# SYLLABUS – 2024

## B. Tech
## (Agricultural Engineering)

**KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND FOOD TECHNOLOGY**
**KERALA AGRICULTURAL UNIVERSITY**
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# Introduction

In recent years, the technological developments in agricultural engineering have seen rapid momentum, specifically in the fields of precision agriculture, high-efficiency irrigation systems, farm energy systems, remote sensing and geographical studies, etc. Digital agriculture, smart farming systems, IoT, sensors, automation, and robotics are increasingly being applied to enhance productivity and minimize environmental impact. There is a focus on optimizing food processing operations through the measurement of food properties, innovations in equipment design, and advancements in heat and mass transfer.

Agricultural engineering has also expanded to include environmental aspects, with a focus on sustainable agricultural systems and the integration of expertise from various engineering fields with biological and socio-economic sciences. In addition to addressing the challenges such as increasing agricultural production, the discipline is evolving to meet the needs of sustainable development, such as improved food security and reduced poverty, and reducing gaseous emissions from agricultural production, which have been contributing towards the UN Sustainable Development Goals. Progress in agricultural engineering technologies and related applications has been leading to the globalization of agricultural mechanization and modernization. Even in the developing countries, agricultural engineering is playing a major role for moving towards more commercialization of agriculture.

In this context, education and research in agricultural engineering are becoming increasingly vital. To fully realize the benefits of these advancements, students must be well-versed in both contemporary technological developments and traditional knowledge. Also, it is imperative that the students acquire both professional and soft skills to contribute to the proper adoption of technologies by the society. It will also make the students more acceptable and fitting as a leader of change that the society strives to see in the next generation graduates.

In view of these, the undergraduate curriculum for Agricultural Engineering has been restructured as per National Education Policy (NEP) guidelines. The revised syllabus focuses on building a solid knowledge foundation while offering increased practical exposure and skills development to build competence and confidence for the application of the gained knowledge. The course curriculum aims at strengthening critical thinking, creativity, communication and collaboration among students. More emphasis has been given on basic skill enhancement courses, exposure visits and case studies, industry attachments, flexibility in choice of courses through electives and also through online courses. Provision has also been made for advanced skill development through project work or experiential learning/incubation, etc. These activities have been intended at conceptual learning than rote learning as well as for inculcating ingenuity and critical thinking.

Aligned with NEP-2020, the curriculum includes provisions for multiple entry and exit options, ensuring flexibility in learning pathways. This restructured course is designed to enhance students' knowledge, skills, and competencies, meeting the expectations of the NEP-2020 and preparing them for the evolving challenges of agricultural engineering.

## Organization of New Curriculum

The B. Tech. (Agricultural Engineering) programme is structured with a total of 180 credits, out of which 174 credits are offered by the parent institute, and 6 credits come from online courses selected by the students. Additionally, there are 4 non-gradial credits allocated to two courses: Deeksharambh (2 credits) and a Study Tour (2 credits).

After the admission of students in the university, the students will register for the Deeksharambh of two weeks' duration in the 1st semester. The course will include, but not restricted to, discussions on operational framework of academic process in university, interactions with alumni, business leaders, scientists and perspective employers, university academic and research managers and classes on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills. It will also create a platform for students to learn from each other's life experiences.

The first year of the course is dedicated for skill development/ enhancement in agricultural engineering sector with few introductory courses. After satisfactory completion of 1st year (two semesters) and subsequent satisfactory completion of 10 credits (10 weeks) of industry/institute training/ internship, the student will become eligible for the award of UG-Certificate in Agricultural Engineering on exit. The students continuing the study further, would not have to attend the internship after 1st year.

The second year has been designed with the basic engineering courses as well as fundamental courses in agricultural engineering with adequate theory and practical components. After satisfactory completion of the courses of 2nd year and subsequent satisfactory completion of 10 credits (10 weeks) of industry/ institute training/ internship, the student will become eligible for the award of UG-Diploma in Agricultural Engineering on exit. The students continuing the study further, would not have to attend the internship after 2nd year.

The Skill Enhancement courses will be offered in three stages. In the first year, the course entitled Skill Enhancement (8 credits) will aim at skill enhancement for employment and entrepreneurship. The students will have flexibility and choice in selection of skill areas from a bouquet of skill enhancement modules to be offered/ listed by the parent institute. After two to three days' common orientation on different skill enhancement modules, students will take up either two or more modules (maximum four modules recommended) as per the local needs and gain complete hands-on experience on these modules. In addition to the modules proposed in this report, the SAUs can formulate other modules relevant to the respective regions or modify the titles of the proposed modules.

In the final year, the Project-I (3 credits in 7th semester) and Project-II (4 credits in 8th semester) are meant for advanced skill development for research, employment and entrepreneurship. Under these courses, the student will have the option to take up a research project (R and D based, field study based) for developing research skills in form of project or take up incubation/ experiential

learning-based activity for entrepreneurship development. The Project-I and - II can also be taken up in collaboration with any organization/ industry.

In the final year, the student will have the liberty to choose any three elective subjects, preferably from one or related disciplines. The objective is to enable the student to acquire deeper understanding in any particular field. In the final year, the students will also undergo an 8-week In-plant training/ research internship to expose them to real working situations in industry/ research institutions. In- plant training may be conducted in split manner in more than one industry/ organization/ institute.

During the 5$^{th}$ semester, the students will have a study tour of 10-14 days duration, which will be counted as 2 credits (non-gradial).

The students will take a minimum of 6 credits of online courses (any one or more courses totaling at least 24 weeks or 80 Hours' duration) during the third and fourth year as a partial requirement for the B. Tech. (Agricultural Engineering) programme. These online courses will be non-gradial as separate certificates would be issued by institutes offering the courses. However, the university/ institute will keep a record of such courses registered and completed by each student and will indicate the title of the (successfully completed) courses in final transcript issued to the student.

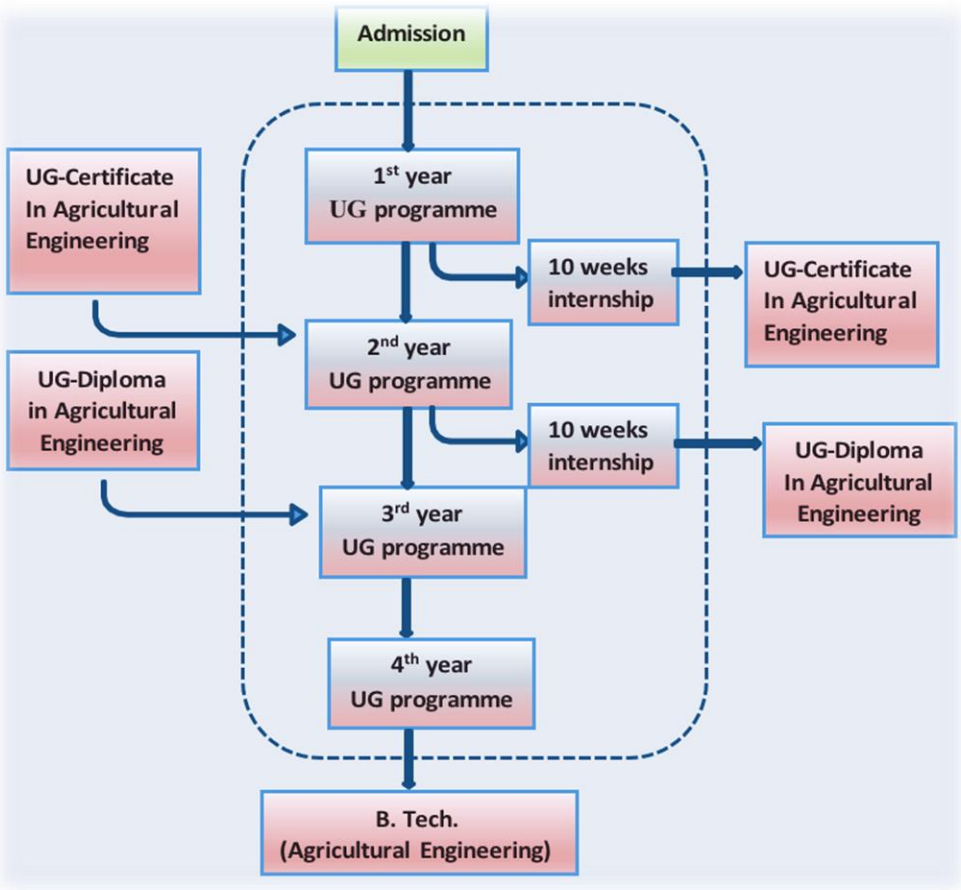


**Fig. 1 Entry and exit options for the UG programs in Agricultural Engineering**

The credits (and contact Hours) have been proposed in such a way that class room teaching can be accommodated in 5 days in a week. On Saturdays, the students will take up activities as NSS/ NCC, 'Physical Education, First Aid and Yoga Practice' during the 1st and 2nd year. The courses as Seminar and Case study (with analysis and presentation of findings in seminars as well as in reports form) will be taken in the 3rd year. However, these are suggestive only and the Universities can plan their timetables as per the local facilities/ university norms and needs.

The entry and exit options for the UG programs in Agricultural Engineering are shown in the Figure 1.

The Universities may consider allowing lateral entry for the candidates having Diploma in Agricultural Engineering. In such cases, the candidates having Diploma in Agricultural Engineering (with minimum 3 years course programme after 10th or equivalent) may be allowed admission into the 2nd year of the UG programme, as per the provisions to be notified by the respective AU from time to time.

## Method of Course Coding

The following course coding method was adopted to easily identify the courses run by various departments in different semesters.

A three letter for department identification tag followed by a four-digit number designates each course. The first digit indicates the year, second for semester and third and fourth jointly indicates the number of the course offered by that department.

*The department identification tags are:*

| | | |
|---|---|---|
| Farm Machinery and Power Engineering | : | FMP |
| Renewable Energy Engineering | : | REE |
| Irrigation and Drainage Engineering | : | IDE |
| Soil and Water Conservation Engineering | : | SWC |
| Processing and Food Engineering | : | PFE |
| Basic Engineering and Applied Sciences | : | BES |

*Common Course Tags*

| | | |
|---|---|---|
| Deeksharambh | : | AGE 1101 |
| Introduction to Agricultural Engineering | : | AGE 1102 |

| | | |
|---|---|---|
| Elective Courses | : | E followed by first two letters of the department Catalogue |
| Skill Enhancement Courses | : | SAE |
| Study Tour | : | STR |
| Case Study | : | CST |
| Project | : | PRO |
| Seminar | : | SEM |

FMP 1111 means a course run by Farm Power Machinery and Energy Department in the I$^{st}$ Year I$^{st}$ Semester 11$^{th}$ Course for B. Tech course

## DISCIPLINE/SECTION-WISE COURSES

The major disciplines are further subdivided into minor disciplines and the courses are allotted as below.

| Major Discipline | Minor Discipline | Courses | | Credit |
|---|---|---|---|---|
| Agricultural Engineering | Farm Machinery and Power Engineering | FMP 2104 | Farm Machinery and Equipment- I | 3 (2+1) |
| | | FMP 2205 | Farm Machinery and Equipment- II | 3 (2+1) |
| | | FMP 3108 | Tractor and Automotive Engines | 3 (2+1) |
| | | FMP 3209 | Tractor Systems and Controls | 3 (2+1) |
| | | | **Sub Total** | **12 (8+4)** |
| | Renewable Energy Engineering | REE 2201 | Renewable Energy Sources | 3 (2+1) |
| | | REE 3202 | Bio-energy Systems: Design and Applications | 3 (2+1) |
| | | | **Sub Total** | **6 (4+2)** |
| | Irrigation and Drainage Engineering | IDE 3105 | Irrigation and Drainage Engineering | 4 (3+1) |
| | | IDE 3206 | Groundwater, Wells and Pumps | 3 (2+1) |
| | | IDE 4107 | Sprinkler and Micro Irrigation Systems | 2 (1+1) |
| | | | **Sub Total** | **9 (6+3)** |
| | Soil and Water Conservation Engineering | SWC 2104 | Fluid Mechanics and Open Channel Hydraulics | 3 (2+1) |
| | | SWC 2205 | Watershed Hydrology | 3 (2+1) |
| | | SWC 2206 | Soil and Water Conservation Engineering | 3 (2+1) |
| | | SWC 4107 | Watershed Planning and Management | 3 (2+1) |
| | | | **Sub Total** | **12 (8+4)** |
| | Processing and Food Engineering | PFE 2101 | Engineering Properties of Agricultural Produce and Food Science | 3 (2+1) |
| | | PFE 2202 | Post-harvest Engineering of Cereals, Pulses and Oilseeds | 3 (2+1) |
| | | PFE 3103 | Food and Dairy Engineering | 4 (3+1) |
| | | PFE 3204 | Agricultural Structures and Environmental Control | 3 (2+1) |

| | | | | |
|---|---|---|---|---|
| | | PFE 3205 | Post-harvest Engineering of Horticultural Crops | 2 (1+1) |
| | | PFE 4106 | Food Quality and Safety | 3 (2+1) |
| | | | **Sub Total** | **18(12+6)** |
| | **Common Agricultural Engineering** | | Electives | 9 (6+3) |
| | | AGE 1102 | Introduction to Agricultural Engineering | 4 (3+1) |
| | | SEM 3101 | Seminar | 1 (0+1) |
| | | CST 3201 | Case Study | 1 (0+1) |
| | | STR 3101 | Study Tour | 2 (0+2) NG |
| | | | **Sub Total** | **15 (9+6)** |
| | | | **TOTAL** | **69(45+24)** |
| **Basic Engineering & Applied Sciences** | **Agricultural Structures and Civil and Environmental Engineering** | SWC 1101 | Surveying and Levelling | 3 (1+2) |
| | | IDE 2101 | Engineering Mechanics | 3 (2+1) |
| | | SWC 2103 | Soil Mechanics | 2 (1+1) |
| | | IDE 2202 | Theory of Structure | 2 (1+1) |
| | | IDE 2203 | Building Construction and Cost Estimation | 2 (2+0) |
| | | IDE 3104 | Strength of Materials | 2 (1+1) |
| | | | **Sub Total** | **14(8+6)** |
| | **Mechanical Engineering** | FMP 1101 | Workshop Technology and Practices | 2 (0+2) |
| | | FMP 1203 | Engineering Drawing | 2 (0+2) |
| | | FMP 3106 | Theory of Machines | 2 (2+0) |
| | | FMP 3107 | Thermodynamics and Heat Transfer | 3 (3+0) |
| | | FMP 3210 | Refrigeration and Air Conditioning | 3 (2+1) |
| | | FMP 4112 | Machine Design | 2 (2+0) |
| | | FMP 4111 | Engineering Graphics and Design | 2 (0+2) |
| | | | **Sub Total** | **16 (9 +7)** |
| | **Electrical & Electronics Engineering** | FMP 1102 | Basic Electrical Gadgets and Instruments | 3 (2+1) |
| | | FMP 4113 | Electrical Machines | 3 (2+1) |
| | | | **Sub Total** | **6 (4+2)** |

| | | | | |
|---|---|---|---|---|
| | **Computer Science & Engineering** | BES 1102 | Agricultural Informatics and Artificial Intelligence | 3 (2+1) |
| | | BES 1203 | Computer programming and data structures | 2 (0+2) |
| | | BES 3213 | Sensors, Artificial Intelligence and Robotics in Agriculture | 3 (2+1) |
| | | | **Sub Total** | **8 (4+4)** |
| | **Basic Agriculture** | BES 1101 | Crop Production and Protection Technologies | 4 (3+1) |
| | | BES 1204 | Farming Based Livelihood Systems | 3 (2+1) |
| | | SWC 1202 | Environmental Studies and Disaster Management | 3 (2+1) |
| | | BES 4114 | Agricultural Statistics and Data Analysis | 2 (1+1) |
| | | | **Sub Total** | **12 (8+4)** |
| | **Social Sciences** | BES 1205 | Communication Skills | 2 (1+1) |
| | | BES 3112 | Personality Development | 2 (1+1) |
| | | BES 2211 | Entrepreneurship Development and Business Management | 3 (2+1) |
| | | | **Sub Total** | **7 (4+3)** |
| | **Basic Sciences** | BES 2106 | Engineering Mathematics- I | 3 (3+0) |
| | | BES 2210 | Engineering Mathematics- II | 3 (3+0) |
| | | BES 2107 | Engineering Physics | 3 (2+1) |
| | | BES 2108 | Engineering Chemistry | 3 (2+1) |
| | | | **Sub Total** | **12(10+2)** |
| | | | **TOTAL** | **78(49+29)** |
| | **Foundation courses/ Ability Enhancement Courses** | AGE 1101 | Deeksharambh | 0+2(NG) |
| | | NSS/NCC 1101 | NSS-I/NCC I | 1 (0+1) |
| | | NSS/NCC 1202 | NSS-II/NCC II | 1 (0+1) |
| | | BES 2109 | Physical Education, First Aid and Yoga Practice | 2 (0+2) |
| | | | **Sub Total** | **4 (0+4)** |
| | **Skill Enhancement** | SAE 1201 | Skill Enhancement | 8 (0+8) |
| | | PRO 4101 | Project- I | 3 (0+3) |

| | | | | |
|---|---|---|---|---|
| | | PRO 4202 | Project- II | 4 (0+4) |
| | | | **Sub Total** | **15(0+15)** |
| | **In-plant training/ Internship** | | Internship only for exit option with UG-Certificate* | 10 (0+10) |
| | | | Internship only for exit option with UG-Diploma* | 10 (0+10) |
| | | IPT 4201 | In-plant Training/ Research Internship | 8 (0+8) |
| | | | **Sub Total** | **8 (0+8)** |

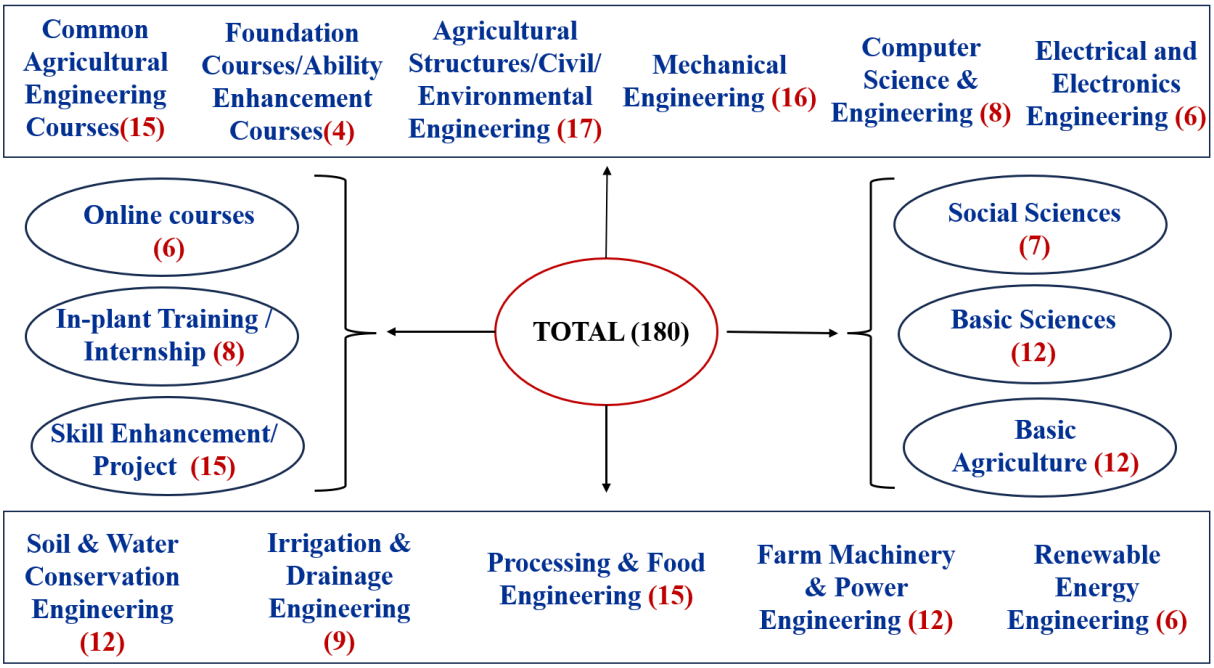


**Fig. 2 Distribution of credits across various disciplines**

All the courses mentioned above are further distributed among the five statutory departments of the Faculty of Agricultural Engineering and Technology for its proper conduct.

# COURSES OFFERED BY DIFFERENT DEPARTMENTS

## (1) Farm Machinery and Power Engineering

| (a) Core Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | FMP 1101 | Workshop Technology and Practices | 2(0+2) |
| 2 | FMP 1102 | Basic Electrical Gadgets and Instruments | 3 (2+1) |
| 3 | FMP 1203 | Engineering Drawing | 2(0+2) |
| 4 | FMP 2104 | Farm Machinery and Equipment-I | 3 (2+1) |
| 5 | FMP 2205 | Farm Machinery and Equipment-II | 3 (2+1) |
| 6 | FMP 3106 | Theory of Machines | 2(2+0) |
| 7 | FMP 3107 | Thermodynamics and Heat Transfer | 3(3+0) |
| 8 | FMP 3108 | Tractor and Automotive Engines | 3 (2+1) |
| 9 | FMP 3209 | Tractor Systems and Controls | 3 (2+1) |
| 10 | FMP 3210 | Refrigeration and Air Conditioning | 3 (2+1) |
| 11 | FMP 4111 | Engineering Graphics and Design | 2(0+2) |
| 12 | FMP 4112 | Machine Design | 2(2+0) |
| 13 | FMP 4113 | Electrical Machines | 3 (2+1) |
| | | **Total Credits** | **34(21+13)** |

| (b) Elective Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | EFM 4201 | Mechanics of Tillage and Traction | 3 (2+1) |
| 2 | EFM 4202 | Farm Machinery Design and Production | 3 (2+1) |
| 3 | EFM 4203 | Tractor Design and Testing | 3 (2+1) |
| 4 | EFM 4204 | Hydraulic Drives and Controls | 3 (2+1) |
| 5 | EFM 4205 | Human Engineering and Safety | 3 (2+1) |
| 6 | EFM 4206 | Precision Agriculture and System Management | 3 (2+1) |
| | | **Total Credits** | **18(12+6)** |

| (c) Skill Enhancement Module | | |
|---|---|---|
| **Sl. No** | **Course Title** | **Credit Hours** |
| 1 | Operation and Maintenance of Farm Machinery | 2 (0+2) |
| 2 | Repair and Maintenance of Tractors and Power Tillers | 2 (0+2) |

| | | |
|---|---|---|
| 3 | Management of Agricultural Machinery Custom Hiring and Maintenance Facilities | 2 (0+2) |
| 4 | Operation and Maintenance of Drones Used for Agricultural Applications | 2 (0+2) |
| | **Total Credits** | **8 (0+8)** |

## (2) Renewable Energy Engineering

| **(a) Core Courses** | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | REE 2201 | Renewable Energy Sources | 3 (2+1) |
| 2 | REE 3202 | Bioenergy Systems: Design and Applications | 3 (2+1) |
| | | **Total Credits** | **6(4+2)** |

| **(b) Elective Courses** | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | ERE 4201 | Photovoltaic Technology and Systems | 3 (2+1) |
| 2 | ERE 4202 | Wind Power Technology and Systems | 3 (2+1) |
| 3 | ERE 4203 | Waste and By-products Utilization | 3 (2+1) |
| | | **Total Credits** | **9(6+3)** |

| **(c) Skill Enhancement Modules** | | |
|---|---|---|
| **Sl. No** | **Course Title** | **Credit Hours** |
| 1 | Fabrication, Operation and Maintenance of Renewable Energy Gadgets | 2 (0+2) |
| 2 | Design of Solar PV Systems Using Softwares | 2 (0+2) |
| 3 | Installation and Maintenance of On-Grid and Off-Grid Solar Systems | 2 (0+2) |
| 4 | Design and Maintenance of Agrivoltaic Systems | 2 (0+2) |
| 5 | Valorisation of Agri-biomass and Organic Waste | 2 (0+2) |
| 6 | Energy audit, Energy Conservation and Energy Efficiency | 2 (0+2) |
| | **Total Credits** | **12 (0+12)** |

## (3) Irrigation and Drainage Engineering

| (a) Core Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | IDE 2101 | Engineering Mechanics | 3 (2+1) |
| 2 | IDE 2202 | Theory of Structures | 2 (1+1) |
| 3 | IDE 2203 | Building Construction and Cost Estimation | 2 (2+0) |
| 4 | IDE 3104 | Strength of Materials | 2 (1+1) |
| 5 | IDE 3105 | Irrigation and Drainage Engineering | 4 (3+1) |
| 6 | IDE 3206 | Groundwater, Wells and Pumps | 3 (2+1) |
| 7 | IDE 4107 | Sprinkler and Micro Irrigation Systems | 2(1+1) |
| | | **Total Credits** | **18 (12+6)** |

| (b) Elective Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | EID 4201 | Water Quality and Management Measures | 3 (2+1) |
| 2 | EID 4202 | Minor Irrigation and Command Area Development | 3 (2+1) |
| 3 | EID 4203 | Management of Canal Irrigation System | 3 (2+1) |
| 4 | EID 4204 | Landscape Irrigation Design and Management | 3 (2+1) |
| 5 | EID 4205 | Applications of Geospatial Techniques for Water Resources | 3 (2+1) |
| 6 | EID 4206 | Environmental Engineering | 3 (2+1) |
| 7 | EID 4207 | Climate Change and use of Geoinformatics | 3 (2+1) |
| 8 | EID 4208 | Design and Maintenance of Greenhouses | 3 (2+1) |
| | | **Total Credits** | **24(16+8)** |

| (c) Skill Enhancement Modules | | |
|---|---|---|
| **Sl. No** | **Course Title** | **Credit Hours** |
| 1 | Repair and maintenance of pumps and irrigation systems | 2 (0+2) |
| 2 | Installation and maintenance of micro-irrigation systems | 2 (0+2) |
| 3 | Geophysical survey and investigations for groundwater exploration and installation of tube well/ bore well | 2 (0+2) |
| 4 | Construction, management and maintenance of protected cultivation structures | 2 (0+2) |
| | **Total Credits** | **8 (0+8)** |

## (4) Soil and Water Conservation Engineering

| (a) Core Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | SWC 1101 | Surveying and Levelling | 3 (1+2) |
| 2 | SWC 1202 | Environmental Studies and Disaster Management | 3 (2+1) |
| 3 | SWC 2103 | Soil Mechanics | 2 (1+1) |
| 4 | SWC 2104 | Fluid Mechanics and Open Channel Hydraulics | 3 (2+1) |
| 5 | SWC 2205 | Watershed Hydrology | 3 (2+1) |
| 6 | SWC 2206 | Soil and Water Conservation Engineering | 3 (2+1) |
| 7 | SWC 4107 | Watershed Planning and Management | 3 (2+1) |
| | | **Total Credits** | **23 (14+9)** |

| (b) Elective Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | ESW 4201 | Floods and Control Measures | 3 (2+1) |
| 2 | ESW 4202 | Remote Sensing and GIS Applications | 3 (2+1) |
| 3 | ESW 4203 | Information Technology for Land and Water Management | 3 (2+1) |
| 4 | ESW 4204 | Wasteland Development | 3 (2+1) |
| 5 | ESW 4205 | Application of Plastics in Agriculture | 3 (2+1) |
| 6 | ESW 4206 | Precision Farming Techniques for Protected Cultivation | 3 (2+1) |
| 7 | ESW 4207 | Quantity Surveying and Valuation | 3 (2+1) |
| 8 | ESW 4208 | Natural Fibre Applications in Agriculture | 3 (2+1) |
| 9 | ESW 4209 | Water Harvesting and Soil Conservation Structures | 3 (2+1) |
| | | **Total Credits** | **27 (18+9)** |

| (c) Skill Enhancement Modules | | |
|---|---|---|
| **Sl. No** | **Course Title** | **Credit Hours** |
| 1 | Application of Remote Sensing and GIS for Agricultural Water Management | 2 (0+2) |
| 2 | Operation and Maintenance of Hydro-meteorological Instruments | 2 (0+2) |
| 3 | Installation and Maintenance of Rooftop Rainwater Harvesting System | 2 (0+2) |
| 4 | Operation and Maintenance of Soil Conservation Structures | 2 (0+2) |
| | **Total Credits** | **8 (0+8)** |

## (5) Department of Processing and Food Engineering

| (a) Core Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | PFE 2101 | Engineering Properties of Agricultural Produce and Food Science | 3 (2+1) |
| 2 | PFE 2202 | Post-harvest Engineering of Cereals, Pulses and Oilseeds | 3 (2+1) |
| 3 | PFE 3103 | Food and Dairy Engineering | 4 (3+1) |
| 4 | PFE 3204 | Agricultural Structures and Environmental Control | 3 (2+1) |
| 5 | PFE 3205 | Post-harvest Engineering of Horticultural Crops | 2 (1+1) |
| 6 | PFE 4106 | Food Quality and Safety | 3 (2+1) |
| | | **Total Credits** | **18 (12+6)** |

| (b) Elective Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | EPF 4201 | Development of Processed Food Products | 3 (2+1) |
| 2 | EPF 4202 | Food Packaging Technology | 3 (2+1) |
| 3 | EPF 4203 | Food Plant and Equipment Design | 3 (2+1) |
| 4 | EPF 4204 | Emerging Technologies in Food Processing | 3 (2+1) |
| 5 | EPF 4205 | Processing of Livestock, Fish and Marine Products | 3 (2+1) |
| 6 | EPF 4206 | Processing of Spices and Plantation crops | 3 (2+1) |
| 7 | EPF 4207 | Food Composition and Analysis | 3 (2+1) |
| | | **Total Credits** | **21(14+7)** |

| (c) Skill Enhancement Modules | | |
|---|---|---|
| **Sl. No** | **Course Title** | **Credit Hours** |
| 1 | Agro Processing Methods, Equipment Operation and Maintenance | 2 (0+2) |
| 2 | Operation and Management of Multi-Commodity Agro-Processing Centre | 2 (0+2) |
| 3 | Primary Processing, Value Addition and Cold Chain Logistics | 2 (0+2) |
| 4 | Food Grain Godown and Warehouse Management | 2 (0+2) |
| 5 | Post-harvest Value Chain Management Including Logistics | 2 (0+2) |
| | **Total Credits** | **10 (0+10)** |

## (6) Basic Engineering and Applied Sciences

| (a) Core Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | BES 1101 | Crop Production and Protection Technologies | 4(3+1) |
| 2 | BES 1102 | Agricultural Informatics and Artificial Intelligence | 3 (2+1) |
| 3 | BES 1203 | Computer Programming and Data Structures | 2(0+2) |
| 4 | BES 1204 | Farming Based Livelihood Systems | 3 (2+1) |
| 5 | BES 1205 | Communication Skills | 2(1+1) |
| 6 | BES 2106 | Engineering Mathematics- I | 3(3+0) |
| 7 | BES 2107 | Engineering Physics | 3 (2+1) |
| 8 | BES 2108 | Engineering Chemistry | 3 (2+1) |
| 9 | BES 2109 | Physical Education, First Aid, Yoga Practice and Meditation | 2(0+2) |
| 10 | BES 2210 | Engineering Mathematics-II | 3(3+0) |
| 11 | BES 2211 | Entrepreneurship Development and Business Management | 3 (2+1) |
| 12 | BES 3112 | Personality Development | 2(1+1) |
| 13 | BES 3213 | Sensors, AI and Robotics in Agriculture | 3 (2+1) |
| 14 | BES 4114 | Agricultural Statistics and Data Analysis | 2(1+1) |
| | | **Total Credits** | **38(24+14)** |

| (b) Elective Courses | | | |
|---|---|---|---|
| **Sl. No** | **Catalogue No.** | **Course Title** | **Credit Hours** |
| 1 | EBE 4201 | Food Business Management and Entrepreneurship Development | 3(3+0) |
| 2 | EBE 4202 | MATLAB Programming | 3 (2+1) |
| 3 | EBE 4203 | Python Programming | 3(2+1) |
| 4 | EBE 4204 | Artificial Intelligence | 3 (2+1) |
| 5 | EBE 4205 | Machine Learning | 3 (2+1) |
| 6 | EBE 4206 | Operations Research | 3(2+1) |
| 7 | EBE 4207 | Agricultural Marketing and Trade | 3 (2+1) |
| | | **Total Credits** | **21(15+6)** |

## DISTRIBUTION OF COURSES IN DIFFERENT SEMESTERS

| **Semester 1** | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Catalogue No.** | **Course Title** | **Credits** | |
| | | | **Theory** | **Practical** |
| 1 | AGE 1101 | *Deeksharambh* | 0 | 2 (NG) |
| 2 | BES 1101 | Crop Production and Protection Technologies | 3 | 1 |
| 3 | AGE 1102 | Introduction to Agricultural Engineering | 3 | 1 |
| 4 | SWC 1101 | Surveying and Levelling | 1 | 2 |
| 5 | FMP 1101 | Workshop Technology and Practice | 0 | 2 |
| 6 | FMP 1102 | Basic Electrical Gadgets and Instruments | 2 | 1 |
| 7 | BES 1102 | Agricultural Informatics and Artificial Intelligence | 2 | 1 |
| 8 | NSS 1101 | NSS- I | 0 | 1 |
| | | **Total Credits - 20 (11+9)** | **11** | **9** |

| **Semester 2** | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Catalogue No.** | **Course Title** | **Credits** | |
| | | | **Theory** | **Practical** |
| 1 | SAE 1201 | Skill Enhancement | 0 | 8 |
| 2 | FMP 1203 | Engineering Drawing | 0 | 2 |
| 3 | BES 1203 | Computer Programing and Data Structures | 0 | 2 |
| 4 | BES 1204 | Farming Based Livelihood Systems | 2 | 1 |
| 5 | SWC 1202 | Environmental Studies and Disaster Management | 2 | 1 |
| 6 | BES 1205 | Communication Skills | 1 | 1 |
| 7 | NSS 1202 | NSS-II | 0 | 1 |
| | | **Total Credits - 21 (5+16)** | **5** | **16** |
| | | **Post-II Semester** | | |
| | | Internship<br>(for 10 weeks, only for exit option for award of UG-Certificate) | **0** | **10** |

| **Semester 3** | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Catalogue No.** | **Course Title** | **Credits** | |
| | | | **Theory** | **Practical** |
| 1 | BES 2106 | Engineering Mathematics- I | 3 | 0 |
| 2 | BES 2107 | Engineering Physics | 2 | 1 |
| 3 | BES 2108 | Engineering Chemistry | 2 | 1 |
| 4 | IDE 2101 | Engineering Mechanics | 2 | 1 |
| 5 | SWC 2103 | Soil Mechanics | 1 | 1 |
| 6 | SWC 2104 | Fluid Mechanics and Open Channel Hydraulics | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| 7 | PFE 2101 | Engineering Properties of Agricultural Produce and Food Science | 2 | 1 |
| 8 | FMP 2104 | Farm Machinery & Equipment- I | 2 | 1 |
| 9 | BES 2109 | Physical Education, First Aid, Yoga Practice and meditation | 0 | 2 |
| | | **Total Credits - 25 (16+9)** | **16** | **9** |

| **Semester 4** | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Catalogue No.** | **Course Title** | **Credits** | |
| | | | **Theory** | **Practical** |
| 1 | BES 2210 | Engineering Mathematics-II | 3 | 0 |
| 2 | IDE 2202 | Theory of Structures | 1 | 1 |
| 3 | IDE 2203 | Building Construction & Cost Estimation | 2 | 0 |
| 4 | SWC 2205 | Watershed Hydrology | 2 | 1 |
| 5 | SWC 2206 | Soil and Water Conservation Engineering | 2 | 1 |
| 6 | FMP 2205 | Farm Machinery & Equipment II | 2 | 1 |
| 7 | REE 2201 | Renewable Energy Sources | 2 | 1 |
| 8 | PFE 2202 | Post-harvest Engineering of Cereals, Pulses and Oilseeds | 2 | 1 |
| 9 | BES 2211 | Entrepreneurship Development and Business Management | 2 | 1 |
| | | **Total Credits - 25 (18+7)** | **18** | **7** |
| **Post-IV Semester** | | | | |
| | Internship (for 10 weeks, only for exit option for award of UG-Diploma) | | **0** | **10** |

| **Semester 5** | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Catalogue No.** | **Course Title** | **Credits** | |
| | | | **Theory** | **Practical** |
| 1 | IDE 3104 | Strength of Materials | 1 | 1 |
| 2 | FMP 3106 | Theory of Machines | 2 | 0 |
| 3 | FMP 3107 | Thermodynamics and Heat Transfer | 3 | 0 |
| 4 | FMP 3108 | Tractor & Automotive Engines | 2 | 1 |
| 5 | IDE 3105 | Irrigation and Drainage Engineering | 3 | 1 |
| 6 | PFE 3103 | Food and Dairy Engineering | 3 | 1 |
| 7 | BES 3112 | Personality Development | 1 | 1 |
| 8 | SEM 3101 | Seminar | 0 | 1 |
| 9 | STR 3101 | Study tour | 0 | 2 (NG) |
| | | **Total Credits - 21 (15+6)+2 NG** | **15** | **6 + 2 (NG)** |

| Semester 6 | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Catalogue No.** | **Course Title** | **Credits** | |
| | | | **Theory** | **Practical** |
| 1 | FMP 3209 | Tractor Systems & Controls | 2 | 1 |
| 2 | IDE 3206 | Groundwater, Wells and Pumps | 2 | 1 |
| 3 | BES 3213 | Sensors, AI and Robotics in Agriculture | 2 | 1 |
| 4 | PFE 3204 | Agricultural Structures & Environment Control | 2 | 1 |
| 5 | REE 3202 | Bioenergy Systems: Design and Applications | 2 | 1 |
| 6 | FMP 3210 | Refrigeration and Air-conditioning | 2 | 1 |
| 7 | PFE 3205 | Post-harvest Engineering of Horticultural Crops | 1 | 1 |
| 8 | CST 3201 | Case Study | 0 | 1 |
| | | **Total Credits - 21 (13+8)** | **13** | **8** |

| Semester 7 | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Catalogue No.** | **Course Title** | **Credits** | |
| | | | **Theory** | **Theory** |
| 1 | PRO 4101 | Project- I | 0 | 3 |
| 2 | FMP 4111 | Engineering Graphics and Design | 0 | 2 |
| 3 | PFE 4106 | Food Quality and Safety | 2 | 1 |
| 4 | SWC 4107 | Watershed Planning and Management | 2 | 1 |
| 5 | IDE 4107 | Sprinkler & Micro Irrigation Systems | 1 | 1 |
| 6 | FMP 4112 | Machine Design | 2 | 0 |
| 7 | FMP 4113 | Electrical Machines | 2 | 1 |
| 8 | BES 4114 | Agricultural Statistics and Data Analysis | 1 | 1 |
| | | **Total Credits - 20 (10+10)** | **10** | **10** |

| Semester 8 | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Catalogue No.** | **Course Title** | **Credits** | |
| | | | **Theory** | **Theory** |
| 1 | PRO 4202 | Project -II | 0 | 4 |
| 2 | IPT 4201 | In-plant Training/ Research Internship | 0 | 8 |
| 3 | | Elective- I | 2 | 1 |
| 4 | | Elective- II | 2 | 1 |
| 5 | | Elective- III | 2 | 1 |
| | | **Total Credits - 21 (6+15)** | **6** | **15** |
| | | | **Total** | **174 (94+80)** |
| | **Online Courses** | | **6** | **0** |
| | | | **GRAND TOTAL** | **180** |

## Foundation courses/ Ability Enhancement Courses

### AGE 1101 *Deeksharambh* (Induction-cum-Foundation Programme) (0+2) (NG)

The activities to be taken under *Deeksharambh*, in addition to giving a broad view and application areas of the subject of study, also will aim at creating a platform for

- Helping students from different backgrounds for cultural integration
- Knowing about the operational framework of academic process in university
- Instilling life and social skills, leadership qualities, team working spirit
- Developing social awareness, ethics and values, creativity
- Helping students to identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

The details of activities/ schedules will be decided by the parent universities. The structure shall include, but not restricted to:

1. Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University
2. Creating awareness on the subject of study, and the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario
3. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences
4. Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences
5. field visits to related fields/ establishments
6. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills.

