineering field. |
| L3 | CO3 | Use basic concepts of thermodynamics in problem solving. |
| L5 | CO4 | Evaluate the ideal thermodynamic air standard cycles and mathematical relationships between different thermodynamic properties. |
| L6 | CO5 | Construct the various thermodynamic models using various properties. |

UNIT-I

Basic Concepts: Macroscopic and microscopic approaches, thermodynamic systems, surrounding and boundary, thermodynamic property – intensive and extensive, thermodynamic equilibrium, state, path, process and cycle, quasi-static, reversible and irreversible processes, working substance; Concept of thermodynamic: work and heat, equality of temperature, zeroth law of thermodynamic and its utility, problems; First Law of thermodynamics: energy and its forms, energy and 1st law of thermodynamics, internal energy and enthalpy, PMMFK, steady flow energy equation, 1st law applied to non- flow process, steady flow process and transient flow process, throttling process and free expansion process, problems.

UNIT-II

Second law of thermodynamics: limitations of first law, thermal reservoir, heat source and heat sink, heat engine, refrigerator and heat pump, kelvin- planck and clausius statements and their equivalence, PMMSK, Carnot cycle, Carnot heat engine and Carnot heat pump, Carnot theorem

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and its corollaries; Thermodynamic temperature scale; Entropy, Clausius inequality, principle of entropy increase, temperature entropy plot, entropy change in different processes, problems; Introduction to third Law of thermodynamics. availability and irreversibility: high and low grade energy, availability and unavailable energy, loss of available energy due to heat transfer through a finite temperature difference, dead state of a system, availability of a non-flow or closed system, availability of a steady flow system, Helmholtz and Gibb's Functions, effectiveness and irreversibility, second law efficiencies of processes & cycles, problems.

UNIT-III

Pure Substance: pure substance and its properties, phase and phase transformation, vaporization, evaporation and boiling, saturated and superheat steam, solid – liquid – vapour equilibrium, T-V, P-V and P-T plots during steam formation, properties of dry, wet and superheated steam, property changes during steam processes, temperature – entropy (T-S) and enthalpy – entropy (H-S) diagrams, throttling and measurement of dryness fraction of steam, problems.

UNIT-IV

Ideal and Real Gases: concept of an ideal gas, basic gas laws, characteristic gas equation, Avogadro's law and universal gas constant, P-V-T surface of an ideal gas; Vander Waal's equation of state, reduced co-ordinates, compressibility factor and law of corresponding states; Mixture of gases, mass, mole and volume fraction, Gibson Dalton's law, gas constant and specific heats, entropy for a mixture of non-reactive gases, problems; Thermodynamic relations: Maxwell relations, Clapyron equation, relations for changes in enthalpy and internal energy & entropy, specific heat capacity relations, Joule Thomson coefficient & inversion curve.

Reference Readings:

1. Jones & Dugan (1995) *Engineering Thermodynamics*, Prentice Hall of India.
2. Radhakrishnan E. (2006) *Fundamentals of Engineering Thermodynamics, 2nd edition*, Prentice Hall of India.
3. Rao Y. V. C. (1994) *Theory and Problems of Thermodynamics*, Wiley Eastern Ltd.
4. Arora C. P. (2001) *Thermodynamics*, Tata McGraw Hill.
5. Nag P. K. (2005) *Engineering Thermodynamics*, Tata McGraw Hill.

Mapping of Course Outcome (CO) and Program Outcome (PO):

| Course Code: Course Code: BTFT 217-19 | | | | | | | | | | | | | Course Title: Thermodynamics | | | | |
|--|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------------------------------|------|------|------|------|
| (1/2/3 indicates strength of the correlation) 3-Strong, 2-Medium, 1-Weak | | | | | | | | | | | | | | | | | |
| | Program Outcome (PO) | | | | | | | | | | | | PSO | | | | |
| | | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | PSO4 |
| Course Outcome (CO) | CO 1 | 3 | 2 | 1 | 1 | | 2 | 2 | | 2 | 2 | 1 | 3 | 2 | 1 | 3 | 3 |
| | CO 2 | 3 | 3 | 2 | 1 | | 3 | 2 | 1 | 2 | 2 | 1 | 3 | 2 | 1 | 3 | 2 |
| | CO 3 | 3 | 3 | 2 | 2 | | 3 | 1 | 1 | 2 | 2 | | 2 | 1 | 1 | 3 | 3 |
| | CO 4 | 2 | 1 | 1 | 1 | | 2 | | | 2 | 1 | | 3 | 1 | 1 | 3 | 2 |
| | CO 5 | 2 | 2 | 2 | 1 | | 1 | | | 2 | 1 | | 3 | 1 | 1 | 3 | 2 |

ENVIRONMENTAL STUDIES

| Sl. No. | Category | Course Code | Course Title | Hours per week | | | Total contact hrs, | Credits |
|---------|-----------------------------|-------------|-----------------------|----------------|----------|-----------|--------------------|---------|
| | | | | Lecture | Tutorial | Practical | | |
| 1 | Mandatory Non-credit Course | EVS101-18 | Environmental Studies | 2 | 0 | 0 | 21 | 0 |

*** 40 Hours are kept for various activities under the head of activities. There will be a final theory examination for the students of 50 marks but these marks will not be added to their final result as assessment will be satisfactory or non-satisfactory.**