### NSS 1101 NSS- I 1(0+1)

**Objective**

1. Evoking social consciousness among students through various activities, viz., working together, constructive, and creative social work
2. To be skilful in executing democratic leadership, developing skill in program
3. To be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society

**Practical/ Awareness activities**

- Orientation: history, objectives, principles, symbol, badge; regular programs under NSS
- Organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.
- NSS programme activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth programs/ schemes of GOI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.

- Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration.
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building. Volunteerism and shramdaan. Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism.
- Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society.

## NCC 1101 NCC- I 1(0+1)

**Objective**

1. To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizens
2. To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation

**Practical/ Awareness activities**

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- Saluting at the halt, getting on parade, dismissing, and falling out.
- Marching, length of pace, and timIe of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honors, and awards
- Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/ personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects.
- Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
- Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

## NSS 1202 NSS- II 1 (0+1)

**Objective**

To evoke social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skillful in executing democratic leadership,

developing skill in programme, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

**Practical/ Awareness activities**

- Importance and role of youth leadership
- Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies
- Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs
- Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations
- Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

## NCC 1202 NCC – II 1 (0+1)

**Objective**

1. To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen.
2. To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation.

**Practical/ Awareness activities**

- Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honor, Platoon/Coy Drill.
- Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.
- Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG.
- Introduction to map, scales, and conventional signs. Topographical forms and technical terms.
- The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs.
- Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water

supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

# Common Agricultural Engineering

## AGE 1102 Introduction to Agricultural Engineering 4 (3+1)

**Objective**

To enable the students to have basic idea on different agricultural engineering applications and the machinery involved in different farm operations, post-harvest and allied activities.

**Theory**

**Module I** **(12 Hours)**

Agricultural Engineering as a discipline; Major divisions of Agricultural Engineering; Importance of Agricultural Engineering for today's agriculture; Different sectors of employment for Agricultural Engineers (government, private, research, consulting, academia); Scope of research and higher studies in Agricultural Engineering in India and abroad (funding agencies, research institutions, international collaborations); Career opportunities and professional development for Agricultural Engineers. Farm mechanization needs and strategy; Classification of farm machinery on the basis of unit operations; Principles of selection of machinery for different sizes of land and matching power sources; Different types of equipment for tillage, sowing, planting and transplanting, fertilizer application, weed control, plant protection; Harvesting and threshing equipment for rice, wheat, maize, cotton, sugarcane, fruits, tuber crops and other locally important crops; Functions and capabilities of tractor and power tillers; Introduction to the IC engine systems, fuel and air supply systems, cooling and lubricating systems, and electrical systems in a tractor; Basic parts of a power tiller; Hitching system.

**Module II** **(9 Hours)**

Introduction to renewable energy systems; Types of biogas plants; Types of solar energy collectors; Solar water heating systems, solar dryers, solar photovoltaic systems; Wind mills and their different parts. Importance of soil and water conservation; Different agronomic measures for control of water erosion, mixed cropping, crop rotation, tillage practices, mulching; Different engineering measures; gully control measures. Use of topographical survey and contour maps. Different types of water harvesting structures.

**Module III** **(8 Hours)**

Introduction to soil-plant-water relationship; Equipment for measurement of irrigation water, viz. weirs, notches, orifices and mouth pieces; Introduction to different surface irrigation methods as border, furrow and check basin, sprinkler, drip irrigation and their different components; Underground water conveyance methods in pipes; Introduction to planning of drainage systems; Introduction to centrifugal pumps and different components.

**Module IV** **(7 Hours)**

Different types of agricultural structures; Introduction to planning and layout of farmsteads, animal houses, poultry houses; Different types of grain storage structures; Greenhouse and its different parts; Low cost protected structures.

**Module V** **(12 Hours)**

Classification of different types of agricultural commodities as durables, perishables, etc.; Moisture content and its importance in grain storage; Common reasons of food spoilage, food

preservation methods; Different primary processing operations and their necessity; Methods and equipment used for cleaning, washing, sorting, grading, peeling, size reduction; Different types of traditional and modern storage structures; Storage of perishable commodities; Different types of packaging materials and their suitability for various food products; Basic principles of value addition of food as drying and dehydration, evaporation, thermal processing, refrigerated and frozen storage, chemical preservation and other novel methods.

**Practical**

Study of various implements (tillage, sowing, planting, weeding, fertilizer application); Studyof farm implements (pesticide application, harvesting and threshing); Study of various componentsof tractor and matching implements; Study of various components of power tiller and matching implements; Study of various types of biogas plants and operational parameters; Study of various solar energy application systems; Study on various components of sprinkler and drip irrigation; Study on various components centrifugal pump; Study of various post-harvest operations; Study of different food processing equipment; Value addition of common crops; Visit to a greenhouse with modern irrigation system; Visit to implement manufacturing unit; Visit to a mechanized farm; Visit to a watershed; Visit to a food processing industry.

**Lecture Schedule**

1. Agricultural Engineering as a Discipline: Introduction and Major Divisions
2. Importance of Agricultural Engineering for today's agriculture
3. Different sectors of employment for Agricultural Engineers (government, private, research, consulting, academia)
4. Scope of research and higher studies in Agricultural Engineering in India and abroad (funding agencies, research institutions, international collaborations)
5. Career opportunities and professional development for Agricultural Engineers
6. Introduction to farm mechanization, its needs and strategy. Farm mechanization constraints.
7. Classification of farm machinery based on unit operations.
8. Principles of selection of machinery for different sizes of land
9. Matching power sources with machinery
10. Different types of equipment for tillage, sowing, planting, and transplanting, fertilizer application, weed control, plant protection.
11. Different types of equipment for tillage, sowing, planting, and transplanting, fertilizer application, weed control, plant protection contd.
12. Introduction to harvesting and threshing equipment for rice, wheat, maize, cotton, sugarcane, fruits, tuber crops and other locally important crops.
13. Introduction to harvesting and threshing equipment for rice, wheat, maize, cotton, sugarcane, fruits, tuber crops and other locally important crops contd.
14. Functions and capabilities of tractor and power tillers it’s parts.
15. IC Engine Systems in Tractors: Fuel and Air Supply
16. Cooling, Lubricating, and Electrical Systems in Tractors
17. Basic Parts of Power Tillers and Hitching Systems
18. Introduction to renewable energy systems
19. Biogas production and types of biogas plants.
20. Introduction to solar energy, types of solar energy collectors
21. Solar water heating systems, solar dryers, solar photovoltaic systems.

22. Introduction to wind energy, wind mills and their different parts.
23. Importance of soil and water conservation
24. Agronomic measures for control of water erosion (mixed cropping, crop rotation, tillage practices, mulching)
25. Engineering measures for soil and water conservation
26. Gully control measures
27. Use of topographical survey and contour maps
28. Different types of water harvesting structures
29. Introduction to soil-plant-water relationship
30. Measurement of Irrigation Water: Weirs, Notches, Orifices, Mouthpieces
31. Surface Irrigation Methods: Border, Furrow, Check Basin, Sprinkler Systems
32. Sprinkler and drip irrigation methods
33. Underground water conveyance methods in pipes
34. Introduction to planning of drainage systems
35. Centrifugal pumps and different components
36. Types of Agricultural Structures: Planning of Farmsteads, Animal and Poultry Houses
37. Grain Storage Structures
38. Greenhouses and Low-Cost Protected Structures: Components and Applications
39. Classification of different types of agricultural commodities as durables, perishables, etc
40. Moisture content and its importance in grain storage
41. Common reasons of food spoilage and food preservation methods
42. Primary processing operations and their necessity
43. Methods and equipment used for cleaning, washing, sorting
44. Methods and equipment used for grading, peeling, size reduction
45. Traditional and modern storage structures
46. Storage of perishable commodities
47. Different types of packaging materials and their suitability
48. Basic principles of value addition of food : drying, dehydration, evaporation, thermal processing, refrigerated and frozen storage, chemical preservation, and other novel methods)

**Practical**

1. Study of various implements (tillage, sowing, planting, weeding, fertilizer application)
2. Study of farm implements (pesticide application, harvesting and threshing)
3. Study of various components of tractor and matching implements
4. Study of various components of power tiller and matching implements
5. Study of various types of biogas plants and operational parameters
6. Study of various solar energy application systems
7. Study on various components of sprinkler and drip irrigation
8. Study on various components of centrifugal pump
9. Study of various post-harvest operations
10. Study of different food processing equipment
11. Value addition of common crops (drying, dehydration, evaporation, thermal processing)
12. Value addition of common crops (refrigerated and frozen storage, chemical preservation, and other novel methods)
13. Visit to a greenhouse with modern irrigation system
14. Visit to implement manufacturing unit
15. Visit to a mechanized farm and a watershed (combined visit)

16. Visit to a food processing industry
17. Practical examination

**Suggested Readings**


1. Chakraverty A. 1999. *Post Harvest Technology of Cereals, Pulses and Oilseeds*. Oxford & IBH publishing Co. Ltd., New Delhi.
2. Dash S K, Bebartta J P and Kar. 2012. A. *Rice Processing and Allied Operations*. Kalyani Publishers, New Delhi.
3. Jain S C and Philip G. 2009. *Farm Machinery - An Approach*. Second Edition. Standard Publishers and Distributors, New Delhi.
4. Mal B C. 2014. *Introduction to Soil and Water Conservation Engineering*. 2014. Kalyani Publishers.
5. Michael A M and Ojha T P. 2003. *Principles of Agricultural Engineering*. Jain Brothers, New Delhi.
6. Michael A M. 2012. *Irrigation: Theory and Practice*. Vikas Publishing House New Delhi
7. Nakra C P. 1980. *Farm Machines and Equipment*. Dhanpat Rai Publishing Company Pvt. Ltd, New Delhi
8. Rai G D. 1995. *Solar Energy Utilization*. Khanna Publishers, New Delhi.
9. Rai G D. 2013. *Non-Conventional Energy Sources*. Khanna Publishers, New Delhi.
10. Sahay K M and Singh K K. 1994. *Unit Operations of Agricultural Processing*. Vikas Publishing house Pvt. Ltd, New Delhi.
11. Suresh R and Kumar Sanjay. 2018. *Farm Power and Machinery Engineering*. Standard Publisher Distributors, New Delhi.
12. Suresh R. 2014. *Soil and Water Conservation Engineering*. Standard Publisher Distributors, New Delhi.


## SEM 3101 Seminar 1(0+1)

**Objectives**

- To enable students to improve their knowledge and understanding of a topic
- To develop confidence and competence to identify and compare technical and practical issues related to the area of course specialization and to present it before a group of people

**Practical**

The student will be assigned to present on a technical and practical issue or on an emerging field. The activities should include establishing motivation for any topic of interest and develop a thought process for technical presentation, conduct a detailed literature survey and to build a document with respect to technical publications, analysis and comprehension of proof-of-concept and related data, and effective presentation with improved soft skills. It should also involve use of new and recent technologies for creating technical reports and presentation. The evaluation shall be based on the ability of the student to describe, interpret and analyze technical issues and competence in presenting.

## CST 3201 Case study 1 (0+1)

**Objective**

To enable the students to generate an in-depth, multi-faceted understanding of a specific case/ situation/ aspect related to the profession in its real-life context

**Activities**

The students will be assigned to visit to a nearby area/ entity to study and analyse any particular case.

The case study can be either problem-solving type or descriptive type. The problem-solving case studies would aim to investigate a problem or situation in a particular individual or group, and recommend solution to the problem(s) based on analysis and theory.

Descriptive case studies would aim to understand a situation better. For example, identifying what happened and why by describing particular aspects of that situation and analysing it in terms of theoretical categories. This will help to make a choice about how to do things in a better way in future for another case having similar features.

Some indicative areas for the case studies are as follows.

1. Study the status of farm mechanization and agro-processing in a particular village and to suggest improvement measures
2. Study a specific watershed and suggest measures for rejuvenating the watershed
3. Study the losses of fruits and vegetables in a local market yard and suggest remedial measures
4. Study the supply chain for a commodity and suggest a suitable value chain
5. Visit to a village to study the energy consumption pattern and suggest measures for efficient energy use and integration of renewable energy for different farm operations
6. Visit to an orchard and suggest measures for optimized water use
7. Visit to a retail store/ farm machinery dealer and report on supply chain network
8. Visit to a retail store and study the different types of packaging materials
9. Visit to an entrepreneur and study his journey to success (or reasons of failure)

After the visit, the students will submit a report to the institution on their observations. They may also be asked to present the report before the other faculty members and students for interaction.

The activity and presentations are recommended to be accommodated on Saturdays. A teacher will be designated as the facilitator for the programme.

## STR 3101 Study tour 2 (0+2) NG

The study tour will be of 10-14 days duration within the 5$^{th}$ semester.

The students will visit industries/ institutions, preferably outside the state, so that, in addition to visiting the organizations/ industries (related to the profession), they will also be exposed to the geographical, social, socio-economic and cultural diversity of different places/ states. After the visit, the students will submit a report/ make a presentation.

## Department of Farm Machinery and Power Engineering-Core Courses

## FMP 1101 Workshop Technology and Practice 2 (0+2)

### Objective

To expose the students to basic manufacturing processes involved for production of different machine elements and to facilitate hands-on experience of using these machines.

### Practical

Introduction about different shops in the workshop; Safety and precautions to be taken in the workshop; Study of different tools used for fitting and different fitting operations; Study of various measuring instruments used for fitting; Exercise in fitting: sawing, filing and right angle fitting of MS flat; Working with complex fitting jobs: operations of drilling, reaming, and threading and with tap dies; Preparation of a paper weight; Study of various carpentry tools, types of wood and their characteristics and working with carpentry tools; Preparation of simple joints in carpentry: cross half lap joint or T-half joint, Mortise and Tenon joint in carpentry; Preparation of dovetail joint in carpentry; Study of welding, types of welding, oxyacetylene gas welding, types of flames, welding techniques and equipment used for gas welding, working with welding equipment; Working with electric arc welding; Equipment and tools, safety and precautions taken in arc welding; Preparation of Butt joint and lap joint with ARC welding; Preparation of Lap and butt joints using gas welding; Working on a lathe machine and study of different tools used in lathe machine; Exercise on simple turning, step turning in lathe machine; Preparation of job on taper turning, drilling, knurling and threading in lathe machine; Working with different machines in machine shop such as shaper, milling machine, etc. and with different tools used in machine shop; Exercise on bending, shaping etc.; Exercise on Drawing, Punching, Riveting; Making different types of sheet metal joints using G.I. sheets; Practice job on shaper; changing a round MS rod into square section with a shaper; Exercise on a milling machine such as making a slot, gear tooth forming and indexing.

### Practical Schedule

1. Introduction to different shops in the workshop.
2. Introduction to workshop safety and precautions.
3. Study of different tools and operations used in fitting shop.
4. Study of different measuring instruments used in fitting shop.
5. Practice in sawing, filing and right-angle fitting of MS flat.
6. Introduction to operations of drilling reaming and threading with tap and dies.
7. Preparation of a paper weight.
8. Study of various carpentry tools, types of wood and their characteristics.
9. Practice in cutting, planning and working with carpentry tools.
10. Preparation of a simple cross half lap carpentry joint.
11. Preparation of a simple T-halving carpentry joint.
12. Preparation of dovetail joint in carpentry.
13. Preparation of mortise and tenon joint in carpentry.
14. Introduction to welding, types, equipment and tools used in welding.
15. Study of different types of flames used in gas welding.

16. Preparation of butt and lap joint using arc welding.
17. Preparation of butt and lap joint using gas welding.
18. Introduction to smithy and forging tools and operations.
19. Preparation of cold work job by changing mild steel round rod to square rod.
20. Preparation of cold work job by changing mild steel round rod to ring.
21. Preparation of hot work job by changing mild steel round rod to square prism.
22. Introduction to lathe machine, tools used and operations performed in machine shop.
23. Practice in simple plain turning and step turning in lathe machine.
24. Preparation of job by taper turning and drilling in lathe machine.
25. Preparation of job by knurling and threading in lathe machine.
26. Introduction to different machines in machine shop such as shaper, milling machine, etc.
27. Demonstration of important operations on a shaper and milling machine.
28. Practice of changing a round MS rod into square section on a shaper.
29. Practice in making a slot, gear tooth forming and indexing
30. Practice in bending, shaping, drawing, punching and riveting etc.
31. Introduction to tools and operations in sheet metal work.
32. Practice in making different types of sheet metal joints using G.I. sheets.

**Suggested Readings**


1. Chapman W A J. 2018. Workshop Technology (Vol. I and II). Arnold Publishers (India) Pvt. Ltd., AB/9, Safdarjung Enclave, New Delhi.
2. Hajra Choudhury S K, Roy N, Hajra Choudhury A K. 2017. Elements of Workshop Technology (Vol. I and II). Media Promoters and Publishers Pvt. Ltd, Mumbai.
3. Khurmi R S and Gupta J K. 2018. A Text Book of Workshop Technology. S. Chand & Company Ltd, New Delhi.
4. Raghuwansi B S. 2016. A Course in Workshop Technology (Vol. I and II). Dhanpat Rai and Sons, 1682, Nai Sarak, New Delhi.


## FMP 1102 Basic Electrical Gadgets and Instruments 3 (2+1)

**Objective**

To enable the students to take up repair and maintenance of different common electrical gadgets and instruments.

**Theory**

**Module I** **(12 Hours)**

Introduction to different electrical appliances used in agricultural buildings, structures and farm operations. Difference between AC and DC supply system; Introduction to AC fundamentals;AC through R, L, C , series RL, RC. AC through series RLC circuits, parallel RLC circuit. Series and parallel resonance; Q-factor and bandwidth. Three- phase AC circuit: Concept of balanced three-phase AC circuits, line and phase quantity in star and delta network, power inthree-phase circuit. Various methods of three phase power measurement like (one wattmeter and two –wattmeter method).

**Module II** **(12 Hours)**

Diode and its applications: Rectifier, Clipper, Clamper, Voltage multiplier and capacitive filter Zener diode as voltage regulator. Transistor and its applications: Bipolar junction transistor, operating point. Various biasing methods, fixed, self-biasing and Potential divider biasing method. OP-AMP, Ideal OP-AMP characteristics, Linear and non-linear applications of OP- AMP , Adder, Subtractor. Integrator, Active rectifier and Comparator using OP-AMP. Introduction to digital electronics and logic gates. Basic theorem of Boolean algebra. SOP rule and K-map. Combinational logic circuits , Adder, Subtractor. Multiplexer, DE multiplexer, Encoder, Decoder

**Module III** **(12 Hours)**

Principles of general instrumentation systems, Transducers, classifications. Measurement of Displacement. Measurement of Temperature. Measurement of Velocity. Measurement ofForce. Measurement of Pressure (using different instruments like strain gauges, load cell, thermistors, thermocouples, pyrometer, linear variable differential transformer (LVDT), capacitive transducers, RTD). Instruments for measurement of speed, Measurement of Wind velocity, Measurement of solar radiation, Working of Anemometer, Working of Multimeter.

**Practical**

To prepare an electrical switch board to control two light points, one plug point, one fan point and fuse (House wiring); To prepare an electrical switch board to control two light points using two two-way switch (staircase wiring); To connect and test a fluorescent lamp; To find faults and repair home appliances such as heater, electric iron, fans and mixer-grinder, etc.; To find faults and repair UPS; To measure the power requirement and power factor in a AC single phase series RLC circuit; To measure energy of a single phase AC circuit with the help of ammeter, voltmeter and power factor meter and energy meter; To measure the power consumption in a three-phase circuit using two-wattmeter method.

**Instrumentation**

To prepare a DC power supply unit using diode and filter circuit; To study the Zener diode as voltage regulator circuit; To study transistor characteristics in CE configurations; To verify different logic gates; To measure unknown resistance using Wheatstone bridge; To measure the displacement and to determine the characteristics of LVDT; To measure the displacement using LVDT and potentiometer; To measure the pressure using strain gauge and Bourdentube; To measure the temperature using RTD, thermistors and thermocouple and study their characteristics; To measure the speed, wind velocity, solar radiation etc., using different measuring tools like tachometer, anemometer, pyrometer, multimeter, etc.; To acquaint with different other types of instruments used in agriculture and food processing applications.

**Lecture Schedule**

1. Introduction To Different Electrical Appliances Used in Agricultural Buildings, Structures and Farm Operations
2. Difference Between AC and DC Supply System
3. Introduction to AC Fundamentals
4. AC Through Series RL, RC, And RLC Circuit
5. Parallel AC Circuit, Series and Parallel
6. Resonance Q-Factor and Bandwidth.
7. Three- Phase AC Circuit:

8. Concept of Balanced Three-Phase AC Circuits
9. Line And Phase Quantity in Star and Delta Network
10. Power In Three-Phase Circuit,
11. Various Methods of Three Phase Power Measurement
12. One Wattmeter and Two –Wattmeter Method
13. Diode And Its Applications: Rectifier, Clipper, Clamper
14. Voltage Multiplier and Capacitive Filter Zener Diode as Voltage Regulator
15. Transistor and its Applications: Bipolar Junction Transistor, Operating Point.
16. Various Biasing Methods, Fixed, Self-Biasing
17. Potential Divider Biasing Method
18. OP-AMP, Ideal OP-AMP Characteristics
19. Linear And Non-Linear Applications Of OP-AMP
20. Adder, Subtractor, Integrator
21. Active Rectifier, Comparator
22. Introduction To Digital Electronics and Logic Gates: Basic Theorem of Boolean Algebra
23. Combinational Logic Circuits (Basic Gates, SOP Rule And K-Map)
24. Binary Adder.
25. Measurement of Displacement
26. Measurement of Temperature
27. Measurement of Velocity
28. Measurement of Force
29. Measurement of Pressure Using Different Instruments
30. Strain Gauges, Load Cell
31. Thermistors, Thermocouples
32. Pyrometer
33. Linear Variable Differential Transformer (LVDT)
34. Capacitive Transducers, RTD
35. Instruments For Measurement of Speed, Wind Velocity
36. Solar Radiation, Anemometer, Multimeter

**Practical Schedule**

1. To prepare an electrical switch board to control two light points, one plug point, one fan point and fuse (House wiring)
2. To prepare an electrical switch board to control two light points using two two-way switches (staircase wiring)
3. To connect and test a fluorescent lamp
4. To find faults and repair home appliances such as heater, electric iron, fans and mixer-grinder
5. To find faults and repair UPS
6. To measure the power requirement and power factor in a AC single phase series RLC circuit
7. To measure energy of a single-phase AC circuit with the help of ammeter, voltmeter and power factor meter and energy meter
8. To measure the power consumption in a three-phase circuit using two-wattmeter method

**Instrumentation**

1. To prepare a DC power supply unit using diode and filter circuit
2. To study the Zener diode as voltage regulator circuit
3. To study transistor characteristics in CE configurations

4. To verify different logic gates
5. To measure unknown resistance using Wheatstone bridge
6. measure the displacement and to determine the characteristics of LVDT
7. To measure the displacement using LVDT and potentiometer
8. To measure the pressure using strain gauge and Bourdon tube
9. To measure the temperature using RTD, thermistors and thermocouple and study their characteristics
10. To measure the speed, wind velocity, solar radiation using different measuring tools like tachometer, anemometer, pyrometer, multimeter
11. To acquaint with different other types of instruments used in agriculture
12. To acquaint with different other types of instruments used in food processing applications.
13. Practical Examination

**Suggested Readings**


1. Boylestad R L and Nashelsky L N. 2011. Electronic Device and Circuit Theory. Pearson.
2. Ghosh S. 2007. Fundamentals of Electrical and Electronics Engineering. Second edition. PHI Learning New Delhi
3. Metha V K and Metha R. 2012. Basic Electrical Engineering. Fifth edition. S Chand & Co., New Delhi.
4. Metha V K and Metha R. 2012. Principle of Electronics. Fifth edition. S Chand & Co., New Delhi.
5. Rajput R K. 2007. Basic Electrical and Electronics Engineering. Laxmi Publications, New Delhi.
6. Theraja B L and Theraja A K. 2005. A Text Book of Electrical Technology. Vol. I & II. S Chand & Co., New Delhi


## FMP 1203 Engineering Drawing 2 (0+2)

**Objective**

To enable the students to draw engineering drawings for some simple machines/ equipment

**Practical**

**Module I** **(9 Hours)**

Introduction to engineering drawing, practice of different layout drawings, Drawing instruments and their use; Introduction to lines, letterings, single stroke letters and gothic letters; Dimensioning, dimension line, extension line, arrow head, continuous and progressive dimensioning; Introduction of drawing scales, representative fraction; Practice on orthographic projections, references planes, points and lines in space.

**Module II** **(11 Hours)**

Drawing for orthographic projection of points by first angle projection method; Third angle methods of projection; Projection of planes; Projections of solids: polyhedra, cylinder, cone; Projections of solids: prisms and pyramids; Development of surfaces of geometrical solids;

Drawing the section of solids: cylinder, cone and sphere; Introduction to isometric scale, isometric view and isometric drawing. Isometric projection of geometrical solids; Preparation of working drawing from models and isometric views; Sectional drawing of simple machine parts.

**Module III** **(8 Hours)**

Nomenclature, thread profiles, multi start threads, left and right hand threads; Conventional representation of threads; Forms of screw threads like metric thread, whit worth thread; Square thread: acme thread, knuckle thread, buttress thread; Square headed and hexagonal nuts and bolts; Different types of lock nuts, studs, machine screws, cap screws and wood screws.

**Module IV** **(8 Hours)**

Processes for producing leak proof joints; Drawing of different types of rivet heads and riveted joints and foundation bolts; Drawing of stud screws, set screws, butt, hexagonal and square; Drawing of keys: taper, rank taper, hollow saddle etc; Symbols for different types of welded joints.

**Practical Schedule**

1. Introduction to engineering drawing, lines and letterings
2. Different layout drawing
3. Drawing instruments and their use
4. Dimensioning, dimension line, extension line, arrow head, continuous and progressive dimensioning,
5. Drawing scales, representative fraction
6. Orthographic projections plane of projection, first and third angle projection
7. Orthographic projections –points
8. Orthographic projections- lines, parallel to and contained by one or both planes
9. Drawing for orthographic projection of points by first angle projection method
10. Drawing for orthographic projection of points by third angle projection method
11. Projections of solids-Polyhedra,cylinder,cone,prisms
12. Projections of solids-pyramids simple positions
13. Projection of solid-axis inclined to one plane and parallel to other, axis inclined to both planes
14. Development of surfaces of geometrical solids
15. Section of solids- concept of sectioning, section plane parallel to one plane, section plane perpendicular to one plane and inclined to other
16. Drawing the section of solids: cylinder, cone and sphere
17. Isometric projection of geometrical solids
18. Preparation of working drawing from models and isometric views.
19. Drawing of missing views.
20. Sectional drawing of simple machine parts.
21. Nomenclature, thread profiles
22. Forms of screw threads
23. Drawing of BSW, Square and Metric threads
24. Drawing of acme thread, knuckle thread, buttress thread
25. Drawing of square headed and hexagonal headed nuts and bolts.
26. Drawing of Different types of lock nuts
27. Drawing of machine screws, cap screws and wood screws
28. Introduction to riveted joints
29. Processes for producing leak proof joints

30. Drawing of different types of rivet heads and riveted joints and foundation bolts
31. Drawing of stud screws, set screws, butt screws
32. Drawing of hexagonal and square screws
33. Drawing of keys: taper, rank taper, hollow saddle etc
34. Symbols for different types of welded joints

**Suggested Readings**


1. Bhatt, N. D. 2010. Elementary Engineering Drawing. Charotar Publishing House Pvt. Ltd., Anand.
2. Bhatt, N. D. and Panchal, V. M. 2013. Machine Drawing. Charotar Publishing House Pvt. Ltd., Anand.
3. Narayana, K. L. and Kannaiah, P. 2010. Machine Drawing. Scitech Publications (India) Pvt. Ltd, Chennai
4. Anilkumar.K.N. 2005.Engineering Graphics.Adhyuthnarayan Publishers, Kottayam
5. Narayana.K L and Kannaiah.P. 2010. Machine Drawing. ScitechPublications (India) Pvt.Ltd.Chennai.


## FMP 2104 Farm Machinery and Equipment- I 3 (2+1)

**Objective**

To make the students acquainted with the basic construction and operational features of different farm machineries used in operations such as seed-bed preparation, sowing, planting and transplanting, etc., and their economics of operation

**Theory**

**Module I** **(6 Hours)**

Introduction to farm mechanization; Scope, Merits, Limitations, Status of mechanization in the country and state, History of farm mechanization, Research and developments in farm machinery; Classification of farm machines; Unit operations in crop production; Identification and selection of machines for various operations on the farm. Classification of farm machines based on operation, power source, in relation to power unit etc.

**Module II** **(5 Hours)**

Materials used in construction of farm machines; Heat treatment processes and their use in farm machines; Properties of materials used for critical and functional components of agricultural machines; Different types of steels and alloys for agricultural applications; Identification of heat treatment processes specially for the agricultural machinery components.

**Module III** **(10 Hours)**

Seed-bed preparation and its classification; Land reclamation and earth moving equipment; Machines used for primary tillage, secondary tillage, rotary tillage, deep tillage and minimum tillage, viz. mould-board plough, disc plough, chisel plough, sub-soiler, harrows, puddler, cultivators, identification of their major functional components; Attachments with tillage machinery; Hitching systems and controls.

**Module IV** **(12 Hours)**

Sowing, planting and transplanting equipment, viz. seed drills, no-till drills, strip-till drills, different types of planters, bed-planters; Planting equipment for crops like sugarcane, potato; Furrow openers and metering systems in drills and planters; Calibration of seed-drills/ planters; Adjustments during operation. Calculation of field capacities and field efficiency; Draft of tillage tools and calculations for power requirement for the tillage machines; Calculation for economics of machinery usage; Comparison of ownership with hiring of machines. Testing and Evaluation of tillage and sowing equipment and their test codes.

**Practical**

Familiarization with different farm implements and tools; Study of hitching systems; Study on draft measurement; Study of different problems on machinery management.; Study of primary tillage machinery- types, construction, operation, adjustments and calculations of power and draft requirements; Study of secondary tillage machinery- types, construction, operation, adjustments and calculations of power and draft requirements; Study of different types of puddlers and determination of puddling index in the field; Study of sowing and planting equipment- construction, types, calculation for calibration and adjustments; Study of seed drill and its calibration; Study of different types of metering mechanisms used in seed drills and planters; Study of paddy transplanters; Study of various pre-germinated paddy seeder; Study of vegetable transplanters; Identification of materials of construction in agricultural machinery and study of material properties; Testing and Evaluation of tillage and sowing equipment; Visit to a site to observe field operations of paddy transplanters; Visit to an implement manufacturing unit.

**Lecture Schedule**

1. Introduction to farm mechanization – Scope, Merits, Limitations, Status of mechanization in the country and state
2. History of farm mechanization, Research and developments in farm machinery
3. Unit operations in crop production
4. Classification of farm machines based on operation, power source, in relation to power unit etc.
5. Classification, Identification and selection of machines for various operations on the farm.
6. Introduction to materials used in construction of farm machines
7. Properties of materials used for critical and functional components of agricultural machines
8. Heat treatment processes and their use/requirement in farm machines
9. Different types of steels and alloys for agricultural applications
10. Identification of heat treatment processes specially for the agricultural machinery components
11. Land reclamation and earth moving equipment
12. Seed-bed preparation and its classification
13. Concepts of deep tillage, rotary tillage and minimum tillage
14. Machines used for primary tillage, secondary tillage, Rotary tillage, deep tillage and minimum tillage operations
15. Mould-board plough, disc plough: Functional components, type, constructional details, accessories and attachments.
16. Study of Chisel plough, sub-soiler, rotary tillers: Functional components, type, constructional details, accessories and attachments

17. Harrows, puddlers, levellers and cultivators: Functional components, type, constructional details, accessories and attachments
18. Attachments with tillage machinery
19. Hitching systems and controls
20. Forces acting on tillage implements
21. Introduction to Sowing, planting and transplanting equipment
22. Introduction to seed drills, no-till drills, strip-till drills
23. Introduction to planters, bed-planters and other planting equipment, Rice transplanters
24. Planting equipment for crops like sugarcane, potato
25. Furrow openers and metering systems in drills and planters
26. Calibration of seed-drills/ planters-problem; Adjustments during operation.
27. Calculation of field capacities and field efficiency-problem
28. Draft of tillage tools and calculations for power requirement for the tillage machines
29. Calculation for economics of machinery usage, fixed cost, variable cost
30. Methods for calculating depreciation-problem
31. Break even analysis – small, large and own, hired machine; Comparison of ownership with hiring of machines
32. Economic considerations in selection of farm implements and machinery
33. Testing and Evaluation of tillage equipment and their test codes
34. Testing and Evaluation of sowing equipment and their test codes

**Practical schedule**

1. Familiarization with different farm implements and tools;
2. Study of hitching systems;
3. Calculations of power and draft requirements
4. Identification of materials of construction in agricultural machinery and study of material properties
5. Study of primary tillage machinery- types, construction, operation, adjustments and calculations of power and draft requirements;
6. Study of secondary tillage machinery- types, construction, operation, adjustments and calculations of power and draft requirements;
7. Study of different types of puddlers and determination of puddling index in the field;
8. Study of sowing and planting equipment- construction, types, calculation for calibration and adjustments
9. Study of seed drill and its calibration
10. Study of different types of metering mechanisms used in seed drills and planters
11. Study of paddy transplanters and various pre-germinated paddy seeder
12. Study of vegetable transplanters
13. Estimating field capacities, field efficiencies and related problems
14. Calculation of cost of operation of farm implements and machinery
15. Problems on selection of farm machinery – economic considerations
16. Testing and Evaluation of tillage and sowing equipment;
17. Visit to a site to observe field operations of paddy transplanters;
18. Visit to an machinery manufacturing units

**Suggested Readings**


1. Jain, S. C. and Phillips, G. 2003. Farm Machinery - An Approach. Standard Publishers and Distributors.
2. Kepner, R. A., Bainer, R. and Barger, E. L. 2005. Principles of Farm Machinery. CBS Publishers and Distributors.
3. Lal, Radhey and Datta, A. C. 1978. Agricultural Engineering through worked out examples. Saroj Prakashan, Allahabad.
4. Nakra, C. P. 2003. Farm Machines and Equipment. Dhanpat Rai and Publishing Co.
5. Smith, H. P. and Wilkes, L. H. 2011. Farm Machinery and Equipment. McGraw Hill Publication, New York.
6. Srivastav, A. K., Goering, C. E. and Rohrbach, R. P. 2005. Engineering Principles of Agricultural Machines. ASAE. St. Joseph, Mich.
7. Srivastava, A. C. 1991. Elements of Farm Machinery. Oxford and IBH Publication.
8. Srivastava, T. K. 2007. A Work Book on Practical Farm Machinery (Vol. I and II). Saroj Prakashan, Allahabad.


## FMP 2205 Farm Machinery and Equipment-II 3 (2+1)

**Objective**

To make the students acquainted with the basic construction and operational features, and economics of operation of different farm machineries used in operations such as spraying, weeding, harvesting, etc., including operations done by combines, etc.

**Theory**

**Module I** **(7 Hours)**

Plant protection equipment- Different types of sprayers and dusters. Classification of sprayers and sprays. Types of nozzles. Calculations for calibration of sprayers and chemical application rates. Introduction to interculture equipment. Weeders- different types of manual and powered weeders. Functional requirements of weeders and main components. Different types of fertilizer application methods and equipment.

**Module II** **(9 Hours)**

Harvesting of crops-Harvesting methods, harvesting terminology. Mowers– types, constructional details, working and adjustments. Shear type harvesting devices- cutter bar, inertia forces, counter balancing, terminology, cutting pattern. Reapers, binders and windrowers- principle of operation and constructional details. Baling and Balers – types, functional components and working principle. Hay conditioning, importance, methods of hay conditioning, and calculation of moisture content of hay.

**Module III** **(9 Hours)**

Threshing- manual and mechanical systems. Types of threshing drums and their applications. Types of threshers- tangential and axial, constructional details and cleaning systems. Factors affecting thresher performance. Grain combines- combine terminology and features, classification

of grain combines, study of material flow in combines. Computation of combine losses, Combine troubles and troubleshooting. Chaff cutters- working principle, constructional features and capacity calculations. Straw combines- working principle and constructional details.

**Module IV** **(6 Hours)**

Root crop diggers- Principles of operation, functional components, blade adjustment and approach angle, calculation of material handled. Potato and groundnut diggers. Maize harvesting combines. Cotton harvesting, cotton harvesting mechanisms, cotton pickers and strippers. Vegetables and fruit harvesting equipment and tools. Tools and equipment for rubber tapping, tea harvesting and tree climbing.

**Module V** **(3 Hours)**

Testing and Evaluation of intercultural, plant protection and harvesting machinery and their test codes.

**Practical**

Familiarization with plant protection and interculture equipment; Study of sprayers, types, functional components, calibration; Study of dusters- types and functional components; Calculations for chemical application rates; Study of nozzle types and spread pattern using patternator; Familiarization with manual and powered weeding equipment and identification of functional components; Study of fertilizer application equipment including manure spreaders and fertilizer broadcasters; Study of various types of mowers, reaper, reaper binder; Study of functional components of mowers and reapers; Study of threshing systems, cleaning systems in threshers, calculations of losses in threshers; Study of functional units of grain combines and their types, calculations for grain losses in a combine; Study of root crop diggers and familiarization with the functional units and attachments; Study of the working of cotton and maize harvesters; Study of different vegetable and fruit harvesters; Testing and evaluation of intercultural, plant protection and harvesting machinery; Visit to field showing operations various machines; Visit to implement manufacturing unit.

**Lecture Schedule**

1. Introduction to plant protection equipment – sprayers and dusters.
2. Classification of sprayers.
3. Types of nozzles – components and functions- droplet size, drift, nozzle designation and nozzle materials.
4. Calculations for calibration of sprayers and chemical application rates.
5. Study of weeders – manual and power weeders.
6. Study of functional requirements of weeders and main components- performance indicators of weeders- problems.
7. Study of fertilizer application methods and equipment.
8. Methods of harvesting – pre-requisites and constraints of mechanical harvesting.
9. Study of various types of mechanical harvesting devices.
10. Study of shear type harvesting devices- terminology, cutter bar adjustments – registration and alignment.
11. Study of shear type harvesting devices- cutter bar, inertial forces, counterbalancing, cutting pattern.
12. Study of mowers – types, constructional details, working and adjustments.

13. Study of reapers- power transmission units – components.
14. Study of reaper binders and windrowers – principle of operation and construction.
15. Study of Balers – types, functional components and working principle.
16. Hay conditioning- importance, methods of hay conditioning, and calculation of moisture content of hay.
17. Threshing methods-manual and mechanical systems, power threshers- components.
18. Types of threshing cylinders- tangential and axial, their constructional details.
19. Study of factors affecting thresher performance – terminologies- threshing and cleaning efficiency, sieve loss, blower loss etc.
20. Study of grain combines- classification, features and terminology.
21. Study of grain combines- functional components and study of material flow in combines.
22. Computation of grain combine losses.
23. Combine troubles and troubleshooting.
24. Chaff cutters- working principle, constructional features and capacity calculations.
25. Straw combines- working principle and constructional details.
26. Study of root crop diggers – principle of operation, functional components, blade adjustment. approach angle and calculation of material handled.
27. Study of potato and groundnut diggers.
28. Study of maize harvesting combines.
29. Study of cotton harvesting, cotton harvesting mechanisms, cotton pickers and strippers.
30. Study of vegetables and fruit harvesting equipment and tools.
31. Study of tools and equipment for rubber tapping, tea harvesting and tree climbing.
32. Study of the testing and evaluation procedures for power sprayers with test codes.
33. Study of the testing and evaluation procedures for weeding equipment with test codes.
34. Study of the testing and evaluation procedures for grain combines with test codes.

**Practical Schedule**

1. Familiarization with sprayers and dusters- types and their functional components.
2. To perform spray calibration of s knapsack sprayer.
3. Calculations for chemical application rates.
4. Familiarization with nozzle types and generation of spread pattern using patternator.
5. Familiarization with manual and powered weeding equipment and identification of functional components.
6. Familiarization with fertilizer application equipment -manure spreaders & fertilizer broadcasters.
7. Familiarization with components of cutter bar, Registration and alignment- adjustments.
8. Familiarization with functional components of mowers, reaper and reaper binder.
9. Study of different types of threshing systems, cleaning systems in threshers, calculations of losses in threshers.
10. Familiarization with functional components of grain combines.
11. Calculations for grain losses in a combine harvester.
12. Familiarization with root crop diggers and their functional units and attachments.
13. Familiarization with various tools and equipment for vegetable and fruit harvesting.
14. Familiarization with various tools and equipment for tea harvesting, rubber tapping and tree climbing.

15. Discussion on testing and evaluation of intercultural, plant protection and harvesting machinery.
16. Visit to field operations of various machines.
17. Visit to machinery manufacturing unit.

**Suggested Readings**


1. Jain, S. C. and Phillips, G. 2003. Farm Machinery - An Approach. Standard Publishers and Distributors.
2. Kepner, R. A., Bainer, R. and Barger, E. L. 2005. Principles of Farm Machinery. CBS Publishers and Distributors.
3. Lal Radhey and Datta, A. C. 1978. Agricultural Engineering through Worked Out Examples. Saroj Prakashan, Allahabad.
4. Mehta M L, Verma S R, Rajan P and Singh S K 2019. Testing and Evaluation of Agricultural Machinery. Daya Publishing House, Delhi.
5. Nakra, C. P. 2003. Farm Machines and Equipment. Dhanpat Rai and Publishing Co.
6. Smith, H. P. and Wilkes, L. H. 2011. Farm Machinery and Equipment. McGraw Hill Publication, New York.
7. Srivastav, A. K., Goering, C. E. and Rohrbach, R. P. 2005. Engineering Principles of Agricultural Machines. ASAE. St. Joseph, Mich.
8. Srivastava, A. C. 1991. Elements of Farm Machinery. Oxford and IBH Publication.
9. Srivastava, T. K. 2007. A work Book on Practical Farm Machinery. Vol. I and II. Saroj Prakashan, Allahabad.
10. Suresh, R. and Kumar, S. 2018. Farm Power and Machinery Engineering. Standard Publishers.


## FMP 3106 Theory of Machines 2(2+0)

**Objectives**

- To enable the students to analyse the relative motion between various parts of machine and forces which act on them
- To apply the theories in designing the various parts of the machine

**Theory**

**Module I** **(9 Hours)**

Simple mechanism: Elements, links, pairs, kinematics chain, and mechanisms; classification of pairs and mechanisms; lower and higher pairs; four bar chain, slider crank chain and their inversions; Velocity mechanism: determination of velocity and acceleration using graphical (instantaneous centres) method.

**Module II** **(9 Hours)**

Types of gears, law of gearing, velocity of sliding between two teeth in mesh; Involute and cycloidal profile for gear teeth; Spur gear, nomenclature; Introduction to helical, spiral, bevel and worm gear; Simple, compound, reverted, and epicyclic trains; determining velocity ratio by tabular method.

**Module III** **(9 Hours)**

Turning moment diagrams, coefficient of fluctuation of speed and energy, weight of flywheel, flywheel applications Belt drives: Types of drives, belt materials, length of belt, transmitted power, velocity ratio, belt size for flat and V belts; effect of centrifugal tension, creep and slip on power transmission; chain drives, classification of chain drive, terms used in chain drive.

**Module IV** **(9 Hours)**

Types of friction, laws of dry friction; friction of pivots and collars; single disc, multiple disc, and cone clutches, rolling friction; Types of governors, constructional details and analysis of Watt, Porter, Proell governors, effect of friction, controlling force curves. sensitiveness, stability, hunting, iso-chronism, power and effort of a governor. Static and dynamic balancing, balancing of rotating masses in one and different planes

**Lecture Schedule**

1. Introduction to elements, links and pairs
2. Kinematic chain and mechanism
3. Classification of pairs and mechanism
4. Lower pair and higher pair
5. Four bar chain
6. Slider crank chain and their inversions
7. Determination of velocity and acceleration using graphical method (relative velocity and acceleration
8. Instantaneous centres method
9. Types of gears and law of gearing
10. Velocity of sliding between two teeth in mesh
11. Involute and cycloidal profile for gear teeth
12. Spur gear nomenclature.
13. Interference and undercutting
14. Introduction to helical, spiral, bevel and worm gear
15. Simple and compound gear train
16. Reverted and epicyclic gear trains
17. Determining velocity ratio by tabular method
18. Turning moment diagrams
19. Coefficient of fluctuation of speed and energy
20. Weight of flywheel. Flywheel applications
21. Belt drives, types of drives, belt materials.
22. Length of belt, power transmitted, velocity ratio, belt size for flat and V belts
23. Effect of centrifugal tension, creep and slip on power transmission
24. Chain drives, terms used in chain drive
25. Types of friction, laws of dry friction
26. Friction of pivots and collars
27. Single disc, multiple disc, and cone clutches
28. Rolling friction, anti-friction bearings.
29. Types of governors.
30. Constructional details and analysis of Watt, Porter, Proell governors

31. Effect of friction, controlling force curves
32. Sensitiveness, stability, hunting, isochronism, power and effort of a governor
33. Static and dynamic balancing
34. Balancing of rotating masses in one and different planes.

**Suggested Readings**


1. Ballaney, P. L. 2016. A Text Book of Theory of Machines. Khanna Publishers, New Delhi.
2. Bansal, R. K. 2009. A Text Book of Theory of Machines. Laxmi Publications (P) Ltd., New Delhi.
3. Khurmi, R. S. and Gupta, J. K. 2010. A Text Book of Theory of Machines. Euresia Publishing House (P) Ltd, New Delhi.
4. Ratan, S. S. 2010. A Text Book of Theory of Machines. Tata McGraw Hill Publishing Company Ltd, New Delhi.


## FMP 3107 Thermodynamics and Heat Transfer 3 (3+0)

**Objectives**

- To make the students acquainted with principles of thermodynamics and heat transfer.
- To make them understand the mathematical and practical aspects of heat exchangers.

**Theory**

**Module I** **(12 Hours)**

Basic concepts and definitions of thermodynamics, statistical and classical thermodynamics, microscopic and macroscopic point of view; Thermodynamic systems- thermodynamic equilibrium, properties of systems; state, path, process, cycle; point function, path function; temperature and zeroth law of thermodynamics; pressure, specific volume, density, energy, work and heat.

**Module II** **(12 Hours)**

First law of thermodynamics: internal energy, law of conservation of energy, first law of thermodynamics, application of first law to a process; energy-a property of system, perpetual motion machine of the first kind-PMM1; characteristic equation of state, specific heats; application of first law of thermodynamics to non-flow or closed system; free expansion and throttling process; Second law of thermodynamics: limitations of first law of thermodynamics and introduction to second law, statements of second law of thermodynamics; Clausius statement, Kelvin-Planck statement; perpetual motion machine of the second kind-PMM2; Clausius inequality; Carnot Cycle, Carnot's Theorem, entropy, entropy changes for a closed system.

**Module III** **(12 Hours)**

Concept, modes of heat transfer, thermal conductivity of materials, measurement, general differential equation of conduction, one dimensional steady state conduction through plane and composite walls, tubes and spheres without heat generation, electrical analogy, insulation materials and fins; Free and forced convection, Newton's law of cooling, heat transfer coefficient in

convection, non-dimensional numbers; equation of laminar boundary layer on flat plate and in a tube, laminar forced convection on a flat plate and tube, combined free and forced convection.

**Module IV** **(12 Hours)**

Thermal radiation, black body radiation, Stefan-Boltzmann law, black body emissive power, emissivity, absorptivity, reflectivity and transmissivity. Heat transfer analysis involving conduction, convection and radiation; Types of heat exchangers; fouling, log mean temperature difference, heat exchanger performance, transfer units; Heat exchanger analysis restricted to parallel and counter flow heat exchangers. Introduction to mass transfer, analogy between heat and mass transfer, Fick's law of diffusion.

**Lecture Schedule**

1. Thermodynamics – macroscopic and microscopic approach.
2. Basic terminologies- systems-homogeneous and heterogeneous- boundary- surroundings.
3. Thermodynamic properties-intensive and extensive properties.
4. Thermodynamic equilibriums-chemical, mechanical and thermal equilibriums.
5. Temperature NTP, STP-problems.
6. Pressure –atmospheric and absolute– problems.
7. Enthalpy, thermodynamic functions- point and path functions.
8. Flow and non-flow processes.
9. Vapour and gas – perfect gas - gas laws – Boyle's and Charles's laws.
10. Characteristic and Universal Gas constants.
11. Relation between Cp and Cv, R, and J- derivations.
12. Relation between Cp and Cv, R, and J- problems.
13. Joule's and Avogadro's law- Laws of thermodynamics- Zeroth law of thermodynamics.
14. First law of thermodynamics- problem – limitations.
15. Second law- Kelvin Plank and Clausius Statements.
16. Heating and expansion of gases in non-flow processes– Constant pressure, constant volume processes, - expressions for work done and internal energy – derivations.
17. Representation of non-flow processes on PV and TS diagrams- problems.
18. Heating and expansion of gases in non-flow processes– Constant temperature, adiabatic and poly tropic processes- expressions for work done and internal energy – derivations.
19. Representation of non-flow processes on PV and TS diagrams- problems.
20. Clausius theorem, concept of entropy.
21. Entropy changes for a closed system -representation of the processes on PV and TS diagrams.
22. Carnot theorem and Carnot cycle.
23. Carnot efficiency -derivation- PV and TS diagrams.
24. Carnot efficiency -problems- PV and TS diagrams.
25. Introduction to modes of heat transfer- conduction, convection and radiation
26. Mechanism of thermal conduction in solids, liquids and gases.
27. Fourier's law, heat transfer at the interference of two solids.
28. Electrical analogy in heat transfer, thermal conductivity of materials.
29. Three-dimensional Fourier conduction equations- derivations.
30. Steady state unidirectional heat flow through slabs, cylinders and spheres.
31. One dimensional steady state conduction through plane and composite walls, tubes and spheres with and without heat generation.

32. Insulators-introduction –purpose-critical thickness of insulation. Heat transfer of extended surface-fins.
33. Introduction to free and forced convection-Newton's law of cooling.
34. Heat transfer coefficient in convection-Dimensional analysis of free and forced convection.
35. Useful non dimensional numbers.
36. Equation of laminar boundary layer and laminar forced convection on flat plate and in a tube.
37. Combined free and forced convection.
38. Fundamentals of radiation – radiation spectrum – thermal radiation.
39. Concept of black body and grey body, Absorptivity, reflectivity and transmissivity of radiation.
40. Monochromatic radiation and total emissive power.
41. Planck's law, Stefan-Boltzman law, Kirchoff's law.
42. Intensity of radiation. Radiation exchange between black surfaces.
43. Radiation between two surfaces - geometric configuration factor.
44. Introduction to Heat Exchangers-Types of heat exchangers, fouling factor, scaling, log mean temperature difference (LMTD).
45. Heat exchanger performance, transfer units, heat exchanger analysis restricted to parallel and counter flow heat exchangers.
46. NTU method of performance evaluation of heat exchangers.
47. Steady state molecular diffusion in fluids at rest and in laminar flow.
48. Introduction to mass transfer – Fick's law of diffusion - Mass transfer coefficients, Reynold's analogy.

**Suggested Readings**


1. Arora, S.C and Domkunderwar, S.1984. A course in Heat & Mass transfer, Dhanpat Rai & Sons, Delhi.
2. Holman, J.P. 1993. Heat Transfer S.I. Metric Edition, McGraw Hill Ltd., New Delhi.
3. Khurmi R S. 1992. Engineering Thermodynamics. S Chand and Co. Ltd., Ram Nagar, New Delhi.
4. Kumar, D. S. 2016. Engineering Thermodynamics. S.K. Kataria & Sons, Delhi.
5. Mathur M L and Mehta F S. 1992. Thermodynamics and Heat Power Engineering. Dhanpat Rai and Sons 1682 Nai Sarak, New Delhi.
6. Nag P K.1995. Engineering Thermodynamics. Tata McGraw Hill Publishing Co.Ltd., 12/4 Asaf Ali Road, New Delhi
7. Yunus A. Cengel. 2003. Heat Transfer a Practical Approach. McGraw Hill Publishing Co. Ltd, New Delhi.
8. Yunus A. Cengel and Michael A. Boles. 2008. Thermodynamics an Engineering Approach. Tata McGraw Hill Publishing Co.Ltd., 12/4 Asaf Ali Road, New Delhi.


## FMP 3108 Tractor and Automotive Engines 3 (2+1)

**Objective**

To make the students acquainted with the working principles of different systems of internal combustion engines and tractor.

**Theory**

**Module I** **(8 Hours)**

Sources of farm power: conventional and non-conventional energy sources; Classification of tractors and IC engines. Review of thermodynamic principles of IC (SI and CI) engines and deviation from ideal cycle; General energy equation and heat balance sheet; Derivation of thermal efficiency of Otto cycle, Diesel cycle and Dual cycle; Mechanical, thermal and volumetric efficiencies.

**Module II** **(8 Hours)**

Study of engine components their construction, operating principles and functions; Engine strokes and comparison of 2-stroke and 4-stroke engine cycles and SI and CI engines; Engine valve systems, valve mechanism, valve timing diagram, valve clearance adjustment; Cam profile, valve lift and valve opening area. Inlet and exhaust systems; Importance of air cleaning system; Types of air cleaners and performance characteristics of various air cleaners; Fuel supply system, types of fuels, properties of fuels, calculation of air-fuel ratio.

**Module III** **(8 Hours)**

Lubrication system - need, types, functional components; Lubricants - physical properties, additives and their application. Engine cooling system - need, cooling methods and main functional components; Need and types of thermostat valves; Additives in the coolant; Radiator efficiency.

**Module IV** **(8 Hours)**

Different tests on fuel for SI and CI engines; Detonation and knocking in IC engines; Carburetion system, carburettors and their main functional components; Fuel injection system - injection pump, their types, working principles; Fuel injector nozzles - types and working principles. Engine governing - need of governors, governor types and governor characteristics; Ignition system of SI engines; Electrical system including battery, starting motor, battery charging, cut-out, etc.; Comparison of dynamo and alternator; Basics of engine testing.

**Practical**

Study of different systems of CI engines; Study of engine parts and functions, working principles, etc.; Study of valve systems construction and adjustments; Determination of physical properties of oil and fuel; Study of air cleaning system; fuel supply system of SI engine; Study of diesel injection system and timing; Study of cooling system, and fan performance, thermostat and radiator performance evaluation; Study of part load efficiencies and governing; Study of lubricating system and adjustments; Study of starting and electrical system; Study of ignition system; Study of tractor engine heat balance and engine performance curves; Study of dynamo; Visit to a nozzle calibration unit; Visit to engine manufacturer/ assembler / spare parts agency.

**Lecture Schedule**

1. Sources of farm power: conventional and non-conventional energy sources.
2. Classification of tractors and Internal Combustion (IC) engines.
3. Thermodynamic principles of IC (Compression Ignition and Spark Ignition) engines and deviation from ideal cycle.
4. General energy equation and heat balance sheet.
5. IC engine working principles: Otto cycle.

6. IC engine working principles: Diesel cycle and Dual cycle.
7. Mechanical, thermal and volumetric efficiencies IC engines.
8. Mechanical, thermal and volumetric efficiencies IC engines-problem
9. Study of engine components their construction, operating principles and functions.
10. Engine strokes and comparison of 2-stroke and 4-stroke engine cycles in CI and SI engines.
11. Engine valve systems, valve timing and clearance adjustments.
12. Cam profile, valve lift and opening area.
13. Inlet and exhaust systems, Importance of air cleaning system.
14. Types of air cleaners and performance characteristics of various air cleaners.
15. Types of fuels, properties of fuels.
16. Importance and calculation of air-fuel ratio.
17. Fuel supply system.
18. Carburetion system, carburettors and functional components.
19. Fuel injection system, working principles and types.
20. Fuel pump, types and working principles.
21. Injector nozzle, types and working principles.
22. Detonation and knocking in IC engines.
23. Lubrication system, types, functional components, lubricants properties, additives and their application.
24. Engine cooling system, cooling methods and functional components.
25. Thermostat valves, additives in the coolant and radiator efficiency.
26. Different tests on fuel for SI and CI engines.
27. Engine governing, governor types, working principles and characteristics.
28. Ignition system of SI engines.
29. Electrical system including battery, starting motor, battery charging, cut-out, etc.
30. Electrical system including battery, starting motor, battery charging, cut-out, etc.
31. Comparison of dynamo and alternator.
32. Basics of engine testing.

**Practical Schedule**

1. Study of different systems of CI engines, diesel injection system and timing.
2. Study of engine working principles, parts and functions.
3. Study of valve systems construction and adjustments.
4. Determination of physical properties of oils and fuels.
5. Study of air cleaning system of IC engines.
6. Fuel supply systems of SI engine.
7. Study of cooling system, fan performance, thermostat and radiator performance evaluation.
8. Study of part load efficiencies and governing.
9. Study of lubrication systems in IC engines.
10. Study of starting and electrical system in IC engines.
11. Study of ignition system of SI engine.
12. Study of tractor engine heat balance and engine performance curves.
13. Study of dynamo / alternator.
14. Visit to engine manufacturer / assembler / spare parts agency.

**Suggested Readings**

1. Ganesan, V. 1999. Internal Combustion Engines. McGraw Hill, New Delhi.

2. Goering, C. E. and Hansen, A. C. 2004. Engine and Tractor Power. ASAE. St. Joseph, Michigan.
3. Heitner, J. 2004. Automotive Mechanics: Principles and Practices. CBS Publishers.
4. Liljedahl, J. B., Turnquist, P. K., Smith, D. W. and Hoki, M. 1989. Tractors and Their Power Units. Van Nostrand Rainhold, New York.
5. Mathur, M. L. and Sharma, R. P. 1996. A course in Internal Combustion Engines. Dhanpat Rai and Sons, New Delhi.
6. Rodichev, V. and Rodicheva, G. 1984. Tractors and Automobiles. Mir Publishers, Moscow.
7. Singh, K. 2020. Automobile Engineering. Vol. II. Standard Publishers and Distributors.

## FMP 3209 Tractor Systems and Controls 3 (2+1)

**Objectives**

- To make the students acquainted with different systems in a tractor, such as the transmission, brake, steering and hydraulic systems
- To understand the ergonomical and safety considerations in tractor

**Theory**

**Module I** **(3 Hours)**

Introduction to Tractor-Review of engine parts and their functions. Introduction to Transmission system- need of the system in a tractor, types, major functional systems;

**Module II** **(17 Hours)**

Study of Clutch- need, types, functional requirements, construction and principle of operation; Single plate, multi-plate, centrifugal and dual clutch systems; Gear box- principle of operation, gear box types, functional requirements, and calculation for speed ratio; Differential system- need, functional components, construction, calculation for speed reduction; Final drive; Brake system- types, principle of operation, construction, calculation for braking torque; Steering system- requirements, steering geometry characteristics, functional components, calculation for turning radius; Ackerman steering; Steering systems in track type tractors; Hydraulic system- principle of operation, types, main functional components, functional requirements. hydraulic system adjustments and ADDC; Tractor power outlets- PTO standards, types and functional requirements. Study of power tiller transmission system and clutches – componenets and functions

**Module III** **(14 Hours)**

Introduction to Traction- traction terminology, theoretical calculation of shear force and rolling resistance of traction device; Wheels and tyres- solid tyres and pneumatic tyres, tyre construction and tyre specifications; Traction aids; Tractor mechanics- forces acting on the tractor, determination of CG of a tractor, Weight transfer in tractor, importance and determination of moment of inertia of a tractor, tractor static equilibrium, tractor stability especially at turns; Maximum drawbar pull and its determination; Tractor as a spring-mass system;

**Module IV** **(2 Hours)**

Ergonomic considerations and operational safety; Tractor testing; Engine test codes.

**Practical**

Study of basic transmission systems and components; Study of clutch functioning, parts and design problem on clutch system; Study of different types of gear box, calculation of speed ratios, design problems on gear box; Study on differential, final drive and planetary gears; Study of brake systems and some design problems; Study of geometry and adjustments of tractor steering; Study of hydraulic systems in a tractor, hydraulic trainer and design problems; Study of various controls in different makes of tractors in relation to anthropometric measurements; Determination of CG and moment of inertia of a tractor; Study of traction performance of a traction wheel; Study of power transmission system of tractor; Study of hitching system of tractor with various matching implements; Study on safety requirements of tractor during operation; Study of tractor testing; Visit to tractor dealers' outlet/ tractor manufacturers.

**Lecture Schedule**

1. Introduction to tractor power train
2. Review of engine parts and their functions
3. Introduction to transmission system- need of the system in a tractor, types, major functional systems;
4. Study of Clutch- need, types, functional requirements, construction and principle of operation
5. Single plate, multi-plate, centrifugal and dual clutch systems
6. Gear box- principle of operation
7. Gear box types, functional requirements
8. Calculation for speed ratio
9. Differential system- need, functional components, construction
10. Calculation for speed reduction
11. Study of Final drive – need, types
12. Brake system- types, principle of operation, construction
13. Calculation for braking torque
14. Steering system- requirements
15. Steering geometry characteristics, functional components, Calculation for turning radius
16. Ackerman steering; Steering systems in track type tractors
17. Steering system in track type tractors
18. Introduction to Hydraulic system- principle of operation,
19. Types , main functional components, functional requirements.
20. Hydraulic system adjustments and ADDC;
21. Tractor power outlets- PTO standards, types and functional requirements.
22. Study of power tiller transmission system and clutches – componenets and functions
23. Introduction to Traction- traction terminology
24. Theoretical calculation of shear force and rolling resistance of traction device
25. Wheels and tyres- solid tyres and pneumatic tyres
26. Tyre construction and tyre specifications

27. Traction aids Tractor mechanics- forces acting on the tractor
28. Determination of CG of a tractor. Weight transfer in tractor
29. Importance and determination of moment of inertia of a tractor
30. Tractor static equilibrium, tractor stability especially at turns
31. Maximum drawbar pull and its determination
32. Tractor as a spring-mass system
33. Ergonomic considerations and operational safety;
34. Tractor testing; Engine test codes and reports

**Practical Schedule**

1. Study of basic transmission systems and components
2. Study of clutch functioning, parts
3. Design problem on clutch system
4. Study of different types of gear box
5. Calculation of speed ratios,
6. Design problems on gear box;
7. Study on differential, final drive and planetary gears
8. Study of brake systems and some design problems
9. Study of geometry and adjustments of tractor steering
10. Study of hydraulic systems in a tractor
11. Hydraulic trainer and design problems;
12. Study of various controls in different makes of tractors in relation to anthropometric measurements
13. Determination of CG and moment of inertia of a tractor
14. Study of traction performance of a traction wheel
15. Study of hitching system of tractor with various matching implements
16. Study on safety requirements of tractor during operation
17. Study of tractor testing
18. Visit to tractor dealers' outlet/ tractor manufacturers

**Suggested Readings**


1. Barger, E. L., Liljedahl, J. B. and McKibben, E. C. 1967. Tractor and their Power Units. Wiley Eastern.
2. BIS Test codes for tractor.
3. Giri, N. K. 2013. Automobile Mechanics (SI Units). Khanna Publishers, Delhi.
4. Jain, S. C. and Rai, C. R. 2013. Farm Tractor, Maintenance and Repair. Standard Publisher and Distributers, Delhi.
5. Singh, K. 2020. Automobile Engineering. Vol. I. Standard Publisher and Distributers, Delhi.
6. Srivastav, A. K., Goering, C. E. and Rohrbach, R. P. 2005. Engineering Principles of Agricultural Machines. ASAE. St. Joseph, Michigan.

# FMP 3210 Refrigeration and Air Conditioning 3 (2+1)

**Objectives**

- To make the students acquainted with the principles of refrigeration, different types of refrigerating equipment
- To enable them to design the refrigeration and air conditioning systems

**Theory**

**Module I** **(6 Hours)**

Definition of pure substance, phases of a pure substance, phase change process of pure substances; compressed liquid and saturated liquid, saturated vapour and superheated vapour, saturated temperature and saturated pressure; T-V diagram for heating of water at constant pressure. Latent heat: Latent heat of fusion, latent heat of vaporization; liquid vapour saturation curve; property diagram for phase change process, T-V diagram, P-V diagram, P-T diagram; property tables, state-liquid and vapour states, saturated liquid-vapour mixture, superheated vapour, compressed liquid.

**Module II** **(14 Hours)**

Principles of refrigeration, units, terminology, production of low temperatures, air refrigerators working on reverse Carnot cycle and Bell Coleman cycle; Vapour refrigeration-mechanism, P-V, T-S, P-h diagrams, vapour compression cycles, dry and wet compression, super cooling and sub cooling; Vapour absorption refrigeration system.

**Module III** **(8 Hours)**

Common refrigerants and their properties; Thermodynamic properties of moist air, perfect gas relationship for approximate calculation, adiabatic saturation process, wet bulb temperature and its measurement, psychometric chart and its use, elementary psychometric processes.

**Module IV** **(7 Hours)**

Air conditioning: principles, type and functions of air conditioning, physiological principles in air conditioning, air distribution and factors considered for designing an air conditioning system; Room ratio line, sensible heat factor, by-pass factor; types of air conditioners and their applications; Cold storage plants; calculation of refrigeration load and cold storage design considerations.

**Practical**

Study of P-V and T-S chart in refrigeration; Study P-h chart (or) Mollier diagram in refrigeration; Solving problems on air refrigeration cycle; Solving problems on vapour compression refrigeration cycle; Study of domestic water cooler; Study of domestic household refrigerator; Study of vapour absorption refrigeration system; Study of cooling tower and to find its efficiency; Study of heat pump test rig; Study of Ice plant test rig; Study of psychrometric chart and various psychrometric processes; Solving problems on psychrometrics; Study of window air conditioner; Study cold storage for fruit and vegetables, freezing load and time calculations for food materials; Study on repair and maintenance of refrigeration and air-conditioning systems; Visit to chilling or ice making and cold storage plants.

**Lecture Schedule**

1. Definition of pure substance- phases of a pure substance, phase change process of pure substances.
2. Compressed liquid and saturated liquid, saturated vapour and superheated vapour, saturated temperature and saturated pressure.
3. T-V diagram for heating of water at constant pressure. Latent heat- Latent heat of fusion, latent heat of vaporization.
4. Liquid vapour saturation curve- property diagram for phase change process.
5. T-V diagram, P-V diagram, P-T diagram.
6. Property tables, state-liquid and vapour states, saturated liquid-vapour mixture, superheated vapour, compressed liquid.
7. Refrigeration- introduction- definition- principle- background with second law of thermodynamics.
8. Application of second law of thermodynamics- refrigerator- unit of refrigeration- coefficient of performance.
9. Production of low temperatures- Expansion of a liquid with flashing, reversible/ irreversible adiabatic expansion of a gas/ real gas.
10. Thermoelectric cooling, adiabatic demagnetization.
11. Air refrigerators working on reverse Carnot cycle and Bell Coleman cycle; p-V and T-s diagrams.
12. Vapour Compression Refrigeration System- mechanism, P-V, T-S, P-h diagrams.
13. Components of mechanical refrigeration- study of compressors.
14. Study of condensers.
15. Study of expansion devices.
16. Study of evaporators.
17. Vapour compression cycles- dry and wet compression- super cooling and sub cooling.
18. Problems on Vapour compression cycles.
19. Vapour absorption refrigeration system- simple and practical- working.
20. VARS- Calculations- COP- maximum COP of a heat operated refrigerating machine.
21. Methods of refrigeration- electrolux refrigerator.
22. Methods of refrigeration- steam jet refrigeration system.
23. Common refrigerants and their properties- physical, chemical, thermodynamic.
24. Thermodynamic properties of moist air.
25. Perfect gas relationship for approximate calculation, adiabatic saturation process.
26. Wet bulb temperature and its measurement.
27. Psychometric chart and its uses.
28. Elementary psychometric processes.
29. Air conditioning: principles, type and functions of air conditioning.
30. Physiological principles in air conditioning. Winter/summer/year round air-conditioning.
31. Air distribution- Duct systems.
32. Factors considered for designing an air conditioning system- Room ratio line, sensible heat factor, by-pass factor.
33. Types of air conditioners and their applications.
34. Cold storage plants- Deferent components of cold storage.
35. Calculation of refrigeration load and cold storage design considerations.

**Practical Schedule**

1. Study of P-V and T-S chart in refrigeration.
2. Study P-h chart (or) Mollier diagram in refrigeration.
3. Solving problems on air refrigeration cycle.
4. Solving problems on vapour compression refrigeration cycle.
5. Study of domestic water cooler.
6. Study of domestic household refrigerator.
7. Study of vapour absorption refrigeration system.
8. Study of cooling tower and to find its efficiency.
9. Study of heat pump test rig.
10. Study of Ice plant test rig.
11. Study of psychrometric chart.
12. Study of various psychrometric processes.
13. Solving problems on psychrometrics.
14. Study of window air conditioner.
15. Study cold storage for fruit and vegetables.
16. Freezing load and time calculations for food materials.
17. Study on repair and maintenance of refrigeration and air-conditioning systems.
18. Visit to chilling or ice making and cold storage plants.

**Suggested Readings**

1. Arora, C. P. 2012. Refrigeration and Air Conditioning. Tata-McGraw-Hill, New Delhi.
2. Khurmi, R. S. 2016. Refrigeration and Air Conditioning. S Chand and Co. Ltd, Ram Nagar, New Delhi.

## FMP 4111 Engineering Graphics and Design 2 (0+2)

**Objectives**

- To acquaint the students with CAD softwares for drawing of machine components.
- To integrate the computers at various levels of planning and manufacturing.

**Practical**

Application of computers for design; CAD- introduction, overview of CAD window; Various options on drawing screen; Practice on draw and dimension tool bar; Practice on OSNAP, line thickness and format tool bar; Practice on mirror, offset; Practice on array commands; Practice on trim, extend; Practice on trim chamfer and fillet commands; Practice on copy, move, scale and rotate commands; Drawing of 2D- drawing using draw tool bar; Practice on creating boundary, region, hatch and gradient commands; Practice on Editing polyline- PEDIT and Explode commands; Setting of view ports for sketched drawings; Printing of selected view ports in various paper sizes; 2D- drawing of machine parts with all dimensions and allowances; Drawing of foot step bearing, knuckle joint; Sectioning of foot step bearing and stuffing box; Drawing of hexagonal, nut and bolt and other machine parts; Practice on 3D commands- Extrusion and loft, sweep and press pull, revolving, joining; Demonstration on CNC machine and practice problems.

**Practical Schedule**

1. Introduction to the use computers in drafting and design, hardware and software requirements, input – output devices, graphic file formats.
2. Familiarizing CAD window and working with menus and files.
3. Practice on setting up of drawing – SNAP, GRID, LIMITS, UNITS etc.
4. Practice on drawing basic entities – Line, Circle, Arc, Rectangle, Ellipse etc.
5. Study of OSNAP, input methods and display commands.
6. Study of coordinate systems.
7. Practice on drawing basic entities – Polyline, Polygon, Spline etc.
8. Practice on edit / modify commands – Copy, Move etc.
9. Practice on edit / modify commands – Mirror, Rotate, Scale etc.
10. Practice on PEDIT, Explode etc.
11. Practice on trim, extend, lengthen.
12. Practice on edit / modify commands –Fillet, Chamfer, Array etc.
13. Study on Layers, line width, colour etc.
14. Practice on Hatch, Boundary, Region etc
15. Practice on dimensioning and adding text to drawing.
16. Creating orthographic views of simple models from pictorial views.
17. Creating orthographic views of simple models from pictorial views.
18. Creating orthographic views of simple models from pictorial views.
19. Preparing drawings with dimensions of machine elements – nuts, bolts etc.
20. Preparing drawings with dimensions of machine elements – nuts, bolts etc.
21. Preparing drawing of machine parts with all dimensions and allowances - Foot step bearing and knuckle joint
22. Preparing drawing of machine parts with all dimensions and allowances - Foot step bearing and knuckle joint
23. Preparing drawing of machine parts with all dimensions and allowances - Foot step bearing and knuckle joint
24. Preparing drawing of machine parts with all dimensions and allowances - Foot step bearing and knuckle joint
25. Creating different view ports, setting up of drawing for printout and plotting.
26. Introduction to 3D modeling, UCS orientation and options.
27. Practice on 3D commands extrude, revolve.
28. Practice on 3D commands sweep, loft etc.
29. Creating 3D models of simple objects.
30. Creating 3D models of simple objects.
31. Introduction to creating complex 3D models.
32. Demonstration of CNC machine.

**Suggested Readings**


1. Lee, K. 1999. Principles of CAD/CAM/CAE Systems. Addison Wesley Longman, Inc.
2. Rao, P. N. 2002. CAD/CAM Principles and Applications. McGraw-Hill Education Pvt. Ltd., New Delhi.
3. Sareen, K. and Grewal, C. D. 2010. CAD/CAM Theory and Practice. S. Chand & Company Ltd., New Delhi.

4. Zeid, I. 2011. Mastering CAD/CAM with Engineering. McGraw-Hill Education Pvt. Ltd., New Delhi.

## FMP 4112 Machine Design 2 (2+0)

**Objective**

To make the students acquainted with design considerations for various machine components so as to enable them to take up the work of new design.

**Theory**

**Module I** **(10 Hours)**

Phases of design, design considerations, Common engineering materials and their mechanical properties. Types of loads and stresses, theories of failure, factor of safety, selection of allowable stress. Stress concentration, elementary fatigue and creep aspects.

**Module II** **(8 Hours)**

Design of shafts under torsion and combined bending and torsion. Design of keys. Design of muff, sleeve, and rigid flange couplings.

**Module III** **(10 Hours)**

Design of helical and leaf springs, Cotter joints, design of socket and spigot cotter joint, knuckle joint, Design of welded joints subjected to static loads. Design of threaded fasteners subjected to direct static loads, bolted joints loaded in shear.

**Module IV** **(8 Hours)**

Design of bolted joints subjected to eccentric loading, Design of flat belt, V-belt drives and pulleys. Design of gears, Selection of anti-friction bearings.