Course Outcomes:

1. Students will enable to understand environmental problems at local and national level through literature and general awareness.
2. The students will gain practical knowledge by visiting wildlife areas, environmental institutes and various personalities who have done practical work on various environmental Issues.
3. The students will apply interdisciplinary approach to understand key environmental issues and critically analyze them to explore the possibilities to mitigate these problems.
4. Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world

Environmental Studies [L:2; T:0; P:0 (Credits-0)]

1. Environment Science (Mandatory non-credit course)

We as human being are not an entity separate from the environment around us rather we are a constituent seamlessly integrated and co-exist with the environment around us. We are not an entity so separate from the environment that we can think of mastering and controlling it rather we must understand that each and every action of ours reflects on the environment and vice versa. Ancient wisdom drawn from Vedas about environment and its sustenance reflects these ethos. There is a direct application of this wisdom even in modern times. Idea of an activity based course on environment protection is to sensitize the students.

Detailed Contents

Module 1 : Natural Resources :Renewable and non-renewable resources

Natural resources and associated problems.

- a) Forest resources : Use and over-exploitation, deforestation, case studies.
Timber extraction, mining, dams and their effects on forest and tribal people.
 - b) Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
 - c) Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
 - d) Food resources : World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.
 - e) Energy resources : Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies.
 - f) Land resources : Land as a resource, land degradation, man induced landslides, soil erosion and desertification.
- Role of an individual in conservation of natural resources.
 - Equitable use of resources for sustainable lifestyles.

Module 2 : Ecosystems

Concept of an ecosystem. Structure and function of an ecosystem.
Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structure and function of following ecosystems:

- a. Forest ecosystem
- b. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Module 3 : Biodiversity and its conservation

- Introduction – Definition : genetic, species and ecosystem diversity.
- Biodiversity at global, National and local levels.
- India as a mega-diversity nation
- Hot-spots of biodiversity.
- Threats to biodiversity : habitat loss, poaching of wildlife, man-wildlife conflicts.
- Endangered and endemic species of India
-

Module 4 : Social Issues and the Environment

- From Unsustainable to Sustainable development
- Resettlement and rehabilitation of people; its problems and concerns.
- Environmental ethics : Issues and possible solutions.
- Climate change, global warming, acid rain, ozone layer depletion, Nuclear accidents and holocaust. Case Studies.
- Public awareness.

***ACTIVITIES**

Nature club (bird watching, recognizing plants at institute/at home, recognizing local animals, appreciating biodiversity)

Impart knowledge and inculcate the habit of taking interest and understanding biodiversity in and around the college campus. The students should be encouraged to take interest in bird watching, recognizing local plants, herbs and local animals. The students should be encouraged to appreciate the difference in the local biodiversity in their hometown, in the place of their study and other places they visit for vacation/breaks etc.

Following activities must be included.

Identify a tree fruit flower peculiar to a place or having origin from the place.

Making high resolution big photographs of small creatures (bees, spiders, ants, mosquitos etc.) especially part of body so that people can recognize (games on recognizing animals/plants).

Videography/ photography/ information collections on specialties/unique features of different types of common creatures.

Search and explore patents and rights related to animals, trees etc. Studying miracles of mechanisms of different body systems.

1 (A) Awareness Activities:

- a) Small group meetings about water management, promotion of recycle use, generation of less waste, avoiding electricity waste
- b) Slogan making event
- c) Poster making event
- d) Cycle rally

- e) Lectures from experts
- f) Plantation
- g) Gifting a tree to see its full growth
- h) Cleanliness drive
- i) To live with some eminent environmentalist for a week or so to understand his work
- vi) To work in kitchen garden for mess
- j) To know about the different varieties of plants
- k) Shutting down the fans and ACs of the campus for an hour or so
- l) Visit to a local area to document environmental assets
river/forest/grassland/hill/mountain/lake/Estuary/Wetlands
- m) Visit to a local polluted site-Urban/Rural/Industrial/Agricultural
- n) Visit to a Wildlife sanctuary, Pushpa Gujral Science City, Kapurthala, National Park or Biosphere Reserve

Suggested Readings

1. Agarwal, K.C. 2001 Environmental Biology, Nidi Publ. Ltd. Bikaner.
2. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad – 380 013, India, Email:mapin@icenet.net (R)
3. Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480p
4. Clark R.S., Marine Pollution, Clarendon Press Oxford (TB)
5. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumbai, 1196p
6. Hawkins R.E., Encyclopedia of Indian Natural History, Bombay Natural History Society, Bombay (R)
7. Heywood, V.H & Weston, R.T. 1995. Global Biodiversity Assessment. Cambridge Univ. Press 1140p.
8. Mhaskar A.K., Matter Hazardous, Techno-Science Publication (TB)
9. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)
10. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Co. USA, 574p

11. Townsend C., Harper J, and Michael Begon, Essentials of Ecology, Blackwell Science (TB)
12. Trivedi R.K., Handbook of Environmental Laws, Rules Guidelines, Compliances and Stadards, Vol I and II, Enviro Media (R)
13. Trivedi R. K. and P.K. Goel, Introduction to air pollution, Techno-Science Publication (TB)
14. Wanger K.D., 1998 Environmental Management. W.B. Saunders Co. Philadelphia, USA 499p