**Lecture Schedule**

1. Introduction to machine design
2. Phases of design
3. Design consideration
4. Common engineering materials
5. Mechanical properties of engineering materials
6. Types of loads and stresses
7. Theories of failure
8. Factor of safety, selection of allowable stress
9. Stress concentration
10. Elementary fatigue and creep aspects
11. Design of shafts under torsion
12. Design of shafts under bending moment
13. Design of shafts under combined bending and torsion
14. Types of Keys
15. Design of keys
16. Introduction to Couplings
17. Design of sleeve or muff coupling

18. Design of flanged coupling
19. Types of springs
20. Design of helical springs
21. Design of leaf springs
22. Cotter joints
23. Design of socket and spigot cotter joint
24. Design of knuckle joint
25. Types of welded joints
26. Design of welded joints subjected to static loads
27. Design of threaded fasteners subjected to direct static loads
28. Design of bolted joints loaded in shear
29. Design of bolted joints subjected to eccentric loading
30. Types of Belt drives
31. Design of flat belt drives
32. Design of V-belt drives
33. Design of pulleys
34. Design of gears
35. Selection of anti-friction bearings

**Suggested Readings**


1. Bhandari, V. B. 2007. Introduction to Machine Design. Tata Mc. Graw Hill Publishing House. New Delhi
2. Jain.R.K. 2013.Machine Design.Khanna Publishers, 2-B Nath Market, NaiSarak, New Delhi.
3. Khurmi, R. S. and Gupta, J. K. 2014. A Text Book of Machine Design. S. Chand & Company Ltd., New Delhi.
4. Sharma, P. C. and Agarwal, D. K. 2010. Machine Design. S. K. Kataria & Sons, New Delhi
5. Anonymous. 1984. Design data Hand book. PSG, Coimbatore.
6. K Mahadevan and K Balaveera Reddy. 2013. Design Data Handbook for Mechanical Engineering in SI and Metric Units. CBSpublications, New Delhi.


## FMP 4113 Electrical Machines 3 (2+1)

**Objectives**

- To make the students acquainted with operating principles of various electrical motors and other machines
- To help them gain practical exposure of different electrical devices and their controls

**Theory**

**Module I** **(12 Hours)**

Introduction to electrical machines; Basic principles of operation of electrical machines used in agricultural engineering such as DC generator, DC motor, 1-phase induction motor, 3-phase induction motor, and BLDC motor; Magnetic circuit: concept of magnetic flux production, magneto motive force, reluctance, determination of ampere-turns for series and parallel magnetic circuits, hysteresis and eddy current losses. laws of electromagnetic induction

**Module II** **(12 Hours)**

Transformer: principle of working, construction of single phase transformer, EMF equation, phasor diagram no load/ load, leakage reactance, voltage regulation, power and energy efficiency, open circuit and short circuit tests, Equivalent circuits. Three phase induction motor: construction, operation, types, concept of slip; slip speed and slip frequency, torque equation, torque-speed and torque-slip characteristics, maximum torque for starting and running condition. phasor diagram, Circle diagram, starting and speed control methods. Single phase induction motor: principle of operation, double field revolving theory, equivalent circuit, characteristics, methods of starting, phase split, shaded pole motors, performance characteristics.

**Module III** **(12 Hours)**

D.C. machines: principles operation and performance of DC machine (generator and motor), Types , EMF and torque equations, excitation of DC generator and their characteristics, Armature reaction,. DC motor characteristics, starting of shunt and series motor, starters, speed control methods-field and armature control.

**Practical**

To study different parts of DC/AC machines; To perform open circuit test on a single phase transformer and determine its iron loss as well as open circuit parameters; To perform short circuit test on a single phase transformer and hence find copper loss, equivalent circuit parameters, voltage regulation and efficiency; To study how to start the D.C motor using 3-point Starter; To start and run the D.C. motor (shunt, series and compound); To control the speed of DC shunt motor using flux control method; To control the speed of DC shunt motor using armature voltage control method; To conduct brake test on DC shunt motor and to determine its performance curves; To obtain the load characteristics of DC shunt motor and draw its characteristics; To start and run the 3-phase induction motor using star-delta starter and to find different voltage and current under star and delta connection; To perform no-load test on 3-phase induction motor and to determine its no-load losses; To perform blocked-rotor tests on 3-phase induction motor to obtain the equivalent circuit parameters and to draw the circle diagram; To perform no load on 1-phase induction motor to determine its no-load losses; To perform blocked-rotor test on 1-phase induction motor and to determine the parameters of equivalent circuit on the basis of double revolving field theory; To perform load-test on 1-phase induction motor and plot torque-speed characteristic.

**Lecture Schedule**

1. Basic Principles of Operation of Electrical Machines Used in Agricultural Engineering Such as DC Generator, Dc Motor, 1-Phase Induction Motor, 3-Phase Induction Motor, and BLDC Motor
2. Magnetic Circuit: Concept of Magnetic Flux Production, Magneto Motive Force
3. Reluctance, Laws of Magnetic Circuits
4. Determination Of Ampere-Turns for Series and Parallel Magnetic Circuits
5. Hysteresis And Eddy Current Losses
6. Transformer: Principle of Working, Construction of Single-Phase Transformer
7. EMF Equation
8. Phasor Diagram on Load/ Load, Leakage Reactance
9. Voltage Regulation, Power and Energy Efficiency

10. Open Circuit and Short Circuit Tests
11. D.C. Machines: Principles Operation
12. Performance of DC Machine (Generator and Motor)
13. EMF and Torque Equations of DC Generator
14. Excitation of DC Generator and Their Characteristics
15. DC Motor Characteristics
16. Starting of Shunt Motor
17. Starting of Shunt Series Motor
18. Starters of DC Motor
19. Speed Control Methods-Field and Armature Control
20. Three Phase Induction Motor: Construction
21. Operation, Types of Three Phase Induction Motor
22. Concept Of Slip; Slip Speed and Slip Frequency
23. Torque Equation Induction Motor
24. Torque-Speed and Torque-Slip Characteristics
25. Maximum Torque for Starting and Running Condition
26. Phasor Diagram Induction Motor
27. Starting and Speed Control Methods
28. Single Phase Induction Motor: Principle of Operation
29. Double Field Revolving Theory
30. Equivalent Circuit of Phase Induction Motor
31. Characteristics of Phase Induction Motor
32. Methods of Starting
33. Phase Split
34. Shaded Pole Motors
35. Performance characteristics

**Practical Schedule**

1. To study different parts of DC/AC machines
2. To perform open circuit test on a single-phase transformer and determine its iron loss as well as open circuit parameters
3. To perform short circuit test on a single-phase transformer and hence find copper loss, equivalent circuit parameters, voltage regulation and efficiency
4. To study how to start the D.C motor using 3-point Starter and to start and run the D.C. motor (shunt, series and compound)
5. To control the speed of DC shunt motor using flux control method
6. To control the speed of DC shunt motor using armature voltage control method
7. To conduct brake test on DC shunt motor and to determine its performance curves
8. To obtain the load characteristics of DC shunt motor and draw its characteristics
9. To start and run the 3-phase induction motor using star-delta starter and to find different voltage and current under star and delta connection
10. To perform no-load test on 3-phase induction motor and to determine its no- load losses
11. To perform blocked-rotor tests on 3-phase induction motor to obtain the equivalent circuit parameters and to draw the circle diagram
12. To perform no load on 1-phase induction motor to determine its no-load losses
13. To perform blocked-rotor test on 1-phase induction motor and determine the parameters of equivalent circuit on the basis of double revolving field theory

14. To perform load-test on 1-phase induction motor and plot torque-speed characteristic
15. Practical Examination

**Suggested Readings**


1. Anwani, M. L. 1997. Basic Electrical Engineering. Dhanpat Rai & Co. (P) LTD. New Delhi.
2. Boylestad, Robert, L. and Louis, N. 2015. Electronic Devices and Circuit. 11th edn. Pearson India.
3. Shaney, A. K. 1997. Measurement of Electrical and Electronic Instrumentation. Khanna Publications
4. Thareja, B. L. and Theraja, A. K. 2005. A Textbook of Electrical Technology. Vol. I. S. Chand & Company LTD., New Delhi.
5. Theraja, B. L. and Theraja, A. K. 2005. A Textbook of Electrical Technology. Vol. II. S. Chand & Company LTD., New Delhi.

## Department of Farm Machinery and Power Engineering-Elective Courses

## EFM 4201 Mechanics of Tillage and Traction 3 (2+1)

**Objectives**

To enable the students to;

- Know various engineering properties of soil and to understand the effect of these properties on the performance of tillage tools
- Know the application of dimensional analysis on soil dynamics and traction
- Understand the effect of soil compaction on crop growth
- Know the use of GIS in soil dynamics

**Module I** **(7 Hours)**

Introduction to mechanics of tillage tools, engineering properties of soil, principles and Concepts, stress strain relationship.

**Module II** **(5 Hours)**

Design of tillage tools, principles of soil cutting, design equation, force analysis

**Module III** **(12 Hours)**

Application of dimensional analysis in soil dynamics and traction prediction equation.

**Module IV** **(12 Hours)**

Introduction to traction and mechanics, off-road traction and mobility, traction model, traction improvement, tyres-functions, size, lug geometry and their effects, tyre selection and testing; Soil compaction and plant growth and variability; Application of GIS in soil dynamics.

**Practical**

Measurement of static and dynamic soil parameters related to tillage; Soil parameters related to puddling and floatation; Draft for passive rotary and oscillating tools, slip and sinkage under dry and wet soil conditions and load and fuel consumption for different farm operations; Weight transfer and tractor loading including placement and traction aids; Studies on tyres, tracks and treads under different conditions, and soil compaction and number of operations.

**Lecture Schedule**

1. Study of tillage operations- forces acting on a tillage implement- draft
2. Physical properties of soils
3. Engineering properties of soil- consistency limits – shear strength
4. Mohr's circle – shear failure- Coulomb's equation- general model of shear failure
5. Mohr's circle – shear failure- Coulomb's equation- general model of shear failure
6. Tri-axial compression test- stress strain theory- relationship
7. Force analysis of tillage implements
8. Design of tillage tools- active and passive tools
9. Dimensional Analysis- units and dimensions - definition- systems of measurements
10. Dimensional Analysis- Dimension of entities- Dimensionless numbers
11. Complete set of dimensionless products

12. Methods of determining dimensionless products- Rayleigh's method
13. Buckingham Pi theorem and method –problems
14. Systematic analysis methods of DA-problems
15. Development of prediction equation through dimensional analysis
16. Application of dimensional analysis in soil dynamics
17. Mechanics of tillage tools-tractive performance of wheeled vehicles- off road traction mechanics- objectives
18. Rolling resistance at different soil and tyre conditions
19. Prediction of sinkage- Bekker's and Columb's equations – plate test
20. Mobility number- Wheel numeric
21. Weismer and Luth Equation- Analysis of soil-machine dynamics in tillage
22. Relation between tractive force and slip.
23. Mechanical properties of soils- strength determining factors and floatation
24. Penetration resistance and mobility number approach for predicting field performance of tyres
25. Typical values of cone penetrometer resistances
26. Traction - tractive efficiency and coefficient of traction at varying slips
27. Draw bar power – its variation w.r.to various pull and slip conditions
28. Traction mechanics
29. Traction models
30. Traction improvement methods
31. Cone index and its determination
32. Tyres for agricultural tractors
33. Tyre and track terminology and selection of tyres
34. Soil compaction studies – compaction measurement
35. Application of GIS in soil dynamics

**Practical Schedule**

1. Measurement of static and dynamic soil parameters related to tillage
2. Measurement of Soil parameters related to puddling and floatation
3. Draft measurement of tractor attached implements
4. Draft measurement for passive tools
5. Draft measurement for active tools
6. Measurement of Slip
7. Measurement sinkage under wet soil conditions
8. Load and fuel consumption tests for tractor engines.
9. Load and fuel consumption tests for tractor engines.
10. Study of weight transfer of a tractor
11. Study of tractor tyres and traction aids
12. Visibility test for tractors
13. Measurement of puddling index of wet soils
14. Measurement of turbidity index
15. Study of different methods of ballasting
16. Determination of cone index
17. Visit to R&D organizations dealing with tillage studies
18. Practical Examination

**Suggested Readings**


1. Bosoi,E.S,Verniaev,O.V.,Smirnov,I.I and Sultan Shakh. 1990. Theory, Construction and Calculations of Agricultural Machines. Vol. I. Oxonian press Pvt. Ltd.,New Delhi.
2. Gill and Vandenberg. 1968. Soil Dynamics in Tillage and Traction. Agricultural Research Service, USDA, Govt. Printing Press, Washington, D.C.
3. Kuipers, H and Koolen, A.J. 1983. Agricultural Soil Mechanics. Sringer-Verlag New York
4. Kumar,V.J.F and Durairaj,C.D.2003. Dimensional Analysis and Similitude (Through worked examples). New Age International Pvt. Ltd., New Delhi.( ISBN-8122414868).
5. Liljedahl, J. B., Turnquist, P. K., Smith, D. W. and Hoki, M. 2004. Tractors and their Power Units. CBS Publishers
6. Macmillan R H. 2002. The Mechanics of Tractor-Implement Performance. International Development Technologies Centre, University of Melbourne.
7. Terzaghi K and Peck R B and Mesri G. 1996. Soil Mechanics in Engineering Practices. John Willey & Sons.


## EFM 4202 Farm Machinery Design and Production 3 (2+1)

**Objective**

To enable the students to design farm machinery and to understand the production principles

**Theory**

**Module I** **(4 Hours)**

Introduction to design parameters of agricultural machines and design procedure, characteristics of farm machinery design. Research and development aspects of farm machinery.

**Module II** **(10 Hours)**

Introduction to safety in power transmission. Design of standard power transmission components used in agricultural machines: mechanical and hydraulic units. Application of design principles to the systems of selected farm machines such as design of disc plough, cultivator, seed drill, reaper, thresher and digger.

**Module III** **(8 Hours)**

Critical appraisal in production of agricultural machinery, advances in material used for agricultural machinery. Cutting tools including CNC tools and finishing tools.

**Module IV** **(5 Hours)**

Heat treatment of steels including pack carburizing, shot pining process, etc. Limits, fits and tolerances, jigs and fixtures.

**Module V** **(7 Hours)**

Industrial lay-out planning, quality production management, reliability. Economics of process selection, familiarization with project report.

**Practical**

Familiarization with different design aspects of farm machinery and selected components; Solving design problems on farm machines and equipment; Visit to agricultural machinery manufacturing

industry, tractor manufacturing industry; Study of jigs and fixtures in relation to agricultural machinery; Study of fits, tolerances and limits; Layout planning of a small scale industry; Problems on economics of process selection; Preparation of a project report; Case study for manufacturing of simple agricultural machinery.

**Lecture Schedule**

1. Introduction to design parameters of agricultural machines.
2. Introduction to design procedure of agricultural machines.
3. Characteristics of farm machinery design.
4. Research and development aspects of farm machinery.
5. Introduction to safety in power transmission.
6. Design of standard power transmission components used in agricultural machines.
7. Components of Power Transmission – mechanical.
8. Components of Power Transmission – hydraulic.
9. Application of design principles to the systems of disc plough.
10. Application of design principles to the systems of cultivator.
11. Application of design principles to the systems of seed drill.
12. Application of design principles to the systems of reaper.
13. Application of design principles to the systems of thresher.
14. Application of design principles to the systems of digger.
15. Critical appraisal in production of agricultural machinery.
16. Advances in materials used for agricultural machinery.
17. Advances in materials used for agricultural machinery.
18. Study of cutting tools including CNC tools and finishing tools.
19. Study of advanced manufacturing techniques.
20. Study of advanced manufacturing techniques.
21. Study of powder metallurgy.
22. Study of Electro-Discharge Machining (EDM).
23. Study of different heat treatment methods of steels.
24. Study of pack carburizing and shot pining process.
25. Study of limits, fits & tolerances.
26. Study of jigs & fixtures.
27. Study of jigs & fixtures.
28. Industrial lay-out planning.
29. Industrial lay-out planning.
30. Study of quality production management- terminology.
31. Reliability.
32. Economics of process selection.
33. Familiarization with Project Report.
34. Familiarization with Project Report

**Practical Schedule**

1. Familiarization with different design aspects of farm machinery and selected components.
2. Solving design problems on farm machines and equipment.
3. Solving design problems on farm machines and equipment.
4. Solving design problems on farm machines and equipment.
5. Solving design problems on farm machines and equipment.

6. Visit to agricultural machinery manufacturing industry.
7. Visit to tractor manufacturing industry.
8. Study of fits, tolerances and limits.
9. Study of fits, tolerances and limits.
10. Study of jigs and fixtures in relation to agricultural machinery.
11. Study of jigs and fixtures in relation to agricultural machinery.
12. Layout planning of a small-scale industry.
13. Layout planning of a small-scale industry.
14. Problems on economics of process selection.
15. Preparation of a project report.
16. Case study for manufacturing of simple agricultural machinery.
17. Case study for manufacturing of simple agricultural machinery.

**Suggested Readings**


1. Adinath, M. and Gupta, A. B. 1996. Manufacturing Technology. New Age International (P) Ltd.
2. Narula, V. 2009. Manufacturing Processes. S K Kataria & Sons, New Delhi.
3. Richey, C. B. 1961. Agricultural Engineering Handbook. McGraw-Hill Inc., US.
4. Sharma, D. N. and Mukesh, S. 2021. Farm Machinery Design (Principles and Problems). 4th Revised Edition. Jain Brothers, New Delhi.
5. Sharma, P. C. and Aggarwal, D. K. 2010. Machine Design. S K Kataria & Sons, New Delhi.
6. Singh, S. 2016. Mechanical Engineer's Handbook. Khanna Publications, New Delhi.


## EFM 4203 Tractor Design and Testing 3 (2+1)

**Objectives**

To enable the student to understand

- Parameters for balanced design of tractor for stability and weight distribution
- Special design features of tractor engines and their selection, viz. cylinder, piston, piston pin, crankshaft, etc.
- Perform testing of tractor

**Theory**

**Module I** **(14 Hours)**

Introduction to procedure for design and development of agricultural tractors. Traction theoryTraction mechanism. mechanics of traction devices. Kinematics and dynamic aspects of Rolling elements. Tire selection. Traction devices for wet lands. Mechanics of traction-Traction performance. Tread design- traction improvements. Mechanics of tractor chassis – Static equilibrium analysis. Centre of gravity & moment of inertia.

**Module II** **(9 Hours)**

Tractor Engine - Parameters affecting design of tractor engine-General design considerations. Design of engine components. Design of fuel injection system, lubrication system, cooling system and ignition system. Design of mechanical power transmission in agricultural tractors. Friction brakes and clutches. Design of Ackerman Steering and tractor hydraulic steering. Mechanics of steering & front suspension.

**Module III** **(5 Hours)**

Hydraulic systems & controls – basic principles, components and symbols. Flow and circuit analysis, motors, actuators, valves, hydraulic fluids and controls. Draft sensing, automatic control, power steering. Hydraulic circuit design. Hitches, hitching and weight transfer. Force and moment relations for a tractor when pulling an implement, control of hitches.

**Module IV** **(8 Hours)**

Human factors in tractor design - environmental factors, noise, vibration. Operator – machine interface, Design aspects of foot and hand controls, rollover protection, thermal comfort and safety. Operator's seat. Pollution control technologies.Tractor Testing: Types, test procedure, national and international codes. Types of tests. Tractor performance criteria- Power measurement methods – types of dynamometers. Drawbar, PTO and three point hitch performances. Power losses in dynamometers and hydraulic test equipment. Review and interpretation of test reports. Case studies.

**Practical**

Design problem of tractor clutch (single/multiple disc clutch); Design of gear box (synchromesh/ constant mesh), variable speed constant mesh drive; Selection of tractor tires; Problem on design of governor; Design and selection of hydraulic pump; Engine testing as per BIS code; Drawbar performance in the lab; PTO test and measure the tractor power in the lab/field; Determining the turning space, turning radius and brake test; Hydraulic pump performance test and air cleaner and noise measurement test; Visit to tractor testing centre/ industry.

**Lecture Schedule**

1. Introduction to procedure for design and development of agricultural tractors.
2. Technical specifications of tractors available in India.
3. Modern trends in tractor design and development.
4. Special design features of tractors in relation to Indian agriculture.
5. Introduction to CAD and its application in agricultural tractors.
6. Traction theory: Co-efficient of traction
7. Deflection between traction devices and soil, slippage and sinkage of wheels.
8. Evaluation and prediction of traction performance, design of traction and transport
9. devices.
10. Traction mechanism: Introduction of traction devices. Tires-types function & size, their selection.
11. Mechanics of traction devices. Off road traction mechanics, Trafficability.
12. Performance evaluation, design considerations traction devices.
13. Kinematics and dynamic aspects of rolling elements.
14. Tire selection. Traction devices for wet lands- Tracks, cage wheels, cage rollers.
15. Mechanics of traction: Traction performance equation, performance of tires, tire size, load & air pressure relationship.
16. Tread design- effect of lug spacing, traction improvements.
17. Mechanics of tractor chassis – assumptions, equations of motion. Static equilibrium analysis, longitudinal stability, Lateral stability.
18. Determination of Centre of gravity & moment of inertia. Problems
19. Tractor Engine - Parameters affecting design of tractor engine and their selection,

20. General considerations in engine design.
21. Design of engines - Stroke-bore ratio, crankshaft & firing order, valve design, valve timing, cam shaft.
22. Combustion chamber design, piston, flywheels, balancing of engines.
23. Design of fuel injection system, lubrication system, cooling system and ignition system.
24. Design of mechanical power transmission in agricultural tractors: Tractor transmission and drive chains – complete drive train, transmission types, gears for power transmission.
25. Differentials, transmission drive shafts. Friction brakes and clutches- single disc, multi disc and cone clutches. Rolling friction and anti-friction bearings.
26. Design of Ackerman Steering and tractor hydraulic steering.
27. Mechanics of steering & front suspension of farm tractor.
28. Hydraulic systems & controls – basic principles of hydraulics, components and symbols.
29. Basics of hydraulic flow and hydraulic circuit analysis motor performance, actuators, valves, hydraulic fluids and controls.
30. Draft sensing, automatic control, power steering. Hydraulic circuit design.
31. Hitches – types, principles, hitching and weight transfer, force and moment relations for a tractor when pulling an implement, control of hitches.
32. Human factors in tractor design – operator exposure to environmental factors, noise, and vibration. Operator – machine interface.
33. Design aspects of foot and hand controls on tractors, rollover protection, thermal comfort and safety.
34. Design of operator's seat for tractors and agricultural equipment. Pollution control
35. technologies.
36. Tractor Testing: Types of tests; test procedure, national and international codes.
37. Test equipment- usage and limitations. Types of tests – compulsory tests, optional tests, static & dynamic tests, noise test.
38. Tractor performance criteria – Power measurement methods – types of dynamometers. Drawbar, PTO and three point hitch performances.
39. Power losses in dynamometers and hydraulic test equipment. Review and interpretation of test reports. Case studies.

**Practical Schedule**

1. Determination of Slip, Rolling resistance and pull of a tractor.
2. Determination of Centre of gravity of Tractor.
3. Determination of Co-efficient of Rolling resistance, Co-efficient of Traction and Tractive efficiency.
4. Measurement of diametric parameters of tyres.
5. Determination of turning space and turning radius.
6. Problems on Mechanics of Traction.
7. Measurement of Tractive parameter by two tractor method.
8. Design problem of tractor engine. Design problem of tractor clutch.
9. Design problem of tractor gear box.
10. Design problem of Fuel injection pump for tractor engine.
11. Design problem of Lubrication system of Tractor
12. Design problem of cooling system of Tractor.
13. Selection of tractor tires – Problem solving.
14. Design and selection of hydraulic pump.

15. Engine testing as per BIS code.
16. Drawbar and PTO performance in the lab/field.
17. Visit to tractor testing centre/industry.
18. Practical examination

**Suggested Readings**


1. Liljedahl, J. B., Turnquist, P. K., Smith, D. W. and Hoki, M. 2004. Tractors and their Power Units. CBS Publishers and Distributors Pvt. Ltd.
2. Maleev, V. L. 1964. Internal Combustion Engines. McGraw-Hill Inc., US.
3. Mehta, M. L., Verma, S. R., Mishra, S. K. and Sharma, V. K. 1995. Testing and Evaluation of Agricultural Machinery. National Agricultural Technology Information Centre. Ludhiana.
4. Raymond N Y, EEzzat A F and Nicolas Skiadas.(1984), Vehicle Traction Mechanics, Elsevier Science Publishers B V, New York.
5. Richey, C. B. 1961. Agricultural Engineering Handbook. McGraw-Hill Inc., US.
6. Singh, K. 2018. Automobile Engineering – Vol I and Vol II. Standard Publishers and Distributors. New Delhi.


## EFM 4204 Hydraulic Drive and Controls 3 (2+1)

**Objective**

To enable the students to understand the basic principles of hydraulic power system and tractor hydraulic system and different control measures

**Theory**

**Module I** **(11 Hours)**

Basics of hydraulics: Pascal's law, flow, energy, work, and power; Hydraulic systems, colour coding, reservoirs, strainers and filters, filtering material and elements, accumulators, pressure gauges and volume meters.

**Module II** **(9 Hours)**

Hydraulic circuit, fittings and connectors; Pumps and its classifications, operation, performance, displacement; Design of gear pumps, vane pumps, piston pumps.

**Module III** **(9 Hours)**

Hydraulic actuators; Cylinders, construction and applications, maintenance; Hydraulic motors, valves, pressure-control valves, directional- control valves, flow-control valves, valve installation, valve failures and remedies, valve assembly, troubleshooting of valves.

**Module IV** **(7 Hours)**

Hydraulic circuit diagrams; USA Standards Institute (USASI) symbols; Tractor hydraulics, Nudging system, ADDC, application of hydraulics and pneumatics drives in agricultural systems.

**Practical**

Introduction to hydraulic systems; Study of hydraulic pumps, hydraulic actuators; Study of hydraulic motors, hydraulic valves, colour codes and circuits; Building simple hydraulic circuits, hydraulics in tractors; Introduction to pneumatics, pneumatics devices, pneumatics in agriculture.

**Lecture Schedule**

1. Basics of hydraulics
2. Pascal's law, flow, energy, work, and power
3. Hydraulic systems
4. Colourcoding
5. Reservoirs
6. Strainers and filters,
7. Filtering material and elements,
8. Accumulators
9. Pressure gauges and volume meters
10. Hydraulic circuit
11. Fittings and connectors;
12. Pumps and its classifications,
13. Pumps -operation, performance, displacement
14. Design of gear pumps, vane pumps, piston pumps.
15. Hydraulic actuators
16. Cylinders, construction and applications, maintenance
17. Hydraulic motors
18. Hydraulic valves
19. Pressure-control valves, directional- control valves, flow-control valves,
20. Valve installation- valve failures and remedies
21. Valve assembly, troubleshooting of valve
22. Hydraulic circuit diagrams
23. USAStandards Institute (USASI) symbols
24. Tractor hydraulics
25. Nudging system, ADDC,
26. Application of hydraulics and pneumatics drives in agricultural systems.

**Practical Schedule**

1. Introduction to hydraulic systems
2. Study of hydraulic pumps, hydraulic actuators
3. Study of hydraulic motors
4. Study of hydraulic valves
5. Study of colour codes and circuits
6. Study of Building simple hydraulic circuits
7. Study of hydraulics in tractors
8. Introduction to pneumatics
9. Study of pneumatics devices
10. Study of pneumatics in agriculture
11. Practical Examination

**Suggested Readings**


1. Anthony, E. 2014. Fluid Power and Applications. Pearson Education Limited. USA.
2. Kepner, R. A., Roy, B. and E. L. B. 2000. Principles of Farm Machinery. CBC Publishers & Distributors, New Delhi.
3. Kuhar, J. E. (Ed.). 1992. Hydraulics (Fundamentals of Service Series). John Deere and Co.

4. Majumdar, S. 2002. Oil Hydraulic System: Principles and Maintenance. McGraw-Hill
5. Meritt, H. E. 1991. Hydraulic Control Systems. John Wiley & Sons.

## EFM 4205 Human Engineering and Safety 3 (2+1)

**Objective**

To enable the students to understand the importance of human factors / human engineering in farm machine design as well as for implementation of ODMR and other safety aspects in farm operation.

**Module I** **(8 Hours)**

Human factors in system development - Concept of systems, basic processes in system development, performance reliability, human performance

**Module II** **(8 Hours)**

Information input process, visual displays, major types and use of displays, auditory displays; Speech communications; Biomechanics of motion, types of movements, range of movements, strength and endurance, speed and accuracy, human control of systems;

**Module III** **(8 Hours)**

Human motor activities, controls, tools and related devices; Anthropometry: arrangement and utilization of work space, atmospheric conditions, thermoregulation in human, thermal comfort, environmental factors, air pollution;

**Module IV** **(8 Hours)**

Dangerous machine (regulation) act, rehabilitation and compensation to accident victims; Safety gadgets for spraying, threshing, chaff cutting and tractor and trailer operation, etc.

**Practical** **(16 Hours)**

Calibration of the subject in the laboratory using bicycle ergometer; Study and calibration of the subject in the laboratory using mechanical treadmill; Use of respiration gas meter from human energy point of view; Use of heart rate monitor; Study of general fatigue of the subject. using Blink ratio method, anthropometric measurements of a selected subject; Optimum work space layout and locations of controls for different tractors; Familiarization with the noise and vibration equipment; Familiarization with safety gadgets for various farm machines; Studies on drudgery of farm women in manual drawn equipment.

**Lecture Schedule**

1. Human factors in system development and concept of systems.
2. Basic processes in system development.
3. Performance reliability and human performance.
4. Metabolic system and human energy machine.
5. Energy liberation in human body and Energy for muscle work.
6. Assessment of energy expenditure: Direct and Indirect calorimetry.
7. Techniques of measuring oxygen consumption and assessment of work load.
8. Information input process and visual displays.
9. Major types and use of displays.

10. Auditory displays.
11. Speech communications.
12. Fundamentals of biomechanics of motion.
13. Types of movements and range of movements.
14. Human strength and endurance, speed and accuracy.
15. Human control of systems, motor activities and controls.
16. Introduction to Anthropometry.
17. Applications of functional anthropometry in ergonomics / human engineering.
18. Arrangement and utilization of work space.
19. Importance of atmospheric conditions in workspace design.
20. Ergonomics in farm tools and related devices.
21. Ergonomic design of farm machinery and equipment.
22. Study of thermoregulation in human and thermal comfort.
23. Environmental factors and air pollution in human engineering.
24. Impact of on human engineering.
25. Dangerous machine (regulation) act.
26. Rehabilitation and compensation to accident victims.
27. Safety aspects in farm operations and machinery design.
28. Safety gadgets for spraying, threshing and chaff cutting.
29. Safety gadgets for power tiller operations.
30. Safety gadgets for tractor and trailer operations.

**Practical Schedule**

1. Calibration of the subject in the laboratory using bicycle ergometer.
2. Study and calibration of the subject in the laboratory using mechanical treadmill.
3. Use of respiration gas meter from human energy point of view.
4. Use of heart rate monitor.
5. Study of general fatigue of the subject using Blink ratio method.
6. Anthropometric measurements of a selected subject.
7. Optimum work space layout and locations of controls for different tractors.
8. Familiarization with the noise and vibration equipment.
9. Familiarization with safety gadgets for various farm machines.
10. Studies on drudgery of farm women in manual drawn equipment.
11. Measurement of heart rate of subjects while using sprayers.
12. Measurement of heart rate of subjects while using weeders.
13. Measurement of heart rate of subjects while using power tiller.
14. Measurement of heart rate of subjects while using reaper.
15. Measurement of heart rate of subjects while using brush-cutter
16. Practical Examination

**Suggested Readings**

1. Astrand, P. and Rodahl, K. 1977. Textbook of Work Physiology. Mc Hill Corporation, New York.
2. Chapanis, A. 1996. Human Factors in System Engineering. John Wiley & Sons, New York.
3. Dul, J. and Weerdmeester, B. 1993. Ergonomics for Beginners. A Quick Reference Guide.

Taylor and Francis, London.
4. Keegan, J. J. and Radke, A. O. 1964. Designing Vehicle Seats for Greater Comfort. SAE Journal, 72:50~5.
5. Mark, S. S. and McCormick, E. J. 1993. Human Factors in Engineering and Design. Mc Hill Corporation, New York.
6. Mathews, J. and Knight, A. A. 1971. Ergonomics in Agricultural Equipment Design. National Institute of Agricultural Engineering
7. Yadav, R. and Tewari, V. K. 1998. Tractor Operator Workplace Design-A Review. Journal of Terra mechanics, 35: 41-53.

## EFM 4206 Precision Agriculture and System Management 3 (2+1)

**Objectives**

- To enable the students to understand the principles of precision agriculture and system management and the use of different equipment in precision agriculture
- To learn the GIS based precision agriculture, sensors and application of sensors for data generation

**Theory**

**Module I** **(8 Hours)**

Precision agriculture - need and functional requirements; Familiarization with issues relating to natural resources.

**Module II** **(8 Hours)**

Equipment for precision agriculture including sowing and planting machines, power sprayers, land clearing machines, laser guided land levellers, straw-chopper, straw-balers, grain combines, etc.

**Module III** **(8 Hours)**

Introduction to GIS based precision agriculture and its applications; Introduction to sensors and application of sensors for data generation.

**Module IV** **(8 Hours)**

Database management; System concept, system approach in farm machinery management, problems on machinery selection, maintenance and scheduling of operations; Application of PERT and CPM in machinery system management.

**Practical**

Familiarization with precision agriculture problems and issues; Familiarization with various machines for resource conservation; Solving problems related to various capacities, pattern efficiency, system limitation, etc; Problems related to cost analysis, inflation and problems related to selection of equipment, replacement, break-even analysis, time value of money, etc.

**Lecture Schedule**

1. Precision agriculture – need and functional requirements.
2. Familiarization with issues relating to natural resources – I
3. Familiarization with issues relating to natural resources – II

4. Equipment for precision agriculture – I
5. Equipment for precision agriculture – II
6. Precision sowing and planting machines.
7. Precision sprayers: Variable Rate Technology.
8. Earthmoving and land clearing machines.
9. Laser guided land levellers.
10. Straw-chopper, straw-balers.
11. Study of combines harvesters.
12. Introduction to GIS.
13. GIS based precision agriculture and its applications.
14. Introduction to sensors.
15. Types of sensors in precision agriculture – I
16. Types of sensors in precision agriculture – II
17. Application of sensors for data generation – I
18. Application of sensors for data generation – II
19. Database management – I
20. Database management – II
21. System concept, system approach in farm machinery management – I
22. System concept, system approach in farm machinery management – II
23. Problems on machinery selection – I
24. Problems on machinery selection – II
25. Maintenance and scheduling of operations – I
26. Maintenance and scheduling of operations – II
27. Application of PERT in machinery system management – II
28. Application of PERT in machinery system management – II
29. Application of CPM in machinery system management – I
30. Application of CPM in machinery system management – II

**Practical Schedule**

1. Familiarization with precision agriculture problems and issues – Field crops.
2. Familiarization with precision agriculture problems and issues – Orchards.
3. Familiarization with various machines for resource conservation – I
4. Familiarization with various machines for resource conservation – II
5. Solving problems related to various capacities.
6. Solving problems related to pattern efficiency.
7. Solving problems related to system limitation.
8. Solving problems related to cost analysis – I
9. Solving problems related to cost analysis – II
10. Solving problems related to inflation.
11. Problems related to selection of equipment.
12. Solving problems related to replacement of equipment.
13. Solving problems related to break-even analysis – I
14. Solving problems related to break-even analysis – II
15. Solving problems related to time value of money.
16. Practical Examination

**Suggested Readings**


1. DeMers M N. 2008. Fundamentals of Geographic Information Systems. Wiley.
2. Dutta, S. K. 1987. Soil Conservation and Land Management. International Book Distributors. Dehradun.
3. Hunt, D. 1956. Farm Power and Machinery Management. Iowa State College Press.
4. Kuhar, J. E. 1977. The Precision Farming Guide for Agriculturist. Lori J. Dhabalt, USA.
5. Sharma, D. N., Jain, M. and Lohan, S. K. 2021. Farm Power and Machinery Management. Jain Brothers.
6. Sigma and Jagmohan. 1976. Earth Moving Machinery. Oxford & IBH.
7. Wood, S. 1977. Heavy Construction: Equipment and Methods. Prentice Hall.

## Department of Farm Machinery and Power Engineering – Skill Enhancement Modules

## Operation and Maintenance of Farm Machinery 2 (0+2)

- Constructional details, adjustment and working of primary tillage equipment such as mould board plough and disc plough
- Constructional details, adjustment and working of secondary tillage equipment such as cultivators, harrows
- Constructional details, adjustment and working of weeding equipment such as manual weeder, power weeder/ dry land weeders/ low land weeders/ interculture equipment
- Constructional details, adjustment and working of rotary tillage / active tillage equipment such as tractor operated /power tiller operated rotavator
- Constructional details, adjustment and working of sowing equipment such as seed drills, planters and transplanters, minimum tillage equipment
- Adjustments and calibration of seed drills
- Working with different types of furrow openers with seed drills/ planters
- Constructional details, adjustment and working of metering mechanisms of drills and planters
- Details of precision farm equipment such as laser levelers, zero till drills, pneumatic planters etc.
- Constructional details, adjustment and working with earth moving equipment such as bulldozers, trenchers and elevators, etc.
- Constructional details, adjustment and working of transplanting equipment such as rice transplanters and vegetable transplanters
- Seedling raising technique for transplanters
- Constructional details, adjustment and working of irrigation equipment such as different types of pumps, sprinkler irrigation system/drip irrigation system
- Constructional details, adjustment and working of harvesting equipment such as root crop harvesters (bullock drawn as well as tractor operated groundnut diggers) and grain crop harvesters (self-propelled / tractor operated/ power tiller operated vertical conveyer reapers) etc.
- Constructional Details, adjustment and working of threshing equipment such as axial flow paddy threshers, combine harvesters etc.

## Repair and Maintenance of Tractors and Power Tillers 2 (0+2)

- Study of different systems of tractor and power tiller
- Study of different components of engine: piston, cylinder, rings, fly wheel, firing interval, firing order
- Study of fuel system, working principle, repair and maintenance
- Working of fuel pumps, fuel filters and injectors
- Study of lubrication system, working principle, repair and maintenance
- Working of oil filters, oil pumps etc.
- Study of cooling system, working principle, repair and maintenance
- Working of thermostat valve
- Study of tractor/ power tiller engine system
- Study of power transmission system of tractor/ power tiller (different types clutches/gears/

sliding mesh gear box/constant mesh gear box/ planetary gear box etc. in tractor; power transmission in power tiller)

- Study of differential / final drive/ PTO drive, their working principle/ repair and maintenance
- Study of braking system: different types of brakes/ their components and working principle/ adjustment / repair
- Study of steering system, types of steering system, steering geometry: caster angle, camber angle, toe-in, toe-out etc. working principle, adjustments, repair and maintenance
- Steering in power tiller: Dog clutch and other arrangements
- Study of hydraulic system of tractor, automatic draft and position control, hitch system, their working principle, practical hitching, repair and maintenance
- Study of tyres, rims, their construction and specification, repair and maintenance
- Daily, weekly and monthly maintenance schedule. Maintenance after each 50, 125, 250 and 500 Hours of operation
- Engine overhauling and assembling.
- Implement hitching and detaching from tractor as well as power tiller
- Safety rules

## Management of Agricultural Machinery Custom Hiring and Maintenance Facilities 2 (0+2)

- Terms associated with machinery management for correct understanding
- Different ways machinery can be obtained for use on the farm
- Factors that affect the purchase of machinery
- Advantages and limitations of two-wheel drive tractors
- Advantages and limitations of four-wheel drive tractors
- Calculation of the theoretical capacity of a farm machines
- General rules concerning field efficiency
- Calculation of field capacity of a farm machines
- Distinguishing between types of costs of machinery ownership
- Understanding how cost and machine use are related
- Calculation of salvage value of a farm machine
- Calculation of average machine investment of a farm machine
- Calculation of annual fixed cost of a farm machine
- Calculation of repair cost for a farm machine
- Calculation of fuel and lubrication costs for a tractor
- Calculation of labor cost for a farm machine
- Understanding causes of fatal tractor accidents
- Learning of procedures for safe machine operation
- Understanding the reasons for efficiency in tractor operation
- Preventative maintenance of farm Machinery
- List five areas of servicing machinery
- Calculate estimated variable cost of a farm machine
- Calculate overall cost per acre for farm machinery
- Calculate equipment width (size) to match tractor horsepower

## Operation and Maintenance of Drones Used for Agricultural Applications 2 (0+2)

- Overview of drone technology, Importance of drones in agriculture. Types of agricultural drones (fixed-wing, rotary-wing, multi-rotor), Regulatory framework and compliance requirements for agricultural drone operations
- Understanding the components of a drone (frame, motors, propellers, flight controller, sensors, etc.), functionality of each component and its role in drone operation, basics of drone aerodynamics and flight principles
- Introduction to various sensors used in agricultural drones (RGB cameras, multispectral cameras, thermal cameras, LiDAR, etc.)
- Applications of different sensors in agriculture (crop monitoring, pest detection, irrigation management, etc.), Payload integration and compatibility considerations
- Principles of flight planning for agricultural drone missions, Selection of appropriate flight parameters (altitude, speed, overlap, etc.), Use of mission planning software and tools, Pre-flight checks and safety protocols
- Techniques for data acquisition during drone flights, Post-flight data processing and analysis, Interpretation of aerial imagery and sensor data, Software tools for data processing and visualization
- Applications of drones in crop monitoring (plant health assessment, yield estimation, disease detection, etc.), Integration of drone data with precision agriculture techniques; Decision support systems for crop management based on drone data
- Using drones for early pest and disease detection, Identification of common pests and diseases in crops, Monitoring strategies for pest infestations and disease outbreaks
- Role of drones in assessing soil moisture levels and irrigation needs, Optimizing irrigation scheduling with drone data, Water resource management and conservation using drone technology
- Routine maintenance procedures for agricultural drones, Diagnosing and troubleshooting common issues (motor failure, GPS signal loss, sensor calibration, etc.), Battery management and care
- Safety protocols for drone operations in agricultural settings, Understanding airspace regulations and restrictions, Emergency procedures and risk mitigation strategies
- Real-world examples of successful drone applications in agriculture, Hands-on exercises and field demonstrations
- Challenges and opportunities for the widespread adoption of drone technology in agriculture, Ethical and societal

## Department of Renewable Energy Engineering-Core Courses

## REE 2201 Renewable Energy Sources 3 (2+1)

**Objective**

To make the students acquainted with the different renewable energy sources and to enable them to analyze and select the appropriate technology to meet the energy demand in different typesof agricultural operations

**Theory**

**Module I** **(8 Hours)**

Different sources of renewable energy: Concepts and limitations of different renewable energy sources (RES) as solar, wind, geothermal, biomass, ocean energy sources; Criteria for assessing the potential of RES; Comparison of renewable energy sources with non-renewable sources.

**Module II** **(8 Hours)**

Solar energy: Energy available from sun, solar radiation data, solar energy conversion into heat through flat plate and concentrating collectors, different solar thermal devices, principle of natural and forced convection solar drying system; Solar photo voltaics- basics and applications, p-n junctions; Solar cells, PV systems, stand alone, grid connected solar power station; Calculation of energy through photovoltaic power generation and cost economics.

**Module III** **(6 Hours)**

Wind energy: Energy availability, general formula, lift and drag; Basics of wind energy conversion, effect of density, frequency variances, angle of attack, wind speed, types of windmill rotors, determination of torque coefficient, induction type generators; Working principle of wind power plant; Wind farms, aero-generators, wind power generation system.

**Module IV** **(8 Hours)**

Biogas: Basics of anaerobic digestion, types and constructional details of biogas plants, biogas generation and its properties, factors affecting biogas generation and usages, design considerations, advantages and disadvantages of biogas spent slurry; Generation of power from biogas; Design and use of different commercial biogas plants.

**Module V** **(6 Hours)**

Power generation from urban, municipal and industrial waste; Ocean thermal and electric power generation, wave and tidal power; Power generation from biomass (gasification and Dendro-thermal); Mini and micro hydel plants; Fuel cells and its associated parameters.

**Practical**

Study of solar thermal devices like solar cookers; Study of solar water heating system; Study of natural convection solar dryer; Study of forced convection solar dryer; Study of solar desalination unit; Study of solar greenhouse for agriculture production; Study of cost economics of solar thermal devices including solar panels; Study of solar photovoltaic system and study of characteristics of solar photovoltaic panel; Study of evaluation of solar air heater/dryer; Study of biogas plants and its components; Performance evaluation of a fixed dome type biogas plant; Performance evaluation

of floating drum type biogas plant; Study of biomass gasifiers; Study of cost economics of biogas system; Visit to a windmill plant.

**Lecture Schedule**

1. Introduction to energy- basic thermodynamics- Exergy and Anergy
2. Classification of energy sources- concept of renewable energy-limitation
3. Criteria for assessing the potential of RES
4. Comparison of renewable energy sources with non-renewable sources.
5. Solar energy: Energy available from sun
6. Solar radiation data
7. Solar energy conversion technologies
8. Flat plate collectors and concentrating type collectors
9. Solar energy conversion into heat through flat plate and concentrating collectors
10. Different solar thermal devices-
11. Principle of natural and forced convection solar drying system
12. Solar photo voltaics
13. Basics and applications of p-njunctions
14. Solar cells
15. PV systems
16. Stand alone, grid connected solar power station
17. Calculation of energy through photovoltaic power generation and cost economics
18. Wind energy-Energy availability, general formula, lift and drag
19. Basics of wind energy conversion
20. Effect of density, frequency variances, angle of attack, wind speed
21. Types of windmill rotors, determination of torque coefficient, induction type generators
22. Working principle of wind power plant
23. Wind farms, aero-generators, wind power generation system
24. Biogas: Basics of anaerobic digestion,
25. Types and constructional details of biogas plants
26. Biogasgeneration and its properties
27. Factors affecting biogas generation and usages
28. Design considerations,advantages and disadvantages of biogas spent slurry
29. Generation of power from biogas
30. Design anduse of different commercial biogas plants.
31. Power generation from urban, municipal and industrial waste
32. Ocean thermal and electric power generation, wave and tidal power
33. Power generation from biomass (gasification and Dendro-thermal)
34. Mini and micro hydrel plants
35. Fuel cells and its associated parameters

**Practical Schedule**

1. Study of solar thermal devices like solar cookers
2. Study of solar water heating system
3. Study ofnatural convection solar dryer
4. Study of forced convection solar dryer
5. Study of solar desalination unit
6. Study of solar greenhouse for agriculture production

7. Study of cost economics of solar thermaldevices including solar panels
8. Study of solar photovoltaic system and study of characteristics of solar photovoltaic panel
9. Study of evaluation of solar air heater/dryer; Study of biogas plants and its components
10. Performance evaluation of a fixed dome type biogas plant
11. Performance evaluationof floating drum type biogas plant
12. Study of biomass gasifiers
13. Study of cost economics of biogas system
14. Visit to a windmill plant

**Suggested Readings**


1. Basu, P. 2018. Biomass Gasification and Pyrolysis Practical Design and Theory. Academic Press.
2. Deublein, D. and Steinhauser, A. 2008. Biogas from Waste and Renewable Resources. WILEY- VCH Verlag GmbH & Co. KGaA, Weinheim.
3. Duffie, J. A. and Beckman, W. A. 2013. Solar Engineering of Thermal Process. John Wiley and Sons.
4. Julian Chen, C. 2011. Physics of Solar Energy. John Wiley & Sons, Inc.
5. Khan, B. H. 2006. Non-Conventional Energy Resources. The McGraw Hill Publishers.
6. Knothe, G., Gerpen, J. V. and Krahl, J. (Eds). 2010. The Biodiesel Handbook. AOCS Press.
7. Patel, M. R. 2005. Wind and Solar Power Systems. CRC Press, Bota Racon.
8. Rai, G. D. 2013. Non-Conventional Energy Sources. Khanna Publishers, New Delhi.
9. Rai, G. D. 2020. Solar Energy Utilization. Khanna Publishers, New Delhi.
10. Reed, T. B. and Das, A. 1988. Handbook of Biomass Downdraft Gassifier Engine Systems. SERI, USA.
11. Ryszard, Petela. 2010. Engineering Thermodynamics of Thermal Radiation for Solar Power Utilization. The McGraw-Hill Companies.
12. Stefan, C. W. and Krauter. 2008. Solar Electric Power Generation – Photovoltaic Energy Systems. Springer.


## REE 3202 Bioenergy Systems: Design and Applications 3 (2+1)

**Objective**

To make the students acquainted with the different biomass sources, and the different thermochemical and biochemical processes for bioenergy and fuel production

**Theory**

**Module I** **(6 Hours)**

Biomass sources and characteristics; Fermentation processes and its general requirements; Aerobic and anaerobic fermentation processes and their industrial applications; Heat transfer processes in anaerobic digestion systems.

**Module II** **(5 Hours)**

Biomass production- wastelands, classification and their use through energy plantation; Selection of species, methods of field preparation and transplanting; Harvesting of biomass and coppicing

characteristics; Biomass preparation techniques for harnessing (size reduction, densification and drying).

**Module III** **(16 Hours)**

Bio-energy- properties of biomass and conversion technologies, pyrolysis of biomass to produce solid, liquid and gaseous fuels; Biomass gasification, types of gasifiers, various types of biomass cook stoves for rural energy needs; Thermo-chemical degradation; History of small gas producer engine system; Chemistry of gasification; Producer gas- type, operating principle; Gasifier fuels, properties, preparation, conditioning of producer gas; Applications, shaft power generation, thermal application and economics; Trans-esterification for biodiesel production and application in CI engines; production process, properties and application of ethanol; Bio-hydrogen production routes.

**Module IV** **(6 Hours)**

Environmental aspect of bio-energy; Assessment of greenhouse gas mitigation potential; Cost economics of bio-energy systems. Carbon foot print and carbon sequestration

**Practical**

Study of anaerobic fermentation system for industrial application; Study of gasification for industrial process heat; Study of biodiesel production unit; Study of ethanol production unit; Study of biomass densification technique (briquetting, pelletization, and cubing); Study of integral bio energy system for industrial application; Study of bio energy efficiency in industry and commercial buildings; Study of energy efficiency in building, study of Brayton, Striling and Rankine cycles; Study of Biomass gasifiers; Study of biomass improved cook-stoves; Estimation of calorific value of biogas and producer gas; Testing of diesel engine operation using dual fuels and gas alone; Performance evaluation of biomass gasifier engine system (throat less and downdraft); Study on producer gas- types, application, shaft power generation, thermal application and economics; Study of cost economics of biofuel.

**Lecture Schedule**

1. Introduction to bioenergy, its status- global and India
2. Biomass sources and characteristics
3. Physical and chemical properties of biomass relevant in energy conversion
4. Physical and chemical properties of biomass relevant in energy conversion
5. Fermentation processes and its general requirements
6. Aerobic and anaerobic fermentation processes and their industrial applications
7. Heat transfer processes in anaerobic digestion systems
8. Biomass production- wastelands, classification and their use through energy plantation
9. Selection of species, methods of field preparation and transplanting
10. Harvesting of biomass and coppicing characteristics
11. Biomass preparation techniques for harnessing (size reduction, densification and drying).
12. Bio chemical and Thermo chemical conversion technologies of biomass
13. Pyrolysis of biomass to produce solid, liquid and gaseous fuels
14. Introduction to biomass gasification

15. Chemistry of gasification- Different types of gasifiers
16. Types of gasifiers, various types of biomass cook stoves for rural energy needs
17. Thermo-chemical degradation
18. History of small gas producer engine system
19. Chemistry of gasification
20. Producer gas- type, operating principle
21. Gasifier fuels, properties, preparation, conditioning of producer gas,
22. Applications of producer gas, shaft power generation
23. Thermal application and economics Gasifier fuels
24. Introduction to bio diesel and its uses
25. Trans-esterification for biodiesel production
26. Application of biodiesel in CI engines
27. Production process, properties and application of ethanol
28. Bio-hydrogen production routes.
29. Environmental aspect of bio-energy
30. Introduction to greenhouse gas, its production adverse effects
31. Assessment of greenhouse gas mitigation potential
32. Cost economics of bio-energy systems.
33. Study on Carbon sequestration and carbon footprint
34. Measurement of Carbon sequestration and carbon footprint

**Practical Schedule**

1. Study of anaerobic fermentation system for industrial application
2. Study of gasification for industrial process heat
3. Study of biodiesel production unit
4. Study of ethanol production unit
5. Study of biomass densification technique (briquetting, pelletization, and cubing)
6. Study of biomass densification technique (briquetting, pelletization, and cubing)
7. Study of integral bio energy system for industrial application
8. Study of bio energy efficiency in industry and commercial buildings
9. Study of energy efficiency in building, study of Brayton, Striling and Rankine cycles
10. Study of Biomass gasifiers
11. Study of biomass improved cook-stoves
12. Estimation of calorific value of biogas and producer gas
13. Testing of diesel engine operation using dual fuels and gas alone
14. Testing of diesel engine operation using dual fuels and gas alone
15. Performance evaluation of biomass gasifier engine system (throat less and downdraft)
16. Study on producer gas- types, application, shaft power generation, thermal application and economics
17. Study on producer gas- types, application, shaft power generation, thermal application and economics
18. Study of cost economics of biofuel.

**Suggested Readings**


1. Basu, P. 2018. Biomass Gasification, Pyrolysis and Torrefaction. Academic Press.
2. Butler, S. 2005. Renewable Energy Academy: Training Wood Energy Professionals.
3. Knothe, G., Gerpen, J. V. and Krahl, J. (Eds). 2010. The Biodiesel Handbook. AOCS Press.
4. Rai, G. D. 2013. Non-Conventional Energy Sources. Khanna Publishers, New Delhi.
5. Reed, T. B. and Das, A. 1988. Handbook of Biomass Downdraft Gasifier Engine Systems. SERI.

## Department of Renewable Energy Engineering-Elective Courses

## ERE 4201 Photovoltaic Technology and Systems 3 (2+1)

**Objectives**

- To enable the students to understand the basic elements of photovoltaics, working of PV cells, designs of PV systems
- To know the installation of PV system both off grid and on grid

**Theory**

**Module I** **(9 Hours)**

Solar PV Technology: advantages, limitations, current status of PV technology, SWOT analysis of PV technology; Types of solar cells: Wafer based silicon cell, Thin film amorphous silicon cell, Thin Cadmium Telluride (CdTe) Cell, Copper Indium Gallium Selenide (CiGS) Cell, Thin film crystalline silicon solar cell.

**Module II** **(9 Hours)**

Solar photo voltaic module: solar cell, solar module, solar array, series & parallel connections of cell, mismatch in cell, fill factor, effect of solar radiation and temperature on power output of module, I-V and power curve of module, balance of solar PV system; Solar PV system designing and cost estimation.

**Module III** **(9 Hours)**

Introduction to batteries, battery classification, lead acid battery, Nicked Cadmium battery, comparison of batteries, battery parameters; Charge controller: types and function of charge controller, PWM (Pulse width modulation) type, MPPT (Maximum Power Point Tracking) type charge controller; Converters: DC to DC converter and DC to AC type converter.

**Module IV** **(9 Hours)**

Application of solar PV system, solar home lighting system, solar lantern, solar fencing, solar street light, solar water pumping system, roof top solar photovoltaic power plant and smart grid.

**Practical**

Study of V-I characteristics of solar PV system; Smart grid technology and application; Manufacturing technique of solar array; Different DC to DC and DC to AC converter; Domestic solar lighting system; Various solar module technologies; Safe measurement of PV modules electrical characteristics and commissioning of complete solar PV system.

**Lecture Schedule**

1. Solar PV Technology.
2. Solar PV Technology: Advantages, Limitations
3. Current Status of PV technology
4. SWOT analysis of PV technology.
5. Types of Solar Cell, Wafer based Silicon Cell,
6. Thin film amorphous silicon cell and Thin Cadmium Telluride (CdTe) Cell.
7. Copper Indium Gallium Selenide (CiGS) Cell

8. Thin film crystalline silicon solar cell.
9. Solar Photo-Voltaic Module: Solar cell.
10. Solar module, solar array.
11. Series and parallel connections of cell.
12. Mismatch in cell, fill factor.
13. Effect of solar radiation and temperature on power output of module
14. Effect of solar radiation and temperature on power output of module
15. I-V and power curve of module.
16. I-V and power curve of module.
17. Balance of Solar PV system: Introduction to batteries.
18. Battery classification,
19. Lead acid battery,
20. Nickel Cadmium battery
21. Comparisonof batteries and battery parameters.
22. Charge controller
23. Types of charge controllers
24. Functionsof charge controller, PWM type.
25. MPPT type charge controller.
26. Converters: DC to DC converter.
27. DC to AC type converter.
28. Applications of Solar PV system
29. Solar home lighting system
30. Solarlantern, solar street light.
31. Solarfencing.
32. Solarwater pumping system.
33. Roof top solar photovoltaic power plant
34. Smartgrid.
35. Smart grid

**Practical Schedule**

1. Estimation of energy demand by a load.
2. Study of I-V characteristics of solar PV system.
3. PV cell manufacturing technology.
4. Efficiency of PV system.
5. Smartgrid technology and its applications.
6. Procedure for building a solar cell array.
7. Procedure for maintaining optimum system voltage.
8. Construction and operation of DC to AC converters.
9. Construction and operation of solar pumping system.
10. Troubleshooting of PV modules.
11. Troubleshooting of PV modules.
12. Troubleshooting of PV modules.
13. Safety precautions for PV modules and solar array.
14. Switching and relays for PV system.
15. Switching and relays for PV system.
16. Electrical characteristics of solar PV system.
17. Commissioning procedure for complete solar PV system.

18. Practical examination

**Suggested Readings**


1. Buresch, Mathew. 1983. Photo-voltaic energy systems : Design and Installation. McGraw-Hill Book Company, New York.
2. Derrick, A., Francis, C. and Bokalders, V. 1991. Solar Photo-voltaic Products. Intermediate Technology Publications.
3. Meinel, A. B. and Meinel, M. P. 1976. Applied Solar Energy: An Introduction. Addison-Wesley Educational Publishers Inc.
4. Rai, G. D. 1998. Non-conventional Sources of Energy. Khanna Pub.
5. Rathore, N. S., Kurchania, A. K. and Panwar, N. L. 2006. Renewable Energy: Theory & Practice. Himanshu Publications.
6. Solanki, C. S. 2011. Solar Photovoltaic: Fundamentals, Technologies and Applications. PHI Learning Private Ltd.


## ERE 4202 Wind Power Technology and Systems 3 (2+1)

**Objective**

To enable the students to calculate and analyse wind resource and energy production from a wind turbine, Understand the typical control methods for wind turbines and the modes of wind power generation

**Theory**

**Module I** **(2 Hours)**

Wind mapping and assessment: Wind energy potential, nature of wind, instruments, history and taxonomy of wind mills, wind power laws.

**Module II** **(10 Hours)**

Aerodynamic operations of wind turbines; Wind energy extraction and wind turbine power generation; Design of wind turbine rotors, estimation of wind turbine power rating, selection of optimum wind energy generator; Types of wind energy systems, wind to electrical energy conversion alternatives, grid interfacing of a wind farm, grid connection, energy storage requirements with wind energy system.

**Module III** **(7 Hours)**

Economics of wind energy system; Modes of wind power generation; standalone mode, wind diesel hybrid system, solar wind hybrid system; Control and monitoring system of a wind farm, wind farm sitting; Wind map of India, wind-electric energy stations in India.

**Practical**

Detailed design and drawing of wind turbine; Study of horizontal axis wind turbine; Study of vertical axis wind turbine; Study of variation of wind speed with elevation; Study of validation of Weibull probability density function; Study of wind power density duration curve; Electrical characteristics and commissioning of complete aero-generator wind power system; Visit to a wind farm.

**Lecture Schedule**

1. Wind mapping and assessment
2. Wind energy potential, nature of wind, instruments, history and taxonomy of wind mills, wind power laws.
3. Aerodynamic operations of wind turbines
4. Wind energy extraction and wind turbine power generation
5. Design of wind turbine rotors
6. Estimation of wind turbine power rating
7. Selection of optimum wind energy generator
8. Types of wind energy systems
9. Wind to electrical energy conversion alternatives
10. Grid interfacing of a wind farm
11. Grid connection
12. Energy storage requirements with wind energy system.
13. Economics of wind energy system
14. Modes of wind power generation
15. Standalone mode
16. Wind diesel hybrid system
17. Solar wind hybrid system
18. Control and monitoring system of a wind farm, wind farm sitting;
19. Wind map of India, wind-electric energy stations in India.

**Practical Schedule**

1. Detailed design and drawing of wind turbine
2. Study of horizontal axis wind turbine
3. Study of vertical axis wind turbine
4. Study of variation of wind speed with elevation
5. Study of validation of Weibull probability density functio
6. Study of wind power density duration curve
7. Electrical characteristics and commissioning of complete aero-generator wind power system
8. Visit to a wind farm.

**Suggested Readings**


1. Kothari, D. P., Singal, K. C. and Ranjan, R. 2012. Renewable energy sources and emerging technologies. PHI Learning Private Limited. New Delhi.
2. Olanki, C. S. 2011. Solar Photovoltaic: Fundamentals, Technologies and Applications. PHI Learning Private Ltd, New Delhi.
3. Powar, A. G. and Mohod, A. G. 2010. Fundamentals of wind energy utilization. Jain Brothers Publisher, Karol Bagh, New Delhi.
4. Rai, G. D. 1998. Non-conventional Sources of Energy. Khanna Publisher, New Delhi.
5. Rao, S. and Parulekar, B. B. 2007. Energy Technology. Khanna Publishers, New Delhi.
6. Rathore, N. S., Kurchania, A. K. and Panwar, N. L. 2006. Renewable Energy: Theory & Practice. Himanshu Publications, Udaipur.
7. Tiwari, G. N. and Ghosal, M. K. 2005. Renewable Energy Resources: Basic Principles and Applications. Narosa Publishing House, New Delhi.

# ERE 4203 Waste and By-product Utilization 3 (2+1)

**Objectives**

- To enable the students to understand the nature of agricultural wastes and the physical, chemical and biological basis of agricultural waste treatment
- To analyze and design systems for the collection, handling, treatment and utilization of wastes

**Theory**

**Module I** **(6 Hours)**

Types and formation of by-products and waste; Magnitude of waste generation in different food processing industries; Uses of different agricultural by-products from rice mill, sugarcane industry, oil mill etc.

**Module II** **(10 Hours)**

Concept, scope and maintenance of waste management and effluent treatment; Waste parameters and their importance in waste management- temperature, pH, Oxygen demands (BOD,COD), fat, oil and grease content, metal content, forms of phosphorous and sulphur in waste waters, microbiology of waste, other ingredients like insecticide, pesticides and fungicides residues.

**Module III** **(10 Hours)**

Waste utilization in various industries, furnaces and boilers run on agricultural wastes and by products, briquetting of biomass as fuel, production of charcoal briquette, generation of electricity using surplus biomass, producer gas generation and utilization; Waste treatment and disposal: Design, construction, operation and management of institutional community and family size biogas plants, vermi-composting.

**Module IV** **(10 Hours)**

Pre-treatment of waste: sedimentation, coagulation, flocculation and floatation; Secondary treatments: biological and chemical oxygen demand for different food plant waste– trickling filters, oxidation ditches, activated sludge process, rotating biological contractors, lagoons; Tertiary treatments: advanced waste water treatment process- sand, coal and activated carbon filters, phosphorous, sulphur, nitrogen and heavy metals removal; Assessment, treatment and disposal of solid waste. Effluent treatment plants; Environmental performance of food industry to comply with ISO- 14001 standards.

**Practical**

Determination of temperature, pH, turbidity solids content, BOD and COD of waste water; Determination of ash content of agricultural wastes and determination of un-burnt carbon in ash; Study about briquetting of agricultural residues; Estimation of excess air for better combustion of briquettes; Study of extraction of oil from rice bran; Study on bioconversion of agricultural wastes; Recovery of germ and germ oil from by-products of cereals; Visit to various industries using waste and food by-products.

**Lecture Schedule**

1. Types and formation of by-products and waste

2. Hydraulic systems
3. Magnitude of waste generation in different food processing industries
4. Uses of different agricultural by-products from rice mill, sugarcane industry, oil mill etc.
5. Concept, scope and maintenance of waste management and effluent treatment
6. Waste parameters and their importance in waste management
7. Waste parameters -temperature, pH, Oxygen demands (BOD,COD)
8. Waste parameters -fat, oil and grease content, metal content, forms of phosphorous and sulphur
9. Microbiology of waste
10. Other ingredients like insecticide, pesticides and fungicides residues
11. Waste utilization in various industries
12. Furnaces and boilers run on agricultural wastes and byproducts
13. Briquetting of biomass as fuel
14. Production of charcoal briquette
15. Generation of electricityusing surplus biomass
16. Producer gas generation and utilization
17. Waste treatment and disposal
18. Design, construction, operation and management of institutional community
19. Family size biogasplants- design, construction, operation and management
20. Vermi-composting.
21. Pre-treatment of waste: sedimentation, coagulation, flocculation and floatation
22. Secondary treatments
23. Biological and chemical oxygen demand for different food plant waste
24. Trickling filters, oxidation ditches
25. Activated sludge process, rotating biological contractors and lagoons
26. Tertiarytreatments
27. Advanced waste water treatment process
28. Sand, coal and activated carbon filters,
29. Phosphorous, sulphur, nitrogen and heavy metals removal
30. Assessment, treatment and disposal of solid waste
31. Effluent treatment plants
32. Environmental performance of food industry to comply with ISO- 14001 standards

**Practical Schedule**

1. Determination of temperature, pH, turbidity solids content
2. Determination of BOD and COD of waste water
3. Determination of ash content of agricultural wastes and
4. determination of un-burnt carbon in ash
5. Study about briquetting of agricultural residues
6. Estimation of excess air for better combustion of briquettes
7. Study of extraction of oil from rice bran
8. Study on bioconversion of agricultural wastes
9. Recovery of germ and germ oil from by-products of cereals
10. Visit to various industries using wasteand food by-products

**Suggested Readings**

1. Bhatia, S. C. 2001. Environmental Pollution and Control in Chemical Process Industries. Khanna Publishers, New Delhi.

2. Garg, S. K. 1998. Environmental Engineering (Vol. II) – Sewage Disposal and Air Pollution Engineering. Khanna Publishers, New Delhi
3. Joshi, V. K. and Sharma, S. K. 2011. Food Processing Waste Management: Treatment & Utilization Technology. New India Publishing Agency.
4. Markel, I. A. 1981. Managing Livestock Waste. AVI Publishing Co.
5. Pantastico, E. C. B. 1975. Post-harvest Physiology, Handling and Utilization of Tropical and Sub- Tropical Fruits and Vegetables. AVI Pub. Co.
6. Prashar, A. and Bansal, P. 2008. Industrial Safety and Environment. S.K. Kataria and Sons, New Delhi.
7. Shewfelt, R. L. and Prussi, S. E. 1992. Post-Harvest Handling - A Systems approach. Academic Press Inc.
8. USDA. 1992. Agricultural Waste Management Field Hand book. USDA, Washington DC.
9. Vasso, O. and Winfried, R. (Eds) 2007. Utilization of By-products and Treatment of Waste in the Food Industry. Springer Science & Business Media, LLC 233 New York.
10. Weichmann, J. 1987. Post-Harvest Physiology of Vegetables. Marcel and Dekker Verlag.

## Department of Renewable Energy Engineering-Skill Enhancement Modules

## Fabrication, Operation and Maintenance of Renewable Energy Gadgets 2 (0+2)

- Acquaintance with different renewable energy sources (solar, wind, hydro, biomass, geothermal)
- Principles of photovoltaic (PV) technology, fabrication processes for solar panels and Installation and maintenance of solar power systems
- Grid-tied vs. off-grid solar systems
- Wind turbine technology and components, fabrication and installation of wind turbines., operation and maintenance practices for wind farms
- Pico hydro and their construction and maintenance
- Biomass sources and conversion technologies (combustion, gasification, anaerobic digestion)
- Fabrication of biomass energy systems like gasifier, Improved challah, etc.
- Routine maintenance procedures for renewable energy systems, Troubleshooting common issues
- Safety protocols for maintenance tasks; Monitoring and performance optimization
- Real-world examples of successful renewable energy projects, Hands-on projects to reinforce learning
- Acquaintance with the emerging trends in renewable energy, exploration of innovative technologies (tidal, wave, solar thermal, etc.)
- Renewable energy policies and incentives, regulatory compliance for renewable energy projects, environmental considerations and permitting processes

## Design of Solar PV Systems Using Softwares 2 (0+2)

- Overview of software tools commonly used for solar PV system design (e.g., PV*SOL, Helioscope, PVSyst, SAM), Purpose and capabilities of each software tool, Installation and setup instructions for the selected softwares
- Features for designing a solar PV system (location, load requirements, shading analysis, etc.), Gathering necessary input data: site location, solar irradiance data, system specifications, electrical load profile, etc.
- Conducting a site analysis to assess the solar potential and available space for PV system installation, using software tools to perform shading analysis and identify potential obstructions or shading issues
- Determining the appropriate size of the solar PV system, Selecting PV modules, inverters, mounting structures, and other system components. Optimizing the system configuration to maximize energy production and efficiency
- Creating a layout for the solar PV array using the software's design tools, Placing PV modules on the roof or ground in optimal orientations and configurations
- Designing the electrical wiring and connection scheme for the PV array, inverters, and other components
- Running simulations to estimate the performance and energy yield of the proposed PV system, analyzing simulation results to evaluate the system's energy production, capacity factor, and financial viability
- Fine-tuning system parameters to optimize performance and maximize energy output

- Performing a financial analysis to assess the economic feasibility of the solar PV project, Calculating the return on investment (ROI), payback period, net present value (NPV), and other financial metrics, Considering incentives, subsidies, and financing options for solar PV installations
- Conducting sensitivity analysis to evaluate the impact of variations in key parameters (e.g., module efficiency, system size, electricity tariffs) on project economics, iteratively refining the system design to achieve the desired performance and economic outcomes
- Generating detailed reports and documentation summarizing the design process, simulation results, and project economics
- Case studies based on real-world projects to apply learned concepts and techniques
- Addressing common challenges and troubleshooting issues encountered during the design process.

## Installation and Maintenance of On-Grid and Off-Grid Solar Systems 2 (0+2)

- Overview of solar photovoltaic technology and its applications, Explanation of on-grid and off-grid solar systems
- Identification and explanation of key components in solar PV systems (solar panels, inverters, charge controllers, batteries, wiring, etc.)
- Understanding the differences between on-grid and off-grid system configurations
- Component identification and system layout design
- Conducting site assessments to determine solar potential and suitability for PV system installation. Considerations for system sizing, orientation, and tilt angle, Planning the layout of solar panels, mounting structures, and electrical components
- Installation of solar panels, inverters, and other components for on-grid systems, Techniques for mounting solar panels on rooftops or ground-mounted structures
- Wiring and connection of components to the electrical grid
- Setting up off-grid solar systems, including battery-based energy storage, Installation of charge controllers, batteries, and DC loads
- Designing and configuring off-grid systems for reliable and efficient operation
- Electrical wiring practices for solar PV systems
- Understanding safety precautions and regulations related to electrical installations
- Wiring solar panels, inverters, charge controllers, and battery banks
- Commissioning and testing of solar PV systems to ensure proper functionality, conducting performance tests and verifying system parameters
- Troubleshooting common issues and addressing installation errors
- Routine maintenance tasks for on-grid solar PV systems, including cleaning, inspection, and performance monitoring, Diagnosis and troubleshooting of grid-connected system components
- Specialized maintenance requirements for off-grid solar systems, including battery maintenance and charge controller calibration
- Techniques for integrating additional solar panels, batteries, or other components into existing systems
- System modification and expansion
- Introduction to remote monitoring systems for tracking the performance of solar PV systems, using data analytics tools to diagnose issues and optimize system performance, Hands-on

practice in accessing system data and interpreting performance metrics

## Design and Maintenance of Agrivoltaic Systems 2 (0+2)

- Overview of agrivoltaic systems and their benefits, Explanation of how solar panels and agriculture can coexist synergistically
- Factors to consider when selecting a site for an agrivoltaic system (climate, soil, topography, etc.), Conducting site assessments to determine solar potential and suitability for agricultural activities
- Design principles for integrating solar panels with agricultural crops or livestock, Planning the layout and configuration of the agrivoltaic system to maximize energy production and crop yield
- Selection of appropriate crops and planting strategies for agrivoltaic systems
- Installation of solar panels on support structures (ground-mounted or elevated) with proper panel orientation and tilt angle for maximum energy capture
- Safety protocols and best practices for working with solar panel arrays
- Crop selection and management practices suitable for agrivoltaic systems, Monitoring soil moisture, nutrient levels, and crop health
- Implementing irrigation, fertilization, and pest management strategies tailored to agrivoltaic conditions
- Designing the electrical layout for connecting solar panels to the grid or off-grid systems, Installation of wiring, inverters, combiner boxes, and other electrical components, Compliance with electrical codes and safety standards
- Routine maintenance tasks for solar panels, support structures, and electrical components, Monitoring system performance and troubleshooting common issues, equipment inspection, cleaning, and maintenance
- Introduction to data monitoring systems for tracking energy production, crop yield, and environmental conditions, Interpretation of data to optimize system performance and agricultural productivity, using data analytics tools to identify trends and patterns
- Overview of regulations, permits, and incentives related to agrivoltaic installations, Compliance with zoning laws, land use regulations, and environmental regulations, Advocacy for supportive policies and incentives to encourage the adoption of agrivoltaics
- Visits to agrivoltaic installations and research sites for hands-on learning opportunities, Practical demonstrations of agrivoltaic techniques and technologies, Interaction with practitioners and experts in the field

## Valorisation of Agri-biomass and Organic Waste 2 (0+2)

- Concept of valorization and its role in waste-to-value processes, Introduction to the types of agri-biomass and organic waste commonly generated in agriculture and food production
- Methods for characterizing agri-biomass and organic waste (composition, moisture content, calorific value, etc.), Understanding the properties and potential uses of different types of biomass and waste materials
- Sample collection, preparation, and analysis
- Introduction to biological conversion methods such as anaerobic digestion and composting,

Principles of microbial decomposition and fermentation in biomass conversion

- Overview of thermochemical conversion techniques including pyrolysis, gasification, and hydrothermal processing, Understanding the principles of heat transfer, chemical reactions, and product formation in thermochemical processes
- Introduction to biochemical and biotechnological approaches for valorizing biomass and organic waste, Utilization of enzymes, microorganisms, and fermentation processes in bioconversion
- Methods for producing biofuels from agri-biomass and organic waste (biogas, biodiesel, bioethanol, etc.)
- Valorization of agri-biomass and organic waste into value-added products such as biochar, bio-based chemicals, and biomaterials
- Strategies for waste minimization, reuse, and recycling in agricultural and food production systems
- Emerging trends such as agri-biomass and organic waste valorization technologies, precision biomass conversion and integrated bio-refinery concepts
- Overview of regulations, standards, and policies governing the valorization of agri-biomass and organic waste

## Energy audit, Energy Conservation and Energy Efficiency 2 (0+2)

- Key concepts and definitions related to energy conservation and efficiency
- Introduction to the principles of energy auditing and analysis
- Methods for collecting and analyzing energy consumption data
- Interpretation of energy bills, utility data, and meter readings
- Conducting energy audits for residential, commercial, and industrial facilities
- Introduction to energy auditing tools and equipment (e.g., power meters, data loggers, thermal imaging cameras)
- Use of software tools for energy data analysis and visualization
- Identifying potential areas for energy savings and efficiency improvements, Evaluation of building systems, equipment, and operations
- Hands-on exercises in identifying ECOs through site inspections and data analysis
- Overview of energy-efficient technologies and best practices in lighting, HVAC, insulation, appliances, etc, Demonstration of energy-saving devices and equipment, Case studies of successful energy efficiency projects
- Analysis of building energy performance using energy modelling software
- Integration of renewable energy systems (solar PV, wind, geothermal, etc.) with energy
- conservation and efficiency measures
- Overview of energy efficiency policies, regulations, and incentives at local, national, and international levels
- Energy efficiency standards, labeling programs, and building codes
- Cost-benefit analysis, return on investment (ROI) calculations, and lifecycle cost analysis
- Use of measurement and verification (M&V) protocols and reporting

## Department of Irrigation and Drainage Engineering- Core Courses

## IDE 2101 Engineering Mechanics 3 (2+1)

**Objective**

To make the students acquainted with the principles of engineering mechanics and the calculation of different stresses to be helpful for design of engineering structures

**Theory**

**Module I** **(5 Hours)**

Basic concepts of engineering mechanics, statics, dynamics, kinetics, scalar quantities, vector quantities, systems of units. Composition and resolution of forces, analytical method, graphical method. Laws of forces, moments and their application, levers, parallel forces and couples. Equilibrium of forces, free body diagrams.

**Module II** **(8 Hours)**

Centre of gravity (CG) of simple geometrical figures, CG by moments, plane figures, axis of references, CG of symmetric sections, unsymmetrical sections, solid bodies and cut sections. Moment of inertia: Methods of finding out M.I., methods of integration, M.I. of different sections, Theorem of perpendicular axes, parallel axes, M.I. of composite sections and cut sections. Frictional forces, static friction, dynamic friction, limiting friction, normal reaction, angle of friction, coefficient of friction, laws of friction, equilibrium of a body lying in horizontal and inclined planes, ladder friction; wedge friction, screw friction, screw jack. Analysis of simple framed structures, methods of sections, force table, methods of joints, hinged joints, roller support, vertical and inclined loads.

**Module III** **(8 Hours)**

Simple stresses and strain, Hooke's law, Poisson's ratio, modulus of elasticity, Strain related problems. Principal stresses and strain, analysis of plane and complex stress, principal planes and principal stresses, Mohr's circle, finding out principal stresses, different analysis.

**Module IV** **(12 Hours)**

Shear force and bending moment, fundamentals of shear force and bending moment, SFD and BMD of cantilever and simply supported and overhanging beams, point of contra-flexture. Torsion of circular shaft, torsional effect, hoop stress, power transmitted by a shaft.

**Practical**

Problems on composition and resolution of forces; Study the moments of a force; Problems related to resultant of a concurrent-coplanar force system; Problems related to non-concurrent coplanar force system; Systems of couples in space; Problems related to centroids of composite areas; Problems on Moment of Inertia, radius of gyration of composite areas; Analysis of equilibrium of concurrent coplanar and non-concurrent coplanar force system; Problems involved with frictions; Analysis of simple trusses by methods of joints and methods of sections; Analysis of simple trusses by graphical method; Problems on simple stress and strains; Problems on shear and bending moment diagrams. Problems on stresses on beams. Problems on torsion of the shafts; Analysis of plane and complex stresses.

**Lecture Schedule**

1. Fundamentals of engineering mechanics – Force – Effects of a force – Characteristics of a force. Particle, Rigid body. Systems of forces. Principle of physical independence of forces. Principle of transmissibility of forces.
2. Resultant of a system of forces, Method of resolution. Resolved components and resolved parts of a force. Theorem of resolved parts and its applications. Numerical problems.
3. Moments and its applications – Moment of a force. Geometrical representation of moment of a force. Varignon's theorem and its applications. Corollaries of Varignon's theorem. Position of resultant force. Numerical problems.
4. Parallel forces – Resultant of two like and two unlike parallel forces. Centre of parallel forces, Couple – Types of couples, moment of a couple characteristics of a couple. Theorems for couples.
5. Equilibrium of forces – Resultant and equilibrant conditions of equilibrium – Principles of equilibrium. Lami's theorem and its applications. Numerical problems.Stable, unstable and neutral equilibrium.
6. Centre of gravity – Centre of gravity of plane sections from geometrical considerations. Centre of gravity of geometrical sections. Reference axes and axes of symmetry. Centre of gravity by the method of moments. Centre of gravity of sections with cut out holes. Numerical problems.
7. Moment of inertia – Units of M.I, Radius of gyration and Modulus of section. M.I. of plane sections by Routhe's rule. M.I. by the method of integration. M.I. of a rectangular section. Perpendicular axis theorem. M.I. of a circular section. M.I. of hollow rectangular and circular section. Numerical problems.
8. Parallel axis theorem and its applications. M.I. of a triangular section about its base, centre of gravity and vertex. M.I. of a semicircular section. Numerical problems.
9. Friction – Types of friction – Limiting friction. Laws of static and dynamic friction. Angle of friction, cone of friction. Friction of bodies on inclined planes –various cases. Numerical problems.
10. Ladder, Wedge and screw jack friction. Numerical problems.
11. Analysis of perfect frames – Types of frames. Assumptions for the analysis of frames. Equation for a perfect frame. Analytical methods – Method of joints and method of sections.
12. Analysis of perfect frames by method of joints. Numerical Problems.
13. Analysis of perfect frames by the method of sections. Numerical problems.
14. Simple stresses and strains – elasticity – stress – strain relationship – types of stresses– Hooke's law – Young's modulus – problems.
15. Elongation in a bar due to its own weight, varying sections – problems.
16. Linear strain – lateral strain – Poisson's ratio – Volumetric strain of a body subjected to three mutually perpendicular stresses – problems.
17. Stress on inclined sections of a bar under tension or compression – state of simple shear – linear strain of the diagonal.
18. Bulk modulus – relation between elastic constants E, K and N – problems.
19. Stresses due to changes of temperature – problems.
20. Principal planes – principal stresses – derivation.
21. Mohr's circle – problems.
22. Shear force and bending moment diagrams for cantilever beams – problems.
23. Shear force and bending moment diagrams for simply supported beams – problems
24. SFD and BMD for overhanging beams – problems.

25. Relation between SF, BM and intensity of load – derivation of the equation.
26. Bending stresses in beams – theory of simple bending – neutral axis – moment of resistance – assumptions for bending analysis.
27. Bending stresses in beams of various sections – strength of a section – problems.
28. Shear stress in beams – derivation of the equation for shear stress.
29. Shear stresses in beams of various sections – problems.
30. Torsion-derivation of the torsional equations
31. Power transmitted by a shaft.
32. Strength of a solid shaft and a hollow shaft
33. Problems in the design of shaft.

**Practical Schedule**

1. Resultant of forces in magnitude and direction
2. Graphical study of equilibrium of forces
3. Graphical study of wedge friction
4. Determination of position of resultant force (numerical problems)
5. Numerical problems on centroids and moment of inertia of plane figures, radius of gyration, section modulus and polar moment of inertia, for plane figures, symmetrical and unsymmetrical sections
6. Numerical problems on frictional forces, ladder and wedge friction
7. Analysis of simple trusses by method of joints
8. Analysis of simple trusses by method of sections
9. Analysis of simple trusses by graphical method
10. Numerical problems on simple stresses and strains
11. Determination of resultant stresses for one-dimensional and two-dimensional stress systems
12. Determination of principal stresses and maximum shear stress for two-dimensional stress systems
13. Numerical problems on shear force and bending moments
14. Numerical problems on bending and shearing stresses in cantilever beams
15. Numerical problems on bending and shearing stresses in simply supported beams
16. Problems on torsion of shafts.
17. Practical examination

**Suggested Readings**


1. Bansal, R. K. 2005. A Text Book of Engineering Mechanics. Laxmi Publishers, New Delhi.
2. Khurmi, R. S. 2006. Strength of Materials. S. Chand Publishing.
3. Khurmi, R. S. 2018. A Text Book of Engineering Mechanics. S. Chand Publishing.
4. Prasad, I. B. 2004. Applied Mechanics and Strength of Materials. Khanna Publishers, New Delhi.
5. Prasad, I. B. 2004. Applied Mechanics. Khanna Publishers, New Delhi.
6. Sundarajan, V. 2002. Engineering Mechanics and Dynamics. Tata McGraw Hill Publishing Co. Ltd, New Delhi.
7. Timoshenko, S. and Young, D. H. 2003. Engineering Mechanics. McGraw Hill Book Co., New Delhi.

# IDE 2202 Theory of Structures 2 (1+1)

**Objective**

To make the students acquainted with the principles of structural design and to enable them to design small and medium RCC and steel structures

**Theory**

**Module I** **(5 Hours)**

Types of Load and use of BIS code; Design of steel structures: Specifications, use of IS code (IS 800-2007) and steel table, design of steel sections under tension, compression and bending, use of any one design software such as Staad Pro, ETABS, etc. for design of roof truss.

**Module II** **(5 Hours)**

Design of RCC structures: Specifications, use of IS code (IS 456-2000), analysis and design of singly and doubly reinforced sections, design of beams.

**Module III** **(6 Hours)**

Design of one way and two-way slabs, columns and foundations, design considerations for retaining walls and silos, use of design software for simple RCC structures.

**Practical**

Design and drawing of steel roof truss including tension member, compression member, and member under bending; use of design softwares; Design and drawing of RCC building, including single reinforced beam, double reinforced beam, one-way slab, two-way slabs, columns and foundations; use of design softwares for simple RCC structures.

**Lecture Schedule**

1. Design of steel structures – Concept of design of steel structures – Structural sections for steel – Use of IS codes (IS 800-2007) and Hand books.
2. Design aspects of tension members – Effective net sectional area – Design of axially loaded tension members – Design problems.
3. Steel columns and compression members – Euler's crippling load – Merchant- Rankine formula – Slenderness ratio – Design aspects of axially loaded compression members and struts – Problems in axial load computation and design.
4. Analysis of steel beams – Use of relevant tables for the design – Design aspects of laterally unsupported beams only – Check for shear, deflection and bearing.
5. Design software: Staad Pro, ETABS, etc. for design of roof truss
6. Design of RCC structures – Specification, use of IS code (IS456-2000), Concept of analysis and design – Grades of concrete and steel – characteristics of concrete and steel – Assumptions for the design of RCC structural elements.
7. Balanced and unbalanced sections – Balanced design – Balanced section as an economical and critical section – Fundamental equations for design – Design constants – Computation of design loads – Use of IS codes.
8. Analysis of singly reinforced beams –Different types of problems – Design.
9. Analysis of doubly reinforced beams – problems – Revised elastic theory and steel beam theory
10. Analysis of T beams – Different types of problems.

11. Analysis of slabs – one way and two way – Problems – Design of two way slabs by IS code method only.
12. Design aspects of RCC columns – short and long –Problems.
13. Design aspects of RCC foundation – Design problems
14. Retaining walls – Types – structural aspects.
15. Bins and silos – Structural aspects of RCC bins and silos.
16. Use of design software for simple RCC structures.

**Practical Schedule**

1. Design and drawing of tension members in steel roof truss
2. Design and drawing of compression members in steel roof truss
3. Design and drawing of simple beams in steel roof truss
4. Practice in the use of design software for steel roof truss
5. Practice in the use of design software for steel roof truss
6. Design and detailing of singly reinforced beam
7. Design and detailing of doubly reinforced beam
8. Design and detailing of one way simply supported slabs
9. Design and detailing of unrestrained two way slabs by IS code method
10. Design and detailing of restrained two way slabs by IS code method
11. Design and drawing of short columns in concrete by IS code method
12. Design and drawing of long columns in concrete by IS code method
13. Design and detailing of foundation
14. Practice in the use of design software for simple RCC structures
15. Practice in the use of design software for steel roof truss
16. Small project for designing and drawing of RCC building using software
17. Practical examination

**Suggested Readings**


1. Bhavikatti, S. S. 2014. Design of Steel Structures: By Limit State Method as Per IS: 800- 2007. I KInternational Publishing House Pvt. Ltd.
2. Duggal, S. K. 2017. Limit State Design of Steel Structures. McGraw Hill Education.
3. Punmia, B. C., Jain, A. K. and Jain, A. K. 2016. Limit State Design of Reinforced Concrete. Laxmi Publications.
4. Raju, N. K. 2019. Design of Reinforced Concrete Structures: IS:456-2000. CBS Publishers &Distributors.


## IDE 2203 Building Construction and Cost Estimation 2 (2+0)

**Objective**

To make the students acquainted with the methods of construction of agricultural buildings and to enable them to prepare various types of estimates of buildings.

**Theory**

**Module I** **(6 Hours)**

Building materials: Description of important building materials, rocks, different stones;formation of stones, types of stones, quarrying process, stone products and uses; Bricks, types, preparation

and burning of bricks, properties and uses; Tiles, types and classification; Lime, properties and uses, cement, different uses and grades.

**Module II** **(6 Hours)**

Concrete: Grades, preparation, mixing and laying of concrete, use of sand; Use of ferrous material, iron and steel products; Use of non-ferrous metals, aluminium, copper, nickel; Timber and its uses, seasoning, defects, a commercial form of timber, miscellaneous building materials: glass, rubber, plastics.

**Module III** **(11 Hours)**

Building construction: Building components, foundations, brickwork, lintels, columns, roofs and staircases, different types of floors, plastering and pointing, damp proofing and waterproofing, whitewashing, distempering and painting, steps for building construction, needs of different agricultural buildings, types and uses, types of roofs, slope and flat roof buildings.

**Module IV** **(10 Hours)**

Estimating and costing: Types of estimates, rough cost, detailed and supplementary estimate, preparation of cost estimate, cost analysis, schedule of rates, analysis of rates, factors affecting building costs, building codes, and estimate development. Cost economics: Measurement and pricing, economic methods for evaluation of buildings, benefit-cost calculation, rate of return period (payback period).

**Lecture Schedule**

1. Stone-classification of rocks – Natural bed of stone and its importance. Qualities of good building stone. quarrying process, Common building stones in India. Artificial stones. ISI tests for stones. Uses of stones.
2. Brick-Composition of good brick earth-Harmful ingredients in brick earth -classification of brick – Qualities of good bricks. Manufacture of bricks; Preparation of clay, Moulding, drying.
3. Burning in Hoffman's kiln. Fire clay bricks. Substitute for bricks-concrete blocks, sand lime bricks and fly ash bricks.
4. Tiles - Common types. Drain tiles, floor tiles and roof tiles. Lime-classification of lime-ISI classification. Uses of lime.
5. Cement-Properties of cement. Composition of cement, Functions of cement ingredients, Setting action of cement, ISI tests for cement -Uses of cement
6. Different types of cement. Manufacture of cement-Mixing of raw materials-Dry and wet processes. Burning in rotary kiln. Grinding in ball mills and tube mills.
7. Cement concrete-Properties, materials required for C.C and R.C.C. Properties of concrete – W/c. ratio and its importance. Workability of concrete and its measurement. Mixing, transportation and placing of concrete. – curing of concrete.
8. Mortar-types of mortar, Sand: use of sand, Sources of sand, Properties of good sand, bulking of sand.
9. Use of ferrous material, Iron – Steel – Market forms of steel – Properties of mild steel and hard steel – Uses of steel.
10. Use of non-ferrous metals- Aluminium – Properties of aluminium – Evaluation as a building material –Economy of using aluminium, copper, nickel.
11. Timber – Qualities of good timber – Seasoning of timber– Preservation of timber Market forms of timber – Industrial forms of Timber

12. Miscellaneous materials- Glass – Types, properties and uses. , Rubber, Plastics-Uses of plastics in buildings – P V C pipes and fibre glass reinforced plastics
13. Building construction: Stone masonry – technical terms – classification of stone masonry –
14. Brick masonry – technical terms – Bonds in brickwork – Features of English bond and Flemish bond
15. Plan and elevation of English bond for various wall thicknesses. Plan and elevation of Flemish bond for various wall thicknesses.
16. Arches – technical terms – Classification of Arches – Lintels – Types of lintels
17. Stairs – Technical terms used – Types of Stairs
18. Doors and Windows – Technical terms used – Types of Doors and Windows
19. Roofs – Classification of Roofs – Roofing materials – Different types of A C sheets, G I sheets and FRP sheets.
20. Floors and floorings – Types – Damp Proofing and waterproofing – methods
21. Plastering, pointing, whitewashing distempering and painting,
22. Functional requirements of a building, important building components,
23. Types of agricultural buildings and related needs
24. Estimating principle, main items of work, deductions for openings
25. Earthwork calculations
26. R.C.C. work, Estimation for Flooring, Roofing, Plastering, Doors, Windows
27. Wood Work, Iron Work, Aluminum work and Lump sum items
28. Types of estimates, Detailed and abstract estimate
29. Method of building estimate – separate or individual wall method, Centre line method
30. Detailed estimate of a small building
31. Schedule of rates – Analysis of rates, Purpose and factors affecting the rate of items
32. Valuation, methods of valuation, book value, market value, scrap and salvage value.
33. Cost economics: Measurement and pricing, economic methods for evaluation of buildings.
34. Benefit-cost calculation, rate of return period (payback period).

**Suggested Readings**


1. Duggal, S. K. 2012. Building Material. New Age International Publishers.
2. Dutta, B. N. 2000. Estimating and Costing. UBS publishers.
3. Punmia, B. C., Jain, A. K. and Jain, A. K. 1984. Building Construction. Laxmi Publications (P) Ltd., New Delhi.
4. Rangwala, S. C. 1994. Engineering Materials. Charotar Publishing House, Anand.
5. Sane, Y. S. 1964. Planning and Designing of Buildings. Engineering Book Publishing Co. Pune


## IDE 3104 Strength of Materials 2 (1+1)

**Objective**

To make the students acquainted with the importance of strength parameters of different materials and the techniques to calculate unknown forces in 2D structures

**Theory**

**Module I** **(8 Hours)**

Introduction to strength of materials. Slope and deflection of beams: Slope and deflection of beam

using integration techniques, moment area theorems, conjugate beam method, problems of slope and deflection.

**Module II** **(6 Hours)**

Theory of columns and struts, problems of column and struts. Steel connections: Analysis of rivet connections, analysis of welded connections. Stability analysis of masonry dam; problems on masonry dam.

**Module III** **(2 Hours)**

Statically indeterminate structures- analysis of propped beams, analysis of fixed beams, analysis of continuous beams using superimposition and three moment equation. Analysis of beam using moment distribution method and solving problems.

**Practical**

To perform the impact test of two different aggregates. To perform the tensile test of steel specimen - to observe the behaviour of materials under load - to calculate the value of e- ultimate stress, permissible stress, percentage elongation etc. And to study its fracture; To prepare mortar specimen of different cement, demoulding of the specimen next day for compression and tension test after $2^{nd}$ and $4^{th}$ week; To prepare concrete specimen to perform the compression, bending test and to measure elasticity - concrete cylinders, cubes and beams to test after $2^{nd}$ and $4^{th}$ week; To perform compression and tension test on mortar specimen prepared 2 weeks before; To perform compression and bending test of the concrete specimen prepared 2 weeks before; To perform compression and tension test on mortar specimen prepared 4 weeks before; To perform compression and bending test of the concrete specimen prepared 4 weeks before; To determine young's modulus of elasticity of beam with the help of deflection produced at centre due to loads placed at centre and quarter points; To perform Brinell's hardness tests on a given specimen; To study the behaviour of materials under torsion and to evaluate various elastic constants; To study load deflection and other physical properties of closely coiled helical spring in tension and compression; To write detail report emphasizing engineering importance of performing tension, compression, bending, torsion, impact and hardness tests on the materials.

**Lecture Schedule**

1. Introduction to strength of materials
2. Deflections of beams – relation between slope, deflection and radius of curvature.
3. Deflection of cantilever beams –Problems.
4. Deflection of simply supported beams –Problems
5. Deflection by moment area method – Mohr's theorem –cantilever beams – Problems.
6. Deflection by moment area method – Mohr's theorem – simply supported beams –Problems.
7. Deflection by conjugate beam method, cantilever beams – Problems
8. Deflection by conjugate beam method, simply supported beams – Problems
9. Combined bending and direct stresses – eccentric loading – limit of eccentricity –middle third rule for rectangular and other sections.
10. Condition for no tension in the sections – Problems.
11. Columns and struts – assumptions for Euler's column theory – derivation for buckling load for four cases of long columns.
12. Rankine's formula for long columns – Problems.
13. Steel connection, analysis of riveted connection, welded connection

14. Stability of masonry dams, problems
15. Statically indeterminate beams – Analysis of fixed beams and propped beams – problems
16. Analysis of continuous beams by Clapeyron's three moment theorem – problems
17. Analysis of beam using moment distribution method and solving problems.

**Practical Schedule**

1. To perform the impact test of two different aggregates;
2. To perform the tensile test of steel specimen - to observe the behaviour of materials under load –
3. To calculate the value of e- ultimate stress, permissible stress, percentage elongation etc of steel specimen. And to study its fracture;
4. To prepare mortar specimen of different cement, demoulding of the specimen next day for compression test after $2^{nd}$ and $4^{th}$ week;
5. To prepare mortar specimen of different cement, demoulding of the specimen next day for tension test after $2^{nd}$ and $4^{th}$ week;
6. To prepare concrete specimen to perform the compression, bending test and to measure elasticity - concrete cylinders, cubes and beams to test after $2^{nd}$ and $4^{th}$ week;
7. To perform compression and tension test on mortar specimen prepared 2 weeks before;
8. To perform compression and bending test of the concrete specimen prepared 2 weeks before;
9. To perform compression and tension test on mortar specimen prepared 4 weeks before;
10. To perform compression and bending test of the concrete specimen prepared 4 weeks before;
11. To determine young's modulus of elasticity of beam with the help of deflection produced at centre due to loads placed at centre and quarter points;
12. To perform Brinell's hardness tests on a given specimen;
13. To study the behaviour of materials under torsion and to evaluate various elastic constants.
14. To study load deflection and other physical properties of closely coiled helical spring in tension;
15. To study load deflection and other physical properties of closely coiled helical spring in compression.
16. To write detail report emphasizing engineering importance of performing tension, compression, bending, torsion, impact and hardness tests on the materials.
17. Practical Examination

**Suggested Readings**


1. Junarkar, S. B. 2001. Mechanics of Structures (Vo-I). Choratar Publishing House, Anand.
2. Khurmi, R. S. 2006. Strength of Materials. S. Chand Publishing, New Delhi.
3. Lehri, R. S. and Leheri, R. S. 2006. Strength of Materials. S.K. Kataria & Sons, New Delhi.
4. Ramamrutham, S. and Narayanan, R. 2003. Strengths of Materials. Dhanpat Rai and Sons, Nai Sarak, New Delhi.
5. Vazirani, V. N., Ratawani, M. M. and Duggal, S. K. 2012. Analysis of Structures. Khanna Publishers, New Delhi.

# IDE 3105 Irrigation and Drainage Engineering 4 (3+1)

**Objective**

To make the students acquainted with the different methods of irrigation depending on the crop water requirement and the different drainage solutions depending on specific situations

**Theory**

**Module I** **(4 Hours)**

Major and medium irrigation schemes of India, purpose of irrigation, merits and demerits of irrigation, source of irrigation water, present status of development and utilization of different water resources of the country; Measurement of irrigation water: weir, flumes and orifices and other methods.

**Module II** **(8 Hours)**

Design and lining of irrigation field channels, on-farm structures for water conveyance, control and distribution; Underground pipe conveyance system: components and design; land grading; Criteria for land levelling, land levelling design methods.

**Module III** **(13 Hours)**

Soil-water-plant relationship: Soil properties influencing irrigation management, soil water movement, infiltration, soil water potential, soil moisture characteristics, soil moisture constants, measurement of soil moisture, moisture stress and plant response; Water requirement of crops: concept of evapotranspiration (ET), measurement and estimation of ET. Water and irrigation requirement of crops, depth of irrigation, frequency of irrigation, irrigation efficiencies.

**Module IV** **(6 Hours)**

Surface methods of water application: Border, check basin and furrow irrigation- adaptability, specification and design considerations;

**Module V** **(4 Hours)**

Water logging-causes and impacts; Drainage, objectives of drainage, familiarization with the drainage problems of the state, drainage coefficient.

**Module VI** **(6 Hours)**

Surface drainage, types and design; Sub-surface drainage: purpose and benefits, investigations of design parameters, hydraulic conductivity, drainable porosity, water table etc., types and use of subsurface drainage system, interceptor and relief drains. Derivation of Hooghoudt's and Ernst's drain spacing equations; Design of subsurface drainage system,

**Module VII** **(7 Hours)**

Drainage materials, drainage pipes, drain envelope; Layout, construction and installation of drains; Drainage structures, vertical drainage, bio-drainage, tile drains, mole drain. Salt balance, reclamation of saline and alkaline soils, leaching requirements; Conjunctive use of fresh and saline waters.

**Practical**

Measurement of soil moisture by different instruments; Measurement of irrigation water;

Measurement of infiltration characteristics; Determination of bulk density, field capacity and wilting point; Estimation of evapotranspiration and water requirement of crops; Study on scheduling of irrigation of field crops; Study of advance, recession and computation of infiltration opportunity time; infiltration by inflow-outflow method; Study on evaluation of border irrigation method; evaluation of furrow irrigation method; evaluation of check basin irrigation method; Study on in- situ measurement of hydraulic conductivity by auger hole method; Study on drainage coefficients determination; Study of piezometer, observation well and measurement of water table; Preparation of iso-bath maps; Design of surface drainage systems; Design and installation of subsurface drainage systems; Determination of various chemical properties of soil and water; Study of tile drainage; cost analysis of surface and sub-surface drainage system; Visit to a waterlogged area and study of a drainage project.

**Lecture Schedule**

1. Water Resources Utilization & Irrigation Development – Present status, Irrigation Potential - Created and Utilized,Causes for Gap in Potential Created and Utilized.
2. Irrigation-Definition, Purpose-Sources of irrigation water-Major and medium irrigation schemes of India.
3. Measurement of irrigation water: Units of measurement – Methods of Water measurement in Open Channels – weir, flumes and orifices and other methods;
4. Flow measurement in pipes. Difference between Pipe Flow and Open Channel Flow
5. Design and lining of irrigation field channels, Discharge Capacity of a Channel ,
6. On farm structures for water conveyance, control &distribution; Drop Structures Chute Spillways Pipe Drop Spillways, Check Gates, Portable Check Dams ,Turnouts , Siphon Tubes , Flumes , Culverts ,Inverted Siphons
7. Underground pipe conveyance system, components
8. Design of underground pipe conveyance system
9. Land Levelling -Leveling Layout of field for Irrigation and Drainage Systems – Survey and Staking – criteria for land levelling,
10. Land levelling design methods – Plane Method , Profile Method, Plan Inspection Method, Contour Adjustment Method
11. Land levelling design methods-contd**,**
12. Estimation of earth work-Equipments for Land Grading
13. Soil-water-plant relationship – soil properties influencing irrigation management, soil Water Relations
14. Kinds of Soil Water, soil water movement-steady and unsteady flow.
15. Infiltration Characteristics of the soil – Infiltration Process – Infiltration Equations
16. Measurement of Infiltration – Factors Affecting Infiltration
17. Soil water potential **–** Soil Moisture Constants
18. Soil moisture characteristics,
19. Measurement of soil moisture,
20. Water requirement of crops, Concept of evapotranspiration (ET)-Different terminologies-Actual ET, PET, Consumptive use.
21. Estimation and measurement of ET-Direct methods.
22. Indirect methods of estimation of ET.
23. Indirect methods of estimation of ET-contd.
24. Water and irrigation requirement of crops, Depth of irrigation, frequency of irrigation,

Irrigation interval, Irrigation period.

25. Irrigation efficiencies
26. Surface methods of water application-Border – adaptability, specification.
27. Border system – design considerations.
28. Surface methods of water application – Check Basin – adaptability, specification.
29. Check basin irrigation– design considerations.
30. Furrow irrigation– adaptability, specification
31. Furrow irrigation-design considerations
32. Water logging – causes and impacts
33. Drainage, objectives of drainage
34. Familiarization with the drainage problems of the state
35. Drainage coefficient
36. Types of surface drainage
37. Design of surface drains;
38. Sub-surface drainage: purpose and benefits
39. Investigations of design parameters-hydraulic conductivity drainable porosity water table;
40. Derivation of Hooghoudt's and Ernst's drain spacing equations.
41. Design of subsurface drainage system;
42. Drainage materials, drainage pipes, drain envelope
43. Layout construction and installation of drains.
44. Drainage structures
45. Special Drainage systems: vertical drainage; bio-drainage; mole drains
46. Salt balance reclamation of saline and alkaline soils
47. Leaching requirements
48. Conjunctive use of fresh and saline water.

**Practical Schedule**

1. Measurement of soil moisture by different soil moisture measuring instruments.
2. Measurement of irrigation water.
3. Measurement of infiltration characteristics.
4. Determination of bulk density and Field capacity and wilting point.
5. Estimation of evapotranspiration.
6. Study on scheduling of irrigation of field crops.
7. Study of advance, recession and computation of infiltration opportunity time; Infiltration by inflow-outflow method.
8. Evaluation of border irrigation method; furrow irrigation method; check basin irrigation method.
9. *In-situ* measurement of hydraulic conductivity by auger hole method.
10. Estimation of drainage coefficients.
11. Study of piezometer, observation well and measurement of water table; Preparation of iso-bath and isobar maps /water contour maps
12. Design of surface drainage systems
13. Design of subsurface drainage systems
14. Determination of chemical properties of soil and water
15. Study of drainage tiles and pipes and Installation techniques of sub-surface drainage system, Cost analysis of surface and sub-surface drainage system.
16. Visit to a waterlogged area and study of a drainage project.

17. Practical Examination

**Suggested Readings**


1. Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. 1998. *Crop Evapotranspiration Guidelines for Computing Crop Water Requirement*. Irrigation and drainage paper 56, FAO of United Nations, Rome.
2. Bhattacharya, A. K. and Michael, A. M. 2013. *Land Drainage, Principles, Methods and Applications*. Vikas Publication House, Noida (UP).
3. Bhattacharya, A. K. *Drainage Engineering*. ICAR Publications, New Delhi.
4. Israelsen, O. W., Hansen, V. E. and Stringham, G. E. 1980. *Irrigation Principles and Practices*. John Wiley & Sons, Inc. USA.
5. Majumdar, D. K. 2013. *Irrigation Water Management Principles*. PHI learning Private Limited, New Delhi.
6. Michael, A. M. 2012. *Irrigation: Theory and Practice*. Vikas Publishing House, New Delhi.
7. Michael, A. M. and Ojha, T. P. 2014. *Principles of Agricultural Engineering.* Vol II. 5th Edition. Jain Brothers Publication, New Delhi.
8. Murthy, V. V. N. 2013. *Land and water Management Engineering*. Kalyani Publishers, New Delhi.
9. Panigrahi, B. 2013. *A Handbook on Irrigation and Drainage*. New India Publishing Agency, New Delhi.
10. Ritzema, H. P. 1994. *Drainage Principles and Applications*. ILRI Publication 16.


## IDE 3206 Groundwater, Wells and Pumps 3 (2+1)

**Objective**

To make the students acquainted with the quality of ground water, equipment and methods for construction of wells, and different types of water lifting devices

**Theory**

**Module I** **(8 Hours)**

Groundwater hydrology and hydrologic cycle, groundwater resources of World and India; Occurrence and movement of groundwater, aquifer and its types, aquifer properties, groundwater flow direction, flow in relation to groundwater contours; Classification of wells, fully penetrating tube wells and open wells, familiarization of various types of bore wells, design of open wells.

**Module II** **(6 Hours)**

Darcy's law, determination of hydraulic conductivity by laboratory and field method; Groundwater hydraulics- Dupuit's assumptions and Dupuit's method, Thiem's method; Well interference; determination of aquifer parameters by different method such as Theis, Jacob and Chow's, Theis recovery method; Design of tube well and gravel pack, sanitary protection of tube wells.

**Module III** **(7 Hours)**

Groundwater exploration techniques; methods of drilling of wells: percussion, rotary, reverse rotary; DTH; Development of tube well; Basin wise groundwater development, safe yield, factors governing safe yield, computation of safe yield by Hill's method, conjunctive use of groundwater.

**Module IV** **(5 Hours)**

Quality of groundwater, groundwater pollution; Artificial groundwater recharge techniques; different direct, indirect and combination of methods; Sea water intrusion, coastal aquifers, sources of saline water intrusion, upconing of saline water, Ghyben-Herzberg relationship between fresh and saline water

**Module V** **(10 Hours)**

Pumping systems: Water lifting devices; Classification of pumps, components of centrifugal pumps, priming, pump selection, installation and troubleshooting, performance curves, effect of speed on capacity, head and power, effect of change of impeller dimensions on performance characteristics; Hydraulic ram, deep well turbine pump and submersible pump, Mixed flow pumps, propeller pumps, axial flow pumps, jet and air lift pumps

**Practical**

Verification of Darcy's law; Determination of hydraulic conductivity by laboratory and field methods; Study of piezometer, observation well and measurement of water table; Study of groundwater flow direction, preparation of iso-bath maps and its application in the field; Study of different drilling equipment; Sieve analysis for gravel and well screens design; testing of well screen; Estimation of specific yield and specific retention; Estimation of aquifer parameters by Theis method, Coopers-Jacob method, Chow method and Theis Recovery method; Design of well; Study of well losses and well efficiency; Determination of safe yield by Hill's method; Determination of various parameters on groundwater quality; Study on various types of wells; Estimation of groundwater balance; Study of various artificial ground- water recharge structures; Study of centrifugal pumps, multistage centrifugal pumps, installation and testing of centrifugal pump; Visit to a drilling site; Visit to a groundwater project and a river lift project

**Lecture Schedule**

1. Groundwater hydrology and hydrologic cycle; Groundwater resources of World and India
2. Occurrence and movement of groundwater
3. Aquifer and its types, aquifer properties
4. Groundwater flow direction, flow in relation to groundwater contours
5. Classification of wells,
6. Fully penetrating tube wells and open wells, familiarization of various types of bore wells
7. Design of open wells.
8. Design of open well contd.
9. Darcy's law, determination of hydraulic conductivity by laboratory and field method
10. Groundwater hydraulics- Dupit's assumptions and Dupit's method, Thiem's method
11. Well interference
12. Determination of aquifer parameters by different method such as Theis and Jacob
13. Chow's, and Theis recovery method
14. Design of tube well and gravel pack, sanitary protection of tube wells.
15. Groundwater exploration techniques
16. Methods of drilling of wells: percussion, rotary, reverse rotary; DTH
17. Development of tube well
18. Basin wise groundwater development
19. Safe yield, factors governing safe yield

20. Computation of safe yield by Hill's method
21. Conjunctive use of groundwater.
22. Quality of groundwater, groundwater pollution
23. Artificial groundwater recharge techniques; different direct, indirect and combination of methods
24. Sea water intrusion, coastal aquifers
25. Sources of saline water intrusion, Upconing of saline water
26. Ghyben-Herzberg relationship between fresh and saline water.
27. Pumping systems: Water lifting devices
28. Working of indigeneous water lifting devices
29. Types of pumps – principle of pumping and classification
30. Positive displacement and variable displacement pumps
31. Reciprocating pump-principles and working
32. Components of centrifugal pumps, principles and working
33. Priming, pump selection, installation and troubleshooting
34. Performance curves, effect of speed on capacity, head and power, effect of change of impeller dimensions on performance characteristic
35. Hydraulic ram, deep well turbine pump and submersible pump.
36. Mixed flow pumps, propeller pumps, axial flow pumps, jet and air lift pumps

**Practical Schedule**

1. Verification of Darcy's Law
2. Determination of hydraulic conductivity by laboratory and field methods
3. Study of piezometer, observation well and measurement of water table
4. Study of groundwater flow direction, preparation of iso-bath maps and its application in the field
5. Study of different drilling equipments;
6. Sieve analysis for gravel and well screens design;
7. Estimation of specific yield and specific retention;
8. Estimation of aquifer parameters by Theis, Coopers-Jacob, Chow method, Theis Recovery method;
9. Open well and Tube well design
10. Study of well losses and well efficiency
11. Determination of safe yield by Hill's method
12. Determination of various parameters on groundwater quality
13. Estimation of groundwater balance
14. Study of various artificial ground- water recharge structures
15. Study of centrifugal pumps, multistage centrifugal pumps, installation and testing
16. Visit to a drilling site/Visit to a groundwater project and a river lift project
17. Practical Examination

**Suggested Readings**


1. Garg, S. P. 1987. Groundwater and Tube Wells. Oxford & IBH Publishing Co. Ltd., New Delhi.
2. Lal, R. 1993. Irrigation Hydraulics. Ajiwan Shiksha Sansthan, Allahabad.
3. Michael, A. M., Khepar, S. D. and Sondhi, S. K. 2008. Water Well & Pump Engineering. Tata Mc-Graw Hill.

4. Nagabhusaniah, H. S. 2020. Groundwater in Hydrosphere. CBS Publishers and Distributors, New Delhi.
5. Raghunath, H. M. 2007. Groundwater. New Age Publications, New Delhi.
6. Todd, D. K. and Mays, L. W. 2011. Groundwater Hydrology. John Wiley & Sons, New York.

## IDE 4107 Sprinkler and Micro Irrigation Systems 2 (1+1)

**Objective**

To make the students acquainted with the importance of micro irrigation systems, their design and layout for efficient water, fertilizer and pesticides applications.

**Theory**

**Module I** **(6 Hours)**

Sprinkler irrigation: adaptability, problems and prospects, types of sprinkler irrigation systems; Design of sprinkler irrigation system: layout selection, hydraulic design of lateral, sub-main and main pipe line, design steps; Selection of pump and power unit for sprinkler irrigation system; Performance evaluation of sprinkler irrigation system: water distribution pattern and overlapping of sprinklers and laterals, uniformity coefficient and pattern efficiency.

**Module II** **(7 Hours)**

Micro Irrigation systems: types- drip, spray, and bubbler systems, merits and demerits, different components; Design of drip irrigation system: general considerations, wetting patterns, irrigation requirement, emitter selection; Hydraulics of drip irrigation system, design steps.

**Module III** **(4 Hours)**

Necessary steps for proper operation of a drip irrigation system, maintenance of micro irrigation system: clogging problems, filter cleaning, flushing and chemical treatment. Fertigation: advantages and limitations of fertigation, fertigation frequency, duration and injection rate, methods of fertigation.

**Practical**

Study of different components of sprinkler irrigation system; Study of wetting pattern of a sprinkler and requirement for overlapping of sprinkler; Study of discharge and uniformity coefficient; Design and installation of sprinkler irrigation system; Study of cost economics of sprinkler irrigation system; Study on maintenance of sprinkler irrigation system; Field visit to a sprinkler irrigation project; Study of different components of drip irrigation; Design and installation of drip irrigation system; Determination of pressure discharge relationship and emission uniformity for given emitter; Study of different types of filters and determination of filtration efficiency; Study of fertigation, types of liquid fertilizers, determination of rate of injection and calibration for chemigation/ fertigation; Design of irrigation and fertigation schedule for crops; Study on removal of clogging of emitters; Study on maintenance of drip irrigation system; Study of cost economics of drip irrigation system; Field visit to micro irrigation system and evaluation of drip system; Field visit to study foggers.

**Lecture Schedule**

1. Sprinkler irrigation: adaptability, problems and prospects

2. Types of sprinkler irrigation systems
3. Design of sprinkler irrigation system: layout selection, hydraulic design of lateral, sub-main and main pipe line
4. Design of sprinkler irrigation system: layout selection, hydraulic design of lateral, sub-main and main pipe line contd.
5. Design steps; selection of pump and power for sprinkler irrigation system
6. Performance evaluation of sprinkler irrigation system: uniformity coefficient and pattern efficiency
7. Micro Irrigation Systems: types-drip, spray, & bubbler systems, merits and demerits
8. Micro Irrigation Systems: different components
9. Design of drip irrigation system: general considerations, wetting patterns,
10. Design of drip irrigation system: general considerations, wetting patterns contd.
11. Design of drip irrigation system: irrigation requirement, emitter selection
12. Hydraulics of drip irrigation system
13. Design steps; necessary steps for proper operation of a drip irrigation system
14. Maintenance of micro irrigation system: clogging problems, filter cleaning, Flushing and chemical treatment
15. Fertigation: advantages and limitations of fertigation, fertilizers solubility and their compatibility, precautions for successful fertigation system
16. Fertigation-frequency, duration and injection rate
17. Methods of fertigation

**Practical Schedule**

1. Study of different components of sprinkler irrigation system
2. Design and installation of sprinkler irrigation system
3. Design and installation of sprinkler irrigation system contd.
4. Determination of precipitation pattern, discharge and uniformity coefficient
5. Cost economics of sprinkler irrigation system
6. Study of different components of drip irrigation
7. Design and installation of drip irrigation system
8. Design and installation of drip irrigation system contd.
9. Determination of pressure discharge relationship and emission uniformity for given emitter
10. Study of different types of filters
11. Determination of filtration efficiency
12. Determination of rate of injection and calibration for chemigation/fertigation
13. Design of irrigation and fertigation schedule for crops
14. Field visit to micro irrigation system
15. Evaluation of drip system
16. Cost economics of drip irrigation system.
17. Practical examination

**Suggested Readings**

1. Jain, S. C. and Philip, G. 2003. Farm Machinery - An Approach. Standard Publishers and Distributors, Delhi.
2. Mane, M. S. and Ayare, B. L. 2007. Principles of Sprinkler Irrigation system. Jain Brothers, New Delhi.
3. Mane, M. S. and Ayare, B. L. and Magar, S. S. 2006. Principles of Drip Irrigation systems.

Jain Brothers, New Delhi.
4. Michael, A. M. 2012. Irrigation: Theory and Practice. Vikas Publishing, New Delhi.
5. Michael, A. M., Shrimohan and Swaminathan, K. R. 1972. Design and evaluation of irrigation methods (IARI Monograph No.1). Water Technology Center, IARI New Delhi.
6. Sivanappan, R. K. 1992. Sprinkler Irrigation. Oxford & IBH Publishing House, New Delhi.
7. Suresh, R. 2010. Micro Irrigation - Theory and Practices. Standard Publishers Distributors, Delhi.

## Department of Irrigation and Drainage Engineering- Elective Courses

## EID 4201 Water Quality and Management Measures 3 (2+1)

**Objective**

To enable the students to understand the quality of surface and ground water, water contamination due to inorganic and organic compounds and the water decontamination technologies and the cultural and management practices for using poor quality water for irrigation

**Theory**

**Module I** **(4 Hours)**

Natural factors affecting quality of surface water and groundwater, sources and pollution of groundwater, salinity.

**Module II** **(8 Hours)**

Water quality objectives in relation to domestic, industrial and agricultural activities; drinking water quality standards; irrigation water quality classification as per USSL and AICRP criteria.

**Module III** **(8 Hours)**

Point and non-point water pollution sources; Water contamination due to inorganic and organic compounds, water contamination related to agricultural chemicals, food industry, hydrocarbon and synthetic organic compounds; Arsenic and fluoride contamination in groundwater and remedial measures

**Module IV** **(13 Hours)**

Water decontamination technologies-screening, sedimentation, coagulation, filtration, disinfection, miscellaneous methods; Cultural and management practices for using poor quality water for irrigation.

**Practical**

Water quality analysis and classification according to USSL and AICRP criteria; Soil chemical analysis and estimation of lime and gypsum requirements; Study of salinity development under shallow and deep water table conditions; Study of saline water ingress in coastal areas; Study of contamination movement and transport in soil profile; Study of turbidity of water through turbidity meter; Study of different water decontamination techniques; Study of different cultural and management practices for using poor quality water for irrigation; Visit to a water treatment plant; Visit to a water quality laboratory; Field visit to industrial effluent disposal sites.

**Lecture Schedule**

1. Introduction -Natural factors affecting quality of surface water and groundwater
2. Pollution and Contamination – Definition of terms
3. Sources and pollution of surface water and ground water.
4. Sources of salinity
5. Water quality objectives in relation to domestic industrial and agricultural activities
6. Types of water pollution – Physical, Chemical and Bacteriological Pollution
7. Quality of groundwater –Physical, Chemical and Bacteriological aspects
8. Measure of water quality

9. Water quality criteria - Domestic, Industrial, Agricultural activities
10. Drinking water quality standards
11. Irrigation water quality classification as per USSL and AICRP criteria.
12. Water quality guidelines for irrigation.
13. Point and non-point water pollution sources
14. Water contamination due to inorganic and organic compounds.
15. Water contamination due to inorganic and organic compound contd.
16. Water contamination related to agricultural chemicals
17. Water contamination related to food industry, hydro carbon and synthetic organic Compounds
18. Water contamination related to food industry, hydro carbon and synthetic organic Compounds contd.
19. Arsenic and fluoride contamination in groundwaterand remedial measures
20. Arsenic and fluoride contamination in groundwaterand remedial measures contd.
21. Water decontamination technologies - Introduction
22. Screening
23. Plain Sedimentation and Sedimentation aided with coagulation
24. Filtration – types of filters
25. Disinfection methods
26. Water softening methods
27. Water softening methods contd.
28. Miscellaneous methods of water treatment.
29. Special problems in using poor quality irrigation water
30. Irrigation with poor quality water – improvement of water quality
31. Cultural and management practices for using poor quality water for irrigation.
32. Irrigation with sewage effluent
33. Environmental legislation on water pollution India and abroad

**Practical Schedule**

1. Water quality analysis – Physical tests.
2. Water quality analysis – Chemical tests.
3. Water quality analysis – Chemical tests.
4. Water quality analysis - Bacteriological test.
5. Classification of water according to USSL and AICRP criteria.
6. Soil chemical analysis.
7. Estimation of lime and gypsum requirements.
8. Study of salinity development under shallow and deep water table conditions.
9. Study of saline water ingress in coastal areas.
10. Study of contamination movement and transport in soil profile.
11. Study of turbidity of water through turbiditymeter.
12. Study of different water decontamination techniques.
13. Study of different cultural and management practices for using poor quality water for irrigation.
14. Visit to a water treatment plant.
15. Visit to a water quality laboratory.
16. Field visit to industrial effluent disposal sites.
17. Practical examination

**Suggested Readings**


1. FAO. 1996. *Control of Water Pollution from Agriculture - FAO Irrigation and Drainage*. Paper 55.
2. Gray, N. F. 2010. *Water Technology*. CRC Press.
3. Hussain, S. K. 1986. *Text Book of Water Supply and Sanitary Engineering*. Oxford & IBH Publishing Co. New Delhi.
4. Manahan, S. E. 2009. *Fundamentals of Environmental Chemistry*. CRC Press, New York.
5. McGauhey, P. H. 1968. *Engineering Management of Water Quality*. McGraw Hill Book Company, New York.
6. Minhas, P. S. and Tyagi, N. K. 1998. *Guidelines for Irrigation with Saline and Alkali Waters*. Bull. No, 1/98, CSSRI, Karnal, p. :36
7. Punmia, B. C. and Lal, P. B. B. 1981. *Irrigation and Water Power Engineering*. Standard Publishers Distributors, Delhi.


## EID 4202 Minor Irrigation and Command Area Development 3 (2+1)

**Objective**

To enable the students to understand the importance of command area development programs in irrigation projects and to plan, design, execute and evaluate on-farm development works

**Theory**

**Module I** **(4 Hours)**

Major, medium and minor irrigation projects, factors affecting performance of irrigation projects; Types of minor irrigation systems in India, surface water and groundwater projects;

**Module II** **(12 Hours)**

Lift irrigation systems: feasibility, type of pumping stations and their site selection, design of lift irrigation systems; Tank irrigation: grouping of tanks, storage capacity, supply works and sluices; Earthen dams: components, types, methods of construction, causes of failure of earthen dams, seepage control in earthen dams.

**Module III** **(8 Hours)**

Command area development (CAD) programme- components, need, scope, and development approaches, historical perspective, command area development authorities- objectives, functions and responsibilities; Farmers' participation in command area development, PIM, water user's association; Reclamation works, cross drainage works; Use of remote sensing techniques for CAD works.

**Module IV** **(9 Hours)**

On farm development works, design of lined and un-lined field channel and its cost estimation; Rotational irrigation system, Warabandi, pre-requisites for warabandi; Conjunctive use of water, optimum utilization of water; Water productivity: concepts and measures for enhancing water productivity.

**Practical**

Preparation of command area development layout plan; Irrigation water requirement of crops of command area; Preparation of irrigation schedules; Planning and layout of water conveyance system; Design of surplus weir of tanks; Determination of storage capacity of tanks; Design of intake pipe and pump house; Planning and design of OFD works; Cost estimation of OFD work; Study of cross-drainage works; Design and cost estimation of earthen dams for minor irrigation project; Estimation of seepage in field channels; Visit to a minor irrigation project; Visit to a command area and study of OFD works; Study of reclamation of waterlogged areas inside command area.

**Lecture Schedule**

1. Major, medium and minor irrigation projects.
2. Factors affecting performance of irrigation projects
3. Factors affecting performance of irrigation projects contd.
4. Types of minor irrigation systems in India, surface water and groundwater projects
5. Lift irrigation systems: feasibility
6. Type of pumping stations and their site selection
7. Type of pumping stations and their site selection contd.
8. Design of lift irrigation systems
9. Design of lift irrigation systems contd.
10. Tank irrigation
11. Grouping of tanks
12. Storage capacity
13. Supply works and sluices
14. Earthen dams: components, types
15. Methods of construction, causes of failure of earthen dams
16. Seepage control in earthen dams
17. Command area development (CAD) programme- components
18. Need, scope, and development approaches
19. Historical perspective
20. Command area development authorities- objectives, functions and responsibilities
21. Farmers' participation in command area development
22. PIM, water user's association
23. Reclamation works, cross drainage works
24. Use of remote sensing techniques for CAD works
25. On farm development works
26. Design of lined field channel and its cost estimation
27. Design of lined field channel and its cost estimation contd.
28. Design of un-lined field channel and its cost estimation
29. Design of un-lined field channel and its cost estimation contd.
30. Rotational irrigation system
31. Warabandi, pre-requisites for warabandi
32. Conjunctive use of water, optimum utilization of water
33. Water productivity: concepts and measures for enhancing water productivity

**Practical Schedule**

1. Preparation of command area development layout plan
2. Irrigation water requirement of crops of command area
3. Irrigation water requirement of crops of command area contd.
4. Preparation of irrigation schedules
5. Preparation of irrigation schedules contd.
6. Planning and layout of water conveyance system
7. Design of surplus weir of tanks
8. Determination of storage capacity of tanks
9. Design of intake pipe and pump house
10. Design of intake pipe and pump house contd.
11. Planning, design and cost estimation of OFD works
12. Study of cross-drainage works
13. Design and cost estimation of earthen dams for minor irrigation project
14. Estimation of seepage in field channels
15. Visit to a minor irrigation project / Visit to a command area and study of OFD works
16. Study of reclamation of waterlogged areas inside command area.
17. Practical examination

**Suggested Readings**


1. Arora, K. R. 2001. Irrigation, Water Power and Water Resources Engineering. Standard Publishers Distributors, Delhi.
2. Garg, S. K. 2014. Irrigation Engineering and Hydraulic Structures. Khanna Publishers, New Delhi.
3. Michael, A. M. 2012. Irrigation: Theory and Practice. Vikas Publishing House New Delhi.
4. Reddi, G. H. S. and Reddy, T. Y. 2005. Efficient use of Irrigation Water. Kalyani Publishers, Ludhiana.
5. Sahasrabudhe, S. R. 2011. Irrigation Engineering and Hydraulic structures. SK Kataria & Sons, Reprint 2015.


## EID 4203 Management of Canal Irrigation System 3 (2+1)

**Objective**

To enable the students to analyse water requirement and availability in a canal command, to take up design of lined and unlined canals and enable control of losses of water in canal commands and for design and layout of different canal outlet structures

**Theory**

**Module I** **(8 Hours)**

Typical network of canal irrigation system and its different physical components; canal classification based on source of water, financial output, purpose, discharge and alignment; canal alignment: general considerations for alignment; different parts of canal sections; performance indicators for canal irrigation system evaluation.

**Module II** **(10 Hours)**

Estimation of water requirements for canal command areas and determination of canal capacity;

water duty and delta, relationship between duty, base period and delta, factors affecting duty and method of improving duty; silt theory: Kennedy's theory, design of channels by Kennedy's theory, Lacey's regime theory and basic regime equations, design of channels by Lacey's theory, Use of Garrett's diagram

**Module III** **(10 Hours)**

Maintenance of unlined irrigation canals, measurement of discharge in canals, rostering (canal running schedule) and warabandhi, Seepage losses in canals measurement – necessity of canal lining: advantages and disadvantages, types of canal lining and desirable characteristics for the suitability of lining materials; design of lined canals.

**Module IV** **(6 Hours)**

Functions of distributaries – head and cross regulators; canal falls, their necessity and factors affecting canal fall; sources of surplus water in canals and types of canal escapes; requirements of a good canal outlet and types of outlet; Participatory irrigation management (PIM), water user's association: necessity, structure, function and duties

**Practical**

Estimation of water requirement of canal commands; Determination of canal capacity; Layout of canal alignments on topographic maps; Drawing of canal sections in cutting; Design of canal by full banking and partial cutting; Determination of longitudinal section (L-section) of canals; Design of irrigation canals based on silt theories (unlined canal); Design of lined canals; Formulation of warabandi system in canal command areas; Study of various types of canal outlet; Study of various types of canal regulators; Study of canal escapes; Study of various types of canal falls; Visit to a canal off taking site; Visit to a canal command area; Visit and discussion with functionaries of water user association.

**Lecture Schedule**

1. Introduction to Canal irrigation system
2. Canal Irrigation network-Different physical components.
3. Canal classification based on source of water,
4. Financial output-purpose of canal irrigation.
5. Canal Discharge
6. Canal alignment: general considerations for alignment.
7. Different parts of canal sections.
8. Performance indicators for canal irrigation system evaluation.
9. Estimation of water requirements for canal command areas
10. Determination of canal capacity;
11. Irrigation terminologies-Water duty, delta and Base period
12. Relationship between duty, base period and delta,
13. Factors affecting duty and method of improving duty
14. Design of channels –Silt Theories.
15. Canal design by Kennedy's theory,
16. Lacey's regime theory and basic regime equations,
17. Design of channels by Lacey's theory-
18. Use of Garrett's diagram
19. Maintenance of unlined irrigation canals

20. Measurement of discharge in canals,
21. Canal water distribution – Rostering
22. Canal running schedule and Warabandhi,
23. Seepage losses in canals-measurement
24. Necessity of canal lining:
25. Advantages and disadvantages of lining
26. Types of canal lining
27. Desirable characteristics for the suitability of lining materials;
28. Design of lined canals;
29. Functions of distributaries – head and cross regulators;
30. Canal falls – their necessity
31. Factors affecting canal fall; Sources of surplus water in canals
32. Types of canal escapes
33. Requirements of a good canal outlet, Types of outlet.
34. Participatory irrigation management (PIM), water user's association: necessity, structure, function and duties.

**Practical Schedule**

1. Estimation of water requirement of canal commands;
2. Estimation of water requirement of canal commands
3. Determination of canal capacity;
4. Layout of canal alignments on topographic maps,
5. Drawing of canal sections in cutting, full banking and partial cutting and partial banking;
6. Determination of longitudinal section of canals;
7. Design of irrigation canals based on silt theories; Kennedy's theory
8. Design of irrigation canals based on silt theories; Kennedy's theory
9. Design of irrigation canals based on Lacey's theory
10. Design of irrigation canals based on Lacey's theory Use of Garret's diagram
11. Design of lined canals;
12. Design of lined canals-contd
13. Formulation of warabandhi;
14. Study of canal outlets,
15. Study of canal regulators
16. Study of canal escapes and canal falls.
17. Visit to a canal off taking site; Visit to a canal command area; Visit and discussion with functionaries of water user association
18. Practical examination

**Suggested Readings**


1. Arora, K. R. 2001. Irrigation, Water Power and Water Resources Engineering. Standard Publishers Distributors, Delhi.
2. Basak, N.N. 2017. Irrigation Engineering. Mc Graw hills
3. Garg, S. K. 2014. Irrigation Engineering and Hydraulic Structures. Khanna Publishers New Delhi.
4. Sahasrabudhe, S. R. 2011. Irrigation Engineering and Hydraulic Structures. S K Kataria & Sons. Reprint 2015.

# EID 4204 Landscape Irrigation Design and Management 3 (2+1)

**Objective**

To enable the students to know about the different conventional and modern methods of landscape irrigation, various types of landscapes and their suitability with regard to different irrigation methods, design the modern landscape irrigation systems, automation of the landscape irrigation system and irrigation scheduling with proper methods of irrigation for different landscapes.

**Theory**

**Module I** **(8 Hours)**

Conventional method of landscape irrigation- hose irrigation system, portable sprinkler with hose pipes; Modern methods of landscape irrigation- pop-up sprinklers, spray pop-up sprinkler, shrub adopter, drip irrigation and bubblers; Merits and demerits of conventional and modern irrigation systems.

**Module II** **(10 Hours)**

Types of landscapes and suitability of different irrigation methods, water requirement for different landscapes; segments of landscape irrigation systems, main components of modern landscape irrigation systems and their selection criteria; Types of pipes, pressure ratings, sizing and selection criteria.

**Module III** **(8 Hours)**

Automation system for landscape irrigation- main components, types of controllers and their application; Use of sensors for irrigation automation and use of IOT in landscape irrigation.

**Module IV** **(6 Hours)**

Use of AutoCAD in irrigation design; Design of modern landscape irrigation systems, operation and maintenance of landscape irrigation systems.

**Practical**

Study of irrigation equipment for landscapes; Design and installation of irrigation system for landscape; Determination of water requirement; Determination of power requirement, pump selection; Irrigation scheduling of landscapes; Study of irrigation controllers and other equipment; Use of AutoCAD in irrigation design; Study of blocks and symbols, head layout, zoning and valves layout, pipe sizing, pressure calculations, etc.; Study of various types of sensors for irrigation automation; Study of IoT in landscaping irrigation; Visit to landscape irrigation system and its evaluation.

**Lecture Schedule**

1. Conventional method of landscape irrigation- hose irrigation system.
2. Quick release coupling system
3. Portable sprinkler with hose pipes.
4. Modern methods of landscape irrigation- pop-up sprinklers.
5. Modern methods of landscape irrigation- spray pop-up sprinkler.
6. Modern methods of landscape irrigation- drip irrigation
7. Modern methods of landscape irrigation- bubbler.
8. Merits and demerits of conventional and modern irrigation systems.

9. Types of landscapes and suitability of different irrigation methods.
10. Water requirement for different landscapes.
11. Water requirement for different landscapes contd.
12. Segments of landscape irrigation systems.
13. Main components of modern landscape irrigation systems.
14. Main components of modern landscape irrigation systems contd.
15. Components of modern landscape irrigation systems
16. Modern landscape irrigation systems - selection criteria.
17. Types of pipes, pressure ratings
18. Pipe sizing and selection criteria.
19. Automation system for landscape irrigation
20. Automation system for landscape irrigation-contd
21. Main components of automation system
22. Use of sensors for irrigation automation
23. Use of IOT in landscape irrigation.
24. Use of IOT in landscape irrigation - contd
25. Types of Automation controllers and their application
26. Types of Automation controllers and their application-contd.
27. Use of AutoCAD in irrigation design.
28. Use of AutoCAD in irrigation design - contd.
29. Design of modern landscape irrigation systems.
30. Design of modern landscape irrigation systems-contd
31. Operation of landscape irrigation systems.
32. Maintenance of landscape irrigation systems

**Practical Schedule**

1. Study of irrigation equipment for landscapes.
2. Design and installation of irrigation system for landscape.
3. Design and installation of irrigation system for landscape contd.
4. Determination of water requirement
5. Determination of water requirement contd.
6. Determination of power requirement, pump selection.
7. Irrigation scheduling of landscapes.
8. Study of irrigation controllers and other equipment.
9. Use of AutoCAD in irrigation design: blocks & symbols.
10. Use of AutoCAD in irrigation design: head layout.
11. Use of AutoCAD in irrigation design: zoning and valves layout.
12. Use of AutoCAD in irrigation design: pipe sizing.
13. Use of AutoCAD in irrigation design: Pressure calculations etc
14. Study of various types of sensors for irrigation automation
15. Study of IoT in landscaping irrigation.
16. Visit to landscape irrigation system and its evaluation.
17. Practical Examination.

**Suggested Readings**

1. Michael A.M. 2012. Irrigation: Theory and Practice. Vikas Publishing Vikas Publ. House New Delhi.

2. Rain Bird Landscape Irrigation Design Manual. 2000. (http://www.rainbird.com/documents/turf/Irrigation Design Manual.pdf). Rain Bird Sprinkler Manufacturing Corporation.
3. Singh Neeraj Partap. 2010. Landscaping Irrigation & Floriculture Terminology, ISBN: 8181895118, 978-8181895110, Ibdc Publishers, Bangalore.
4. Stephen W. Smith, 1997. Landscape Irrigation: Design and Management, ISBN: 0471038245, 9780471038245, John Wiley & Sons, N.Y.
5. Waller, P., Yitayew, M. 2016. Landscape Irrigation Design and Management. In: Irrigation and Drainage Engineering: Springer International Publishing. p. 271-288. https://doi.org/10.1007/978-3-319-05699-9_16

## EID 4205 Applications of Geospatial Techniques for Water Resources 3 (2+1)

**Objective**

To introduce the principles and basic concepts of Remote Sensing and GIS and to acquaint the students with its applications in water resources

**Theory**

**Module I** **(11 Hours)**

Remote Sensing Systems: Introduction, Basic concepts of remote sensing, Energy sources and radiation principles, Energy interactions with atmosphere and earth surface features, Spectral reflectance curves, Polar orbiting satellites, Spectral, radiometric and spatial resolutions, Geometric corrections, Atmospheric corrections, Solar illumination corrections, Supervised and unsupervised classification; Multispectral, thermal and hyperspectral remote sensing.

**Module II** **(6 Hours)**

GIS and basic components, different sources of spatial data, basic spatial entities, major components of spatial data, map projections and their properties; Co-ordinate systems- Methods of data input into GIS, Data editing, spatial data models and structures, Attribute data management, integrating data (map overlay) in GIS.

**Module III** **(8 Hours)**

Digital Elevation Modeling, DEM for Slope, Aspect, Flow direction, Flow pathways, Flow accumulation, Streams, Watershed delineation. Remote sensing applications for watershed management; Change detection analysis, Principal component analysis, Ratio images, Vegetation indices.

**Module IV** **(8 Hours)**

Microwave remote sensing, Global positioning System (GPS), Rainfall runoff modeling, Watershed management, Irrigation management, Flood mapping, Drought assessment, Environmental monitoring

**Practical**

Familiarization with remote sensing and GIS hardware; use of software for image interpretation; interpretation of satellite imagery; basic GIS operations such as image display; study of various features of GIS software package; scanning, digitization of maps and data editing; data base query and map algebra. GIS supported case studies in water resources management.

**Lecture Schedule**

1. Basic concepts of remote sensing, sensors, Passive and active remote sensing
2. EMR Spectrum, Energy sources and radiation principles
3. Energy interactions in the atmosphere and earth surface features
4. Spectral reflectance curves
5. Satellites and orbits, Polar orbiting satellites
6. Resolution of satellites
7. Some remote sensing satellites and their features
8. Geometric corrections
9. Atmospheric corrections, Solar illumination corrections
10. Supervised and unsupervised classification
11. Multispectral, thermal and hyperspectral sensing
12. Geographical information system: introduction
13. Components of GIS, GIS data models – vector and raster data
14. Map projections and their properties
15. Coordinate system and geo-referencing
16. Methods of data input into GIS, Data editing, spatial data models and structures
17. Attribute data management, integrating data (map overlay) in GIS.
18. Digital Elevation Modeling, Sources of digital elevation data, Types of DEM
19. DEM for Slope, Aspect, Flow direction, Flow pathways,
20. Flow accumulation, Streams, Catchment area delineation.
21. Watershed delineation from DEM
22. Remote sensing applications for watershed management.
23. Change detection analysis, Principal component analysis
24. Ratio images, Vegetation indices
25. Image processing software, Multispectral classification algorithms
26. Microwave remote sensing
27. Global positioning System (GPS)
28. GPS for ground truth collection
29. Rainfall runoff modeling,
30. Irrigation management, Flood mapping
31. Watershed management
32. Drought assessment
33. Environmental monitoring

**Practical Schedule**

1. Familiarization with remote sensing and GIS hardware
2. Interpretation of satellite imagery
3. Digital image processing - image enhancement
4. Image classification – unsupervised
5. Image classification – supervised
6. Introduction to GIS software
7. Study of various features of GIS
8. Digitization of maps and data editing
9. Digital elevation model
10. Preparation of slope map and aspect map

11. DEM application
12. Soil erosion modelling using GIS and RS
13. Rainfall runoff modelling using GIS
14. Rainfall runoff modelling using GIS contd.
15. Watershed prioritization using GIS
16. Preparation of water table contour maps
17. Practical examination

**Suggested Readings**


1. Burrough and McDonnel. Principles of GIS, Oxford University press.
2. Elangovan, K. 2006. GIS Fundamentals Applications and Implementations. New India Publication Agency, New Delhi.
3. George Joseph. 2005. Fundamentals of Remote Sensing. 2nd Edition. Universities Press (India) Private Limited, Hyderabad.
4. Jensen, J.R. 2013. Remote Sensing of the Environment: An Earth Resource Perspective. Pearson Education Limited, UK.
5. Lillesand, T., R.W. Kiefer and J. Chipman. 2015. Remote Sensing and Image Interpretation. 7th Edition, John Wiley and Sons Singapore Pvt. Ltd., Singapore.
6. Reddy Anji, M. 2006. Textbook of Remote Sensing and Geographical Information Systems. BS Publications, Hyderabad.
7. Sabins, F.F. 2007. Remote Sensing: Principles and Interpretation. Third Edition, Waveland Press Inc., Illinois, USA.
8. Sahu, K.C. 2008. Text Book of Remote Sensing and Geographic Information
9. Shultz, G.A. and E.T. Engman. 2000. Remote Sensing in Hydrology and Water Management. Springer, New York


## EID 4206 Environmental Engineering 3 (2+1)

**Objectives**

To enable the students to understand-

- The water requirements for domestic, industrial and commercial demand and sources of water supply, analysis of water quality. importance to sanitation, domestic waste water treatment, sewer design, disposal of waste water in urban and rural areas
- The air pollution, types of pollutants, and their abetments

**Theory**

**Module I** **(5 Hours)**

Importance of safe water supply system; Water requirements for urban and rural areas; domestic, industrial and commercial demand, per capita demand- variation in demand, population estimation- design period, population forecasting methods

**Module II** **(7 Hours)**

Sources of water supply- surface and sub-surface sources of water, surface sources-lakes, rivers, reservoirs; Intakes and transportation of water- various types of conduits including gravity conduits such as canals, flumes, aqueducts, pressure conduits- design of pressure pipes as gravity

mains, Darcy-Wesbach, Manning, Hazen- William formula, flow in pipes system- forces acting on pressure conduits-cast iron pipes, steel, RCC, PVC, asbestos and concrete pipes, laying of pipes and testing of pipes, testing of pipes. Selection of pumps, efficiency of pumps, economic diameter of pumping mains.

**Module III** **(7 Hours)**

Drinking water quality: Indian standards of drinking water; Introduction to water treatment: purification of water supply, sedimentation, filtration-coagulation, water softening, water treatment methods.

**Module IV** **(12 Hours)**

Importance to sanitation, domestic waste water: quantity, characteristics, disposal in urban and rural areas; Sewer: types, design discharge and hydraulic design, Introduction to domestic wastewater treatment. Design of septic tank, sewerage system- domestic and municipal wastes, storm sewage, flow through sewers, design of sewers, manhole, sewage characteristics, BOD, COD, dissolved oxygen, nitrogen; Solid waste collection and disposal, Solid waste quantity, characteristics and disposal for urban and rural areas.

**Module V** **(3 Hours)**

Introduction to air pollution, types of pollutants, properties and their effects on living beings, BIS standards for pollutants in air and their abetments.

**Practical**

Study of population forecasting problems; Determination of turbidity, pH and EC of water; Study of suspended solids, dissolved solids and total solids; Study of temporary and permanent hardness; Determination of fluorides and chlorides in drinking water; Determination of dissolved oxygen, COD and BOD of water; Study of hydraulics of pipe lines and distribution network design; Visit to a water treatment plant; Study of maintenance of distribution system; Collection of air samples and their analysis; Design of septic tank, sewer pipe lines and waste disposal measures; Visit to a sewage treatment plant; Visit to a municipal solid waste management plant; Visit to a community bio gas plant.

**Lecture Schedule**

1. Importance of safe water supply system; Water requirements for urban and rural areas
2. Domestic, industrial and commercial demand, per capita demand- variation in demand
3. Population estimation- design period
4. Population forecasting methods
5. Population forecasting methods contd.
6. Sources of water supply- surface and sub-surface sources of water, surface sources-lakes, rivers, reservoirs
7. Intakes and transportation of water- various types of conduits including gravity conduits such as canals, flumes, aqueducts,
8. Pressure conduits- design of pressure pipes as gravity mains, Darcy-Weisbach, Manning, Hazen- William formula.
9. Flow in pipes system- forces acting on pressure conduits-cast iron pipes, steel, RCC, PVC, asbestos and concrete pipes,
10. Laying of pipes and testing of pipes

11. Selection of pumps
12. Efficiency of pumps, economic diameter of pumping mains
13. Drinking water quality: Indian standards of drinking water
14. Introduction to water treatment: purification of water supply
15. Sedimentation
16. Coagulation
17. Filtration
18. Disinfection
19. Water softening and miscellaneous water treatment methods.
20. Importance to sanitation, Domestic waste water: quantity
21. Characteristics, disposal of domestic waste water in urban and rural areas
22. Sewer: types, design discharge
23. Hydraulic design of sewers
24. Introduction to domestic wastewater treatment.
25. Design of septic tank
26. Sewerage system- domestic and municipal wastes
27. Storm sewage, flow through sewers,
28. Design of storm sewers, manhole,
29. Sewage characteristics, BOD, COD, dissolved oxygen, nitrogen
30. Solid waste collection and disposal
31. Solid waste quantity, characteristics and disposal for urban and rural areas.
32. Introduction to air pollution, types of pollutants
33. Properties and their effects on living beings
34. BIS standards for pollutants in air and their abetments

**Practical Schedule**

1. Study of population forecasting problems
2. Determination of turbidity, pH and EC of water
3. Study of suspended solids, dissolved solids and total solids
4. Study of temporary and permanent hardness
5. Determination of fluorides and chlorides in drinking water
6. Determination of dissolved oxygen, COD and BOD of water
7. Study of hydraulics of pipe lines
8. Distribution network design
9. Visit to a water treatment plant
10. Study of maintenance of distribution system
11. Collection of air samples and their analysis;
12. Design of septic tank
13. Design of sewer pipe lines and waste disposal measures
14. Visit to a sewage treatment plant
15. Visit to a municipal solid waste management plant
16. Visit to a community bio gas plant
17. Practical Examination

**Suggested Readings**


1. Chatterjee, A. K. 2006. Water Supply, Waste Disposal & Environmental Engineering. Khanna Publishers, Delhi
2. Garg, S. K. (1992) Enviornmental Engineering (Vol. I) Water Supply Engineering. Khanna Publishers, Delhi. pp. 656.
3. Metcalf and Eddy (1997) Wastewater Engineering - Treatment, Disposal, Reuse. Tata-McGraw-Hill Publishing Co. Ltd. New Delhi. pp. 1334.
4. Peavy, H. S., Rowe, D. R. and Tchobanoglous, G. C. (1986) Environmental Engineering. McGraw-Hill Book Co., New York. pp. 700.
5. Rangwala, S. C. (1992) Water Supply and Sanitary Engineering. Charotar Publishing House, Anand. pp. 783.
6. Rao, P. V. 2002. Text book of Environmental Engineering. Prentice Hall of India Pvt. Ltd.


## EID 4207 Climate Change and use of Geoinformatics 3 (2+1)

**Objective**

To introduce the basic concepts of Climate change and Geoinformatics and to familiarize the students with the use of geospatial technologies in climate change studies.

**Theory**

**Module I** **(8 Hours)**

Energy issues and climate change: Climate change, global warming and greenhouse effect, greenhouse gases (GHGs) and their sources, quantifying $CO_2$ and methane emissions, global warming potential (GWP), the radiative balance, earth's carbon reservoirs and carbon cycle. Impacts of climate change in different ecosystems: Models of global and Indian changes including temperature rise, sea level rise, coastal erosion and flooding. Climate change Scenarios.

**Module II** **(7 Hours)**

Controlling carbon dioxide: Efforts to restrict carbon dioxide levels: Kyoto Protocol, recent protocols, methods to increase carbon dioxide absorption in power production, agricultural production, forestry, and industry, the Copenhagen Summit and its implications, future predictions. Carbon Trading: concept of carbon credits.

**Module III** **(10 Hours)**

Introduction, GIS definition and terminology, data types, raster and vector data, GIS database design, spatial database creation-digitization, scanning; processing of data, GIS implementation and project management. Commercially available remote sensing and GIS softwares. Satellite based navigation systems: concepts and applications; map projections and datums, coordinate systems; Survey of India topographical maps types and numbering system. Introduction to the softwares (ArcGIS and Erdas Imagine).

**Module IV** **(9 Hours)**

Climate Change Policy-Mitigation and Adaptation: Carbon storage and sequestration, carbon management through biotic sequestration - forest ecosystems, wetlands; soil carbon sequestration; bio fuels, carbon farming and carbon trading. Climate change impact assessment - applications for

agriculture and water management. Case studies-Projected impact of climate change in India; temperature, rainfall, forests, agriculture, water resources; India's response to climate change.

**Practical**

Case studies on effects of climate change: greenhouse gas emissions, sea level rise, crop productivity. Case studies on clean development mechanisms. Comparative evaluation of data from IPCC reports and climate scenarios. Case studies on successful green energy initiatives. Familiarization with remote sensing and GIS hardware; use of software for image interpretation-Preparation of maps; Introduction to GIS softwares–Q-GIS, ERDAS, Arc GIS etc. Visual interpretation of satellite imagery; land use mapping-Digital image processing-Exercises in viewing, editing, overlay-GIS supported case studies in climate change and water management.

**Lecture Schedule**

1. Energy issues and climate change
2. Climate change, global warming and greenhouse effect,
3. Greenhouse gases (GHGs) and their sources.
4. Quantifying $CO_2$ and methane emissions, global warming potential (GWP),
5. The radiative balance, earth's carbon reservoirs and carbon cycle.
6. Impacts of climate change in different ecosystems
7. Models of global and Indian changes including temperature rise, sea level rise, coastal erosion and flooding.
8. Climate change scenarios.
9. Controlling carbon dioxide: Efforts to restrict carbon dioxide levels:
10. Kyoto Protocol, recent protocols.
11. Methods to increase carbon dioxide absorption in power production, agricultural production, forestry, and industry
12. Methods to increase carbon dioxide absorption in power production, agricultural production, forestry, and industry contd.
13. Copenhagen Summit and its implications, future predictions.
14. Carbon Trading: concept of carbon credits.
15. Carbon Trading: concept of carbon credits contd.
16. Introduction- GIS definition and terminology, data types, raster and vector data,
17. Introduction- GIS definition and terminology, data types, raster and vector data contd.
18. GIS database design,
19. Spatial database creation – digitization, scanning; processing of data,
20. GIS implementation and project management.
21. Commercially available remote sensing and GIS softwares.
22. Satellite based navigation systems: concepts and applications;
23. Map projections and datums, coordinate systems;
24. Survey of India topographical maps types and numbering system.
25. Introduction to ArcGIS 24. and ERDAS Imagine.
26. Climate Change Policy-Mitigation and Adaptation.
27. Climate Change Policy-Mitigation and Adaptation contd.
28. Climate Change Policy-Mitigation and Adaptation contd.
29. Carbon storage and sequestration
30. Carbon management through biotic sequestration- forest ecosystems, wetlands; soil carbon sequestration.

31. Carbon management through biotic sequestration- forest ecosystems, wetlands; soil carbon sequestration contd.
32. Climate change impact assessment – applications for agriculture and water management.
33. Case studies- Projected impact of climate change in India; temperature, rainfall, forests, agriculture, water resources; India's response to climate change.
34. Case studies- Projected impact of climate change in India; temperature, rainfall, forests, agriculture, water resources; India's response to climate change contd.

**Practical Schedule**

1. Case studies on effects of climate change: greenhouse gas emissions, sea level rise crop productivity.
2. Case studies on clean development mechanisms.
3. Comparative evaluation of data from IPCC reports and climate scenarios.
4. Case studies on successful green energy initiatives.
5. Familiarization with remote sensing and GIS hardware; use of software for image
6. interpretation-Preparation of maps.
7. Familiarization with remote sensing and GIS hardware; use of software for image
8. interpretation-Preparation of maps contd.
9. Introduction to GIS software–Q-GIS
10. Introduction to GIS software–Q-GIS contd.
11. Overview of GIS software Arc GIS.
12. Coordinate system, Geo-referencing, Attribute data preparation
13. Digitization and creating maps
14. Digital image processing-Exercises in viewing, editing, overlay
15. Digital image processing-Exercises in viewing, editing, overlay contd.
16. GIS supported case studies in climate change and water management.
17. Practical examination

**Suggested Readings**


1. AkimasaSuni, Kensuke, F., and Ai, Hiramatsu. 2010. Adaptation and mitigation strategies for climate change. Springer.
2. Burroughs, W.J. 2007. Climate change: A multidisciplinary approach (2nd edition.). Cambridge University Press. Dash,
3. Gautam, P.L. Singh, V. and Melkania, U. (Eds.). 2009. Ecosystem diversity and carbon sequestration: climate change challenge and a way out for ushering in a sustainable future. Daya Publishing House, Delhi.
4. IPCC (2007): Summary for policymakers. In: Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change, M.L.
5. Lillisand, Thomas, Ralph W. Kiefer and Jonathan Chipman. 2007. Remote Sensing and Image Interpretation. Wiley India.
6. Lo, C.P., and Albert K.W. Yeung. 2009. Concepts and Techniques of Geographic Information Systems, 2nd Edition. PHI Learning.
7. Parry, O.F. Canziani, J.P. Palutikof, P.J van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7- 22.
8. Sushil Kumar. 2007. Climate change: An Indian perspective. Cambridge University Press India pvt.ltd. New Delhi.

## EID 4208 Design and Maintenance of Greenhouse 3 (2+1)

**Objective**

To acquaint the students with the concepts and design of greenhouse technology and the cultivation aspects which will help them to adopt the technology for increasing production.

**Theory**

**Module I** **(10 Hours)**

History and types of greenhouses; importance, function and features of green house; scope and development of greenhouse technology; polyhouses /shed nets, Cladding materials and its characteristics. Location, planning and various component of greenhouse; design criteria and calculation; constructional material and methods of construction.

**Module II** **(7 Hours)**

Solar heat transfer, steady state analysis of green house, Greenhouse heating, cooling, shedding and ventilation systems; Carbon Dioxide generation and monitoring and lighting systems, instrumentation and computerized environmental control systems.

**Module III** **(10 Hours)**

Green house irrigation system designs; components, installation and material requirement. Fogging system for greenhouses and net houses - maintenance of irrigation and fogging systems. Types of valves and accessories, fertilization, root substrata and its pasteurization, containers and benches, plant nutrition. Alternative cropping systems.

**Module IV** **(7 Hours)**

Plant tissue culture, chemical growth regulation. Pest and disease control; integrated pest management; postproduction quality and handling - cost analysis of greenhouse production; Applications of green house and its repair & maintenance.

**Practical**

Study/visit to a functional green house; Planning and layout of green house and associated utilities. Material selection for the construction of green house. Measurement of temp. using thermistor & thermocouples inside the green house; measurement of humidity, solar radiations & air velocity using various methods; application of psychometric charts. Greenhouse irrigation design; estimation of cooling requirements in a green house. Estimation of ventilation requirements. Thermal performance of greenhouse. Application of data loggers for simultaneous estimation & control of different parameters like temp., RH, solar radiations etc. Calculations of environment indices inside a greenhouse. Determination of fertilization schedule and rate of application for various crops. Structural analysis of green house. Economic analysis of green house. Visit to a commercial green house

**Lecture Schedule**

1. History and types of greenhouses
2. Importance, function and features of green house
3. Scope and development of greenhouse technology.
4. Location, planning and various components of greenhouse
5. Location, planning and various components of greenhouse contd.

6. Design criteria and calculation
7. Design criteria and calculation contd.
8. Constructional material and methods of construction
9. Constructional material and methods of construction contd.
10. Covering materials and its characteristics
11. Solar heat transfer
12. Steady state analysis of green house
13. Greenhouse heating and cooling
14. Shedding and ventilation systems
15. Carbon Dioxide generation and monitoring and lighting systems
16. Instrumentation & computerized environmental control Systems
17. Instrumentation & computerized environmental control Systems contd.
18. Greenhouse irrigation system designs
19. Greenhouse irrigation system design contd.
20. Types of valves and accessories
21. Fertigation in greenhouses
22. Fertigation in greenhouses contd.
23. Root substrata and its pasteurization
24. Containers and benches in polyhouse, plant nutrition.
25. Alternative cropping systems
26. Alternative cropping systems contd.
27. Plant tissue culture, chemical growth regulation
28. Disease control; integrated pest management
29. Postproduction quality and handling
30. Cost analysis of greenhouse production
31. Applications of green house
32. Greenhouse repair and maintenance

**Practical Schedule**

1. Study/visit to a functional green house
2. Planning and layout of green house and associated utilities
3. Material selection for the construction of green house
4. Measurement of temp. using thermistor. thermocouples inside the greenhouse
5. Measurement of humidity, solar radiations, air velocity using various methods
6. Application of psychometric charts
7. Greenhouse irrigation design
8. Estimation of cooling requirements in a green house
9. Estimation of ventilation requirements
10. Thermal performance of green house
11. Application of data loggers for simultaneous estimation & control of different parameters like temp., RH, solar radiations etc.
12. Calculations of environment indices inside a green house
13. Fertigation calculations for greenhouse
14. Structural analysis of green house
15. Economic analysis of green house
16. Visit to a commercial green house
17. Practical examination

**Suggested Readings**


1. Manohar, K.R. and Iga Thinathane. C. Greenhouse technology and management. B.S. Publications, Hyderabad.
2. Nelson, P.V. Greenhouse operation and maintenance. Prentice Hall, 2011. ISBN 10: 0132439360 ISBN 13: 9780132439367.
3. Prasad and Kumar. 2012. Greenhouse management for horticulture crops. Agrobios (India), Jodhpur
4. Salokhe, V.M. and Sharma, A.K. 2012.Greenhouse technology and applications. Geeta Somani Agrotech publishing Academy, Udaipur.
5. Sharma P. 2007.Precision Farming. Daya Publishing House New Delhi
6. Singh Brahma and Balraj Singh. 2014. Advances in protected cultivation, New India Publishing Company.

## Department of Irrigation and Drainage Engineering- Skill Enhancement Modules

### Repair and maintenance of pumps and irrigation systems 2 (0+2)

- Acquaint with different pumps and motors used in irrigation system
- Study of various water lifting devices and their limitations
- Study of components of centrifugal pump and its function
- Study of components of submersible pump and its function
- Components of reciprocating pump and its function
- Dismantling and assembling of irrigation pumps
- Performance testing of centrifugal pumps
- Preparation of pump housing
- Pump alignment and troubleshooting
- Knowing different accessories for electric pump
- Winding of 3-phase and single-phase electric motor
- Causes of trouble shooting in electrical pump set and their remedial measures
- Dismantling and assembling of diesel pump set
- Causes of trouble shooting in diesel pump set and their remedial measures
- Regular maintenance and overhauling, lubrication of pumps
- Study of solar pump set, and its components
- Step-wise installation of solar pump set including earthing

### Installation and maintenance of micro irrigation systems 2 (0+2)

- Acquaint with different components of micro irrigation
- Installing of micro irrigation (both drip and micro sprinkler) system
- Design of micro irrigation system (both drip and micro irrigation) in field
- Computation crop water requirement of crops
- Acquaint with fertigation equipment, their operation and maintenance
- Execution of fertigation with water soluble fertilizers
- Fixation of fertigation equipment with micro irrigation system
- Doing maintenance schedule in micro irrigation
- Operating automated micro irrigation system
- Operating IOT based irrigation system

### Geophysical Survey and Investigations for Groundwater Exploration and Installation of Tube Well/ Bore Well 2 (0+2)

- Learn about different features of groundwater system
- Study of different types of geophysical survey
- Components of a resistivity meter
- Wenner-Schlumberger arrangement and comparison
- Process of geophysical survey in field
- Surveyed data analysis and interpretation
- Different types of well log and preparation of commonly used well log

- Study of different types of wells
- Study the components of a tube well/ bore well
- Study of different types of drilling methods/ equipment
- Installation of well assembly: types of casing, screen
- Study on gravel packing
- Study of well development process
- Sanitary protection of tube wells

## Construction, Management and Maintenance of protected cultivation structures 2 (0+2)

- Study of different protected structures and their uses
- Acquaint with different components of protected structures
- Construction of different protected structures
- Study of glazing materials and their properties
- Selection of different construction materials and their specifications
- Management of micro climate parameters in protected structures
- Monitoring of micro climate inside protected structures
- Automatic monitoring of micro climate inside protected structure
- Use of Irrigation and fertigation in protected cultivation
- Visit to different hydroponics systems under protected structures

## Department of Soil and Water Conservation Engineering - Core Courses

## SWC 1101 Surveying and Levelling 3 (1+2)

**Objective**

To enable the students to conduct the survey work for any area and also to prepare layout of engineering structures.

**Theory**

**Module I** **(5 Hours)**

Surveying – introduction and basic principles – objects and uses of surveying – classification and methods of surveying. Linear measurements – principles in chain surveying – selection of survey stations and lines – types of ranging – direct ranging and indirect ranging – chaining – folding and unfolding of chains – reading the chain – leader and follower and their duties – conventional signs. Types of chains - ranging rod - offsets – types - measurement of offsets – cross staff - optical square. Steps involved in chain survey – reconnaissance - marking stations - reference sketches – running survey lines - booking field notes - plotting a chain survey; Testing of chain - degree of accuracy in chaining – error in length due to incorrect chain - compensating and cumulative errors – mistakes - Chaining on sloping ground – direct and indirect methods – obstacles in chaining - chain and tape corrections. Compass Surveying – Prismatic compass - Surveyor's compass – whole circle and reduced bearings. True and magnetic bearing – dip and declination - local attraction – traversing – plotting.

**Module II** **(4 Hours)**

Plane table Surveying – instruments and accessories – setting up – orientation – different methods – radiation – intersection – traversing. Two-point problem – three-point problem - advantages and disadvantages – errors in plane tabling. Levelling – definitions – classification of levelling – difficulties and error in levelling - principles in levelling – sensitivity of bubble – adjustments of levels – types of bench marks – booking the reading. Reduction of levels – collimation system and Rise and fall system – problem.

**Module III** **(5 Hours)**

Levelling: profile levelling – cross sectioning – plotting – curvature and refraction, contouring: characteristics – uses – different methods – direct and indirect interpolation, computation of area and volume. Theodolite Traversing – definitions – parts of a theodolite – adjustment of a theodolite – measurement of angles – horizontal angles – different methods – vertical angle, Introduction to setting of curves, Theodolite traverses –traverse computations– adjustment of closed traverse – problems, Tacheometric surveying- stadia system- fixed and movable hair methods - instrument constants- analytic lens- tangential tacheometry.

**Module IV** **(3 Hours)**

Areas and volumes - mid ordinate rule – average ordinate rule – trapezoidal rule – Simpson's rule - use of planimeter - errors in measurement – their elimination and correction - volumes – trapezoidal and prismoidal formula, Minor instruments – Hand levels – Clinometer. Electronic theodolite. Total station – Introduction to total station survey. GPS survey - Introduction to GPS survey

**Practical**

Linear measurements using different instruments; Reconnaissance survey in the field; Useof field book; Study on various types of chain used in chain survey and its components; Study of errors in chain surveying; Use of ranging rods and ranging in the field; Obstacles during chaining; Offsets in chain survey; Cross Staff; Survey of an area; Preparation of map; Study on various types of compass; Compass survey of an area; Plotting of compass survey; Plane table surveying and different methods; Study on various types of levels and its components; Setting up of dumpy level in the field; Computation of various methods for RL; Study on Levelling, L section and X sections and its plotting; Measurement of slope in the field; Study on contour and its characteristics; Contour survey of an area and preparation of contour map; Introduction of software in drawing contour; Theodolite surveying; Ranging by Theodolite; Height of object by using Theodolite; Setting out curves by Theodolite; Use of minor instruments; Use of total station, EDM in the field; Use of modern computers for surveying

**Lecture Schedule**

1. Surveying – introduction and basic principles – objects and uses of surveying – classification and methods of surveying
2. Linear measurements – principles in chain surveying – selection of survey stations and lines – types of ranging – direct ranging and indirect ranging – chaining – folding and unfolding of chains – reading the chain – leader and follower and their duties – conventional signs, Types of chains - ranging rod - offsets – types, measurement of offsets – cross staff - optical square
3. Steps involved in chain survey – reconnaissance - marking stations - reference sketches – running survey lines - booking field notes - plotting a chain survey; Testing of chain - degree of accuracy in chaining – error in length due to incorrect chain - compensating and cumulative errors – mistakes; Chaining on sloping ground – direct and indirect methods – obstacles in chaining - chain and tape corrections
4. Compass Surveying – Prismatic compass - Surveyor’s compass – whole circle and reduced bearings
5. True and magnetic bearing – dip and declination - local attraction – traversing – plotting
6. Plane table Survey – instruments and accessories – setting up – orientation - different methods – radiation – intersection – traversing
7. Two-point problem – three-point problem - advantages and disadvantages – errors in plane tabling
8. Levelling – definitions – classification of levelling – difficulties and error in levelling – – principles in levelling – sensitivity of bubble – adjustments of levels – types of bench marks – booking the reading
9. Reduction of levels – collimation system and Rise and fall system – problems
10. Levelling: profile levelling – cross sectioning – plotting – curvature and refraction – contouring: characteristics – uses – different methods – direct and indirect interpolation – Computation of area and volume
11. Theodolite Traversing – definitions – parts of a theodolite – adjustment of a theodolite
12. Theodolite Traversing – measurement of angles – horizontal angles – different methods – vertical angle, Introduction to setting of curves
13. Theodolite traverses –traverse computations – adjustment of closed traverse – problems.
14. Tacheometric surveying- stadia system- fixed and movable hair methods - instrument constants- analytic lens- tangential tacheometry

15. Areas and volumes - mid ordinate rule – average ordinate rule – trapezoidal rule – Simpson's rule - use of planimeter - errors in measurement – their elimination and correction, volumes: trapezoidal and prismoidal formula
16. Minor instruments – Hand levels, Clinometer, Electronic theodolite
17. Total station – Introduction to total station survey, GPS survey - Introduction to GPS survey

**Practical Schedule**

1. Study on various types of chain used in chain survey and its components, Study of errors in chain surveying, Use of ranging rods and ranging in the field and obstacles during chaining
2. Linear measurements using different instruments, Reconnaissance survey in the field, Use of field book, Offsets in chain survey
3. Chain survey – triangulation
4. Cross Staff survey of an area, preparation of map
5. Study on various types of compass and compass survey of an area, Plotting of compass survey
6. Chain and compass traversing
7. Plane Table Surveying – Radiation
8. Plane Table Surveying - Intersection
9. Plane Table Surveying- Traversing
10. Plane Table Surveying – Solving Two Point Problem
11. Plane Table Surveying - Solving Three Point Problem
12. Study on various types of levels and its components, setting up of dumpy level in the field
13. Computation of various methods for RL – Height of collimation method
14. Computation of various methods for RL – Rise and fall method
15. Study on Levelling, L section and X sections and its plotting
16. Measurement of slope in the field
17. Study on contour and its characteristics and contour survey of an area and preparation of contour map
18. Study on contour and its characteristics and contour survey of an area and preparation of contour map
19. Introduction of software in drawing contour
20. Theodolite Surveying – ranging by theodolite - closed
21. Theodolite Surveying – open
22. Determination of tacheometric constants
23. Heights and distances by stadia method – line of sight horizontal
24. Heights and distances by stadia method - line of sight inclined
25. Heights and distances by tangential method
26. Heights and distances by tangential method
27. Heights and distances by solution of triangles
28. Heights and distances by solution of triangles
29. Trigonometric levelling- base of the object accessible
30. Use of total station, EDM in the field
31. Use of total station, EDM in the field
32. Use of modern computers for surveying
33. Use of minor instruments
34. Practical examination

**Suggested Readings**


1. Agor, R. A. 1980. Text Book of Surveying & Levelling. Khanna Publishers, New Delhi
2. Arora, K. R. 2019. Surveying (Vol. I), Standard Book House, Delhi.
3. Kanetkar, T. P. 2008. Surveying and Levelling (Vol. I & II). Pune Vidyarthi Griha, Prakashan, Pune.
4. Punmia, B C. 2018. Surveying (Vol. I). Laxmi Publications, New Delhi.
5. Rangwala, 1991. Surveying and levelling. Charotar Publishing House Pvt. Ltd. Gujarat.


## SWC 1202 Environmental Studies and Disaster Management 3 (2+1)

**Objective**

To expose and acquire knowledge on the environment and to gain the state-of-the-art – skill and expertise on management of disasters.

**Theory**

**Module I** **(6 Hours)**

Introduction to Environment - Environmental studies - Definition, scope, and importance - Multidisciplinary nature of environmental studies - Segments of Environment - Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification - Forest resources, water resources, mineral resources, food resources, energy resources, land resources, soil resources.

**Module II** **(7 Hours)**

Ecosystems - Concept of an ecosystem - Structure and function of an ecosystem - Energy flow in the ecosystem - Types of ecosystems. Biodiversity and its conservation: Introduction, definition, types - Biogeographical classification of India - Importance and value of biodiversity - Biodiversity hotspots - Threats and conservation of biodiversity.

**Module III** **(8 Hours)**

Environmental Pollution: Definition, cause, effects, and control measures of air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, light pollution. Solid Waste Management: Classification of solid wastes and management methods - Composting, incineration, pyrolysis, biogas production - causes, effects, and control measures of urban and industrial wastes.

**Module IV** **(7 Hours)**

Social Issues and the Environment: Urban problems related to energy - Water conservation, rainwater harvesting, watershed management - Environmental ethics: Issues and possible solutions - Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents, and holocaust - Environment Protection Act - Air (Prevention and Control of Pollution) Act - Water (Prevention and Control of Pollution) Act - Wildlife Protection Act - Forest Conservation Act.

**Module V** **(6 Hours)**

Human Population and the Environment: Environment and human health - Human rights, value education - Women and child welfare - Role of information technology in environment and human health. Disaster Management: Disaster definition - Types: Natural Disasters (floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, heat and cold waves) - Man-Made Disasters (nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents) - International and national strategy for disaster reduction - Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community-based organizations, and media in disaster management - Central, state, district, and local administration in disaster control; armed forces in disaster response; police and other organizations in disaster management.

**Practical**

Visit to a local area to document environmental assets river/ forest/ grassland/hill/mountain. Energy: Biogas production from organic wastes. Visit to wind mill/ hydro power/solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and unpolluted system. Visit to local polluted site - Urban/Rural/Industrial/Agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis: pH, EC and TDS. Estimation of Acidity, Alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of E. coli in water sample. Assessment of Suspended Particulate Matter (SPM). Study of simple ecosystem – Visit to pond/river/hills. Visit to areas affected by natural disaster.

**Lecture Schedule**

1. Introduction to Environmental Studies: Definition, scope, and importance. Multidisciplinary nature of environmental studies
2. Segments of the Environment. Earth spheres: Lithosphere, Hydrosphere, Atmosphere
3. Different layers of the atmosphere
4. Natural Resources: Classification and overview. Forest resources
5. Water resources and mineral resources
6. Food, energy, land, and soil resources
7. Concept of an ecosystem: Definition, structure, and function
8. Energy flow in the ecosystem. Types of ecosystems
9. Introduction to Biodiversity: Definition and types
10. Biogeographical classification of India
11. Importance and value of biodiversity
12. Biodiversity hotspots
13. Threats to biodiversity and conservation strategies
14. Environmental pollution: Air pollution - definition, causes, effects, and control measures
15. Water pollution: Definition, causes, effects, and control measures
16. Soil pollution and marine pollution: Definition, causes, effects, and control measure
17. Noise pollution, thermal pollution, and light pollution: Definition, causes, effects, and Control measures
18. Solid Waste Management: Classification of solid wastes
19. Management methods: Composting, incineration, pyrolysis, biogas production

20. Causes, effects, and control measures of urban and industrial wastes
21. Social issues and environment
22. Urban problems related to energy
23. Water conservation, rainwater harvesting and watershed management
24. Environmental ethics: Issues and possible solutions
25. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents, and holocaust
26. Environmental Protection Act, Air and Water (Prevention and Control of Pollution) Acts
27. Wildlife Protection Act and Forest Conservation Act
28. Human population and environment: Health, human rights, and value education
29. Women and child welfare
30. Role of information technology in environment and human health
31. Disaster Management: Definition and overview, Natural disasters: Floods, droughts, cyclones, earthquakes, landslides, avalanches, volcanic eruptions, heat and cold waves
32. Man-made disasters: Nuclear, chemical, biological, fires (building, coal, forest, oil), Accidents (road, rail, air, sea)
33. National and international strategies for disaster reduction, concept of disaster management, National disaster management framework, financial arrangements, role of NGOs, media, community organizations
34. Central, state, district, and local administration in disaster control; armed forces in disaster response; police and other organizations in disaster management

**Practical Schedule**

1. Visit to a local area to document environmental assets: river, forest, grassland, hill, mountain
2. Biogas production from organic wastes
3. Visit to wind mill, hydro power, and solar power generation units
4. Biodiversity assessment in farming systems
5. Floral and faunal diversity assessment in polluted and unpolluted systems
6. Visit to a local polluted site: Urban/Rural/Industrial/Agricultural to study of common plants, insects, and birds at the polluted site.
7. Environmental sampling and preservation
8. Water quality analysis: pH, Electrical Conductivity (EC), and Total Dissolved Solids (TDS)
9. Estimation of acidity and alkalinity in water samples
10. Estimation of water hardness
11. Estimation of dissolved oxygen (DO) in water samples
12. Estimation of dissolved oxygen (DO) in water samples
13. Estimation of biological oxygen demand (BOD) and chemical oxygen demand (COD) in water samples
14. Enumeration of *E. coli* in water samples
15. Assessment of suspended particulate matter (SPM)
16. Study of simple eco-system – visit to pond/river/hills/areas affected by natural disaster
17. Practical Examination

**Suggested Readings**

1. De. A.K. 2010. Environmental chemistry. Published by New Age International Publishers, New Delhi. ISBN:13–978 81 224 2617 5. 384 pp

2. Dhar Chakrabarti. P.G. 2011. Disaster management - India's risk management policy frameworks and key challenges. Published by Centre for Social Markets (India), Bangalore. 36 pp.
3. Erach Bharucha, Text book for Environmental studies. University Grants Commission, New Delhi.
4. Parthiban, K.T. Vennila, S. Prasanthrajan, M. Umesh Kanna, S. 2023. Forest, Environment, Biodiversity and Sustainable development. Narendra Publishing House, New Delhi, India (In Press).
5. Prasanthrajan M, Mahendran, P. P. 2008. A text book on Ecology and Environmental Science. ISBN 81-8321-104-6. Agrotech Publishing Academy, Udaipur - 313 002. First Edition.
6. Prasanthrajan M. 2018. Objective environmental studies and disaster management. ISBN 9789387893825. Scientific publishers, Jodhpur, India. Pp. 146
7. Sharma, P.D. 2009, Ecology and Environment, Rastogi Publications, Meerut, India
8. Tyler Miller and Scot Spoolman. 2009. Living in the Environment (Concepts, Connections, and Solutions). Brooks/cole, Cengage learning publication, Belmont, USA.

## SWC 2103 Soil Mechanics 2 (1+1)

**Objective**

To make the students acquainted with the principles of soil mechanics and the calculation of different stresses in soil, which will be helpful in designing the retaining walls and other engineering structures.

**Theory**

**Module I** **(5 Hours)**

Introduction to soil mechanics, field and scope of soil mechanics; Phase diagram, physical and index properties of soil, particle size distribution, grain size distribution curve, soil indices; plastic limit, liquid limit, shrinkage limit; Classification of soils, effective and neutral stress, Boussinesq and Westerguard's analysis, New-mark's influence chart, stress distribution and diagrams.

**Module II** **(4 Hours)**

Shear stress, Mohr's circle, direct shear stress, triaxial test and vane shear test; Mohr coulomb failure theory, effective stress principle, determination of shear parameters by direct shear test, triangle test and vane shear test. Numerical exercise based on various types of tests.

**Module III** **(4 Hours)**

Compaction of soils, standard and modified protector test, Abbot's compaction and Jodhpur mini compaction test, field compaction method and control; Consolidation of soils, Terzaghi's theory of one-dimensional consolidation, spring analogy, Laboratory consolidation test, calculation of void ratio and coefficient of volume change, Taylor's and Casagrande's method.

**Module IV** **(4 Hours)**

Earth pressure: Plastic equilibrium in soils, active and passive states, Rankine's theory of earth pressure, active and passive earth pressure for cohesive soils, simple numerical exercises; stability of slopes: introduction to stability analysis of infinite and finite slopes, friction circle method, Taylor's stability number, friction circle method.

**Practical**

Determination of moisture content of soil sample, Determination of specific gravity of soil sample, Study of field density by core cutter, Study of bulk density, dry density by sand replacement method, Determination of grain size distribution of coarse grained soil by sieving, Determination of grain size by hydrometer method, Determination of liquid limit by Casagrande's apparatus, Determination of liquid limit by cone penetrometer, Determination of plastic limit of soil specimen, Determination of shrinkage limit of soil, Determination of optimum moisture content of saturated soil by Abbot's compaction test, Determination of optimum moisture content of saturated soil by Proctor's mould, Consolidation characteristics of soils, Shear strength of soil by direct shear test, Shear strength of soil by tri-axial shear test

**Lecture Schedule**

1. Introduction to soil mechanics, field and scope of soil mechanics, phase diagram
2. Physical and index properties of soil
3. Particle size distribution, grain size distribution curve, soil indices: plastic limit, liquid limit, shrinkage limit
4. Classification of soils, effective and neutral stress, Boussinesq and Westerguard's analysis
5. New-mark's influence chart, stress distribution and diagrams
6. Shear stress, Mohr's circle, Direct shear stress, triaxial test and vane shear test
7. Mohr coulomb failure theory, effective stress principle
8. Determination of shear parameters by direct shear test, triangle test and vane shear test
9. Numerical exercise based on various types of tests
10. Compaction of soils, standard and modified protector test
11. Abbot's compaction and Jodhpur mini compaction test, field compaction method and control
12. Consolidation of soils, Terzaghi's theory of one-dimensional consolidation, spring analogy
13. Laboratory consolidation test, calculation of void ratio and coefficient of volume change, Taylor's and Casagrande's method
14. Earth pressure: Plastic equilibrium in soils, active and passive states
15. Rankine's theory of earth pressure, active and passive earth pressure for cohesive soils, simple numerical exercises
16. Stability of slopes: introduction to stability analysis of infinite and finite slopes, friction circle method
17. Taylor's stability number, friction circle method

**Practical Schedule**

1. Determination of moisture content of soil sample
2. Determination of specific gravity of soil sample
3. Determination of field density by core cutter
4. Study of bulk density, dry density by sand replacement method
5. Determination of grain size distribution of coarse-grained soil by sieving
6. Determination of grain size by hydrometer method
7. Determination of grain size by hydrometer method
8. Determination of liquid limit by Casagrande's apparatus
9. Determination of liquid limit by cone penetrometer
10. Determination of plastic limit of soil specimen
11. Determination of shrinkage limit of soil

12. Determination of optimum moisture content of saturated soil by Abbot's compaction test
13. Determination of optimum moisture content of saturated soil by Proctor's mould
14. Consolidation characteristics of soils
15. Shear strength of soil by direct shear test
16. Shear strength of soil by Tri-axial test
17. Practical Examination

**Suggested Readings**


1. Punmia, B. C., Jain, A. K. and Jain, A. K. 2017. *Soil Mechanics and Foundations*. Laxmi Publications (P) Ltd. New Delhi.
2. Ranjan, G. and Rao, A. S. R. 1993. *Basic and Applied Soil Mechanics*. Welley Easters Ltd., New Delhi.
3. Singh, A. 1994. *Soil Engineering*. Vol. I. CBS Publishers and Distributions, Delhi.


## SWC 2104 Fluid Mechanics and Open Channel Hydraulics 3 (2+1)

**Objective**

To make the students acquainted with the behaviour of fluids at rest and in motion and to enable them to apply the principles to design simple fluid mechanical systems in engineering.

**Theory**

**Module I** **(8 Hours)**

Properties of fluids - Ideal and real fluid; Pressure and its measurement, units of measurement, Pascal's law, pressure forces on plane and curved surfaces, centre of pressure, pressure diagram; Application of hydrostatics in engineering structures - Buoyancy, Archimede's principle, metacentre and metacentric height, condition of floatation and stability of submerged and floating bodies.

**Module II** **(9 Hours)**

Kinematics of fluid flow - Lagrangian and Eulerian description of fluid motion, continuity equation; Path lines, streak lines and streamlines, stream function, velocity potential and flow net. Types of fluid flow, translation, rotation, circulation and vorticity, vortex motion; Dynamics of fluid flow - Bernoulli's theorem, venturi meter, orifice meter and pitot tube, siphon. Application of Bernoulli's theorem - flow through orifices (measurement of discharge and time), flow through mouthpieces, flow over notches, flow over weirs, end contraction of rectangular weirs, ventilation of weirs, and various types of nappe.

**Module III** **(6 Hours)**

Flow through pipes - Laminar and turbulent flow in pipes; Head loss in pipes - minor and major hydraulic losses through pipes and fittings; General equations - Darcy's equation, Moody's diagram, Chezy's formula for loss of head in pipes; Flow through network of pipes; Hydraulic gradient and energy gradient; Flow through simple and compound pipes; Transmission of power through pipes.

**Module IV** **(11 Hours)**

Open channel design and hydraulics: types of flow in open channels, velocity and pressure profiles in open channels; Specific energy, critical depth and discharge; Discharge measurement in open channels - Current meter, parshall flumes, Cut throat flumes and venture flumes, Chezy's formula, Bazin's formula, Kutter's formula, Manning's formula; Best hydraulic section; velocity and pressure profile in open channels, Hydraulic jump. Dimensional analysis and similitude: Rayleigh's method and Buckingham's `pi' theorem, types of similarities, dimensionless numbers; Introduction to fluid machinery - pumps and turbines.

**Practical**

Study of manometers and pressure gauges; Study of transmissibility of liquid pressure; Study of various types of flow such as laminar flow, uniform flow, steady flow, vortex flow, rotational flow; Determination of meta-centric height; Verification of Bernoulli's theorem; Determination of coefficient of discharge of venturi-meter and orifice meter; Determination of coefficient of friction in pipeline; Determination of minor losses in pipelines; Determination of coefficient of discharge for rectangular and triangular notch; Determination of coefficient of discharge, coefficient of velocity and coefficient of contraction for flow through orifice; Determination of coefficient of discharge for mouth piece; Determination of efficiency of hydraulic ram; Measurement of velocity by current meter; Study of open channel flow: velocity distribution in open channels and determination of Manning's coefficient of Rugosity and Chezy's roughness coefficient; Study of various types of models and prototypes: geometrical, kinematic and dynamic similarities; Study on non-dimensional constants such as Froude's number and Reynold's number; Study of various types of pumps and its components.

**Lecture Schedule**

1. Properties of fluids - Ideal and real fluid; Pressure and its measurement, units of measurement
2. Pascal's law, Pressure variation in a fluid - absolute, gauge, atmospheric pressure and vacuum pressure
3. Measurement of pressure - Manometers, differential manometers and mechanical gauges
4. Hydrostatics in engineering structures - total pressure and centre of pressure
5. Pressure on immersed surfaces - vertical plane surface, inclined surface, curved surface and pressure diagrams
6. Buoyancy and flotation – Archimedes' principle, expression for buoyant force and centre of buoyancy
7. Metacentre and determination of metacentric height - experimental and analytical method
8. Principle and conditions of flotation, stability of floating and submerged bodies
9. Kinematics of fluid flow - Lagrangian and Eulerian description of fluid motion - continuity equation in three dimensions, velocity and acceleration
10. Path lines, streak lines and streamlines, stream function, velocity potential function and flow net
11. Types of fluid flow - steady, unsteady, uniform and non-uniform flows - Laminar and turbulent flows - compressible and incompressible flows – Translation, Rotational and irrotational flows - Circulation - one, two and three-dimensional flows
12. Vorticity, vortex motion - free vortex and forced vortex
13. Dynamics of fluid flow - Bernoulli's theorem

14. Application of Bernoulli's theorem - venturi meter, orifice meter, nozzle meter and pitot tube, siphon
15. Flow measuring devices - orifices and mouthpieces (measurement of discharge and time).
16. Classification of Notches and weirs
17. Flow over notches and weirs, end contraction of rectangular weirs, ventilation of weirs, types of nappe
18. Flow through pipes - Laminar and turbulent flow
19. Head loss in pipes - Minor and major hydraulic losses through pipes and fittings
20. General equations for head loss - Darcy's equation, Moody's diagram and Chezy's formula for loss of head in pipes
21. Hydraulic gradient line and total energy line
22. Flow through a network of pipes - flow through simple and compound pipes
23. Transmission of power through pipes
24. Open channel flow - types of flow in channels, velocity and pressure profiles in open channels
25. Energy and momentum principles in open channels - specific energy and specific force and critical flow, critical depth and discharge
26. Discharge measurement in open channels - Current meter, parshall flumes, Cut throat flumes and venture flumes
27. Design and hydraulics of open channels - Chezy's formula, Bazin's formula, Kutter's formula and Manning's equation
28. Best hydraulic section of channels - Rectangular and trapezoidal, Triangular and circular channel, velocity and pressure profiles in open channels
29. Hydraulic jump - Applications, types of hydraulic jump, energy dissipation due to the jump and Froude number
30. Dimensional analysis and similitude – units and dimensions, dimensional homogeneity
31. Rayleigh's method and Buckingham's 'pi' theorem, example problems
32. Types of similarities and similitude; Dimensionless numbers - Reynold's number, Froude number, Euler's number, Weber's number and Mach's number.
33. Introduction to fluid machinery: pumps and turbines
34. Classification of pumps: centrifugal pumps, hydraulic ram, propeller pumps, mixed flow pumps

**Practical Schedule**

1. Study of manometers and pressure gauges
2. Study of transmissibility of liquid pressure: Verification of Pascal's law
3. Study of various types of flow such as laminar flow, uniform flow, steady flow, vortex flow, and rotational flow.
4. Determination of meta-centric height
5. Verification of Bernoulli's theorem
6. Determination of coefficient of discharge of venturi-meter and orifice meter
7. Determination of coefficient of friction and minor losses in pipeline
8. Determination of coefficient of discharge for rectangular and triangular notch
9. Determination of coefficient of discharge, coefficient of velocity and coefficient of contraction for flow through orifice
10. Determination of coefficient of discharge for mouthpiece
11. Determination of efficiency of hydraulic ram

12. Measurement of velocity by current meter
13. Study of open channel flow: velocity distribution in open channels and determination of Manning's coefficient of Rugosity and Chezy's roughness coefficient
14. Study of various types of models and prototypes: geometrical, kinematic and dynamic similarities
15. Study on non-dimensional constants such as Froude's number and Reynold's number
16. Study of various types of pumps and their components
17. Practical examination

**Suggested Readings**


1. Bansal, R. K. 2019. A Textbook of Fluid Mechanics. Laxmi Publications, New Delhi.
2. Subramanya, K. 2019. Flow in Open Channels. McGraw-Hill Co., New Delhi.
3. Modi, P. N. and Seth, S. M. 2017. Hydraulics & Fluid Mechanics including Hydraulic Machines. Standard Book House, Delhi.
4. Ramanuthan, S. 2011. Hydraulics, Fluid Mechanics & Hydraulic Machines. Dhanpat Rai & Sons, Delhi.
5. Khurmi, R. S. and Khurmi, N. 1987. Hydraulics, Fluid Mechanics and Hydraulic Machines. S. Chand & Co. Ltd., New Delhi.
6. Chow, V. T. 1983. Open Channel Hydraulics. McGraw-Hill Book Co., New Delhi.


## SWC 2205 Watershed Hydrology 3 (2+1)

**Objective**

To make the students acquainted with the different hydrological processes, their methods of analysis so as to enable them to apply these for watershed development, water harvesting, minor irrigation, drought and flood control, etc.

**Theory**

**Module I** **(11 Hours)**

Hydrologic cycle, components; Precipitation and its forms, rainfall measurement and estimation of mean rainfall, estimation of missing rainfall, optimum number of rain gauges. Frequency analysis of point rainfall; Mass curve, hyetograph, depth-area-duration curves and intensity-duration-frequency relationship.

**Module II** **(10 Hours)**

Hydrologic processes- interception, infiltration - factors influencing, measurement and indices; Evaporation - estimation and measurement; Runoff - factors affecting, measurement, stage - discharge rating curve, estimation of peak runoff rate and volume, rational method, Cook's method and SCS curve number method.

**Module III** **(7 Hours)**

Geomorphology of watersheds – linear, aerial and relief aspects of watersheds - stream order, drainage density and stream frequency; Hydrograph - components, base flow separation, unit hydrograph theory, s-curve, synthetic hydrograph, applications and limitations.

**Module IV** **(6 Hours)**

Flood routing – channel and reservoir routing; Hydrology of dry land areas, Troll's climatic classification; Drought - classification, causes and impacts, drought management strategy

**Practical**

Visit to meteorological observatory and study of different instruments; Study of optimal rain gauge network; Study of intensity - frequency - duration curves; Study of depth - area – duration curve; Analysis of rainfall data and estimation of mean rainfall by different methods; Analysis of frequency of hydrologic data and estimation of missing data, test for consistency of rainfall records; Computation of infiltration indices; Computation of peak runoff and runoff volume by Cook's method and rational formula; Computation of runoff volume by SCS curve number method; Study of stream gauging instruments- current meter and stage level recorder; Study and determination of geomorphic parameters of watersheds; Study of runoff hydrograph and separation of base flow and surface flow ; Study of unit hydrograph; Study of synthetic hydrograph; Study of flood routing; Study of various discharge measuring devices.

**Lecture Schedule**

1. Introduction; Hydrologic cycle
2. Hydrologic components
3. Precipitation and its forms
4. Rainfall measurement – various types of rain gauges
5. Rainfall measurement – various types of rain gauges
6. Estimation of mean rainfall
7. Estimation of missing rainfall
8. Optimum number of rain gauges
9. Frequency analysis of point rainfall
10. Mass curve and hyetograph
11. Depth-area-duration curves and intensity-duration-frequency relationship
12. Hydrologic processes - Interception
13. Infiltration -factors influencing, measurement and indices
14. Evaporation - estimation and measurement
15. Evaporation - estimation and measurement
16. Runoff - factors affecting, measurement of runoff
17. Stage - discharge rating curve
18. Estimation of peak runoff rate and volume, Cook's method
19. Rational method of runoff estimation
20. SCS Curve Number method
21. SCS Curve Number method
22. Geomorphology of watersheds - linear, aerial and relief aspects of watersheds
23. Geomorphology of watersheds - linear, aerial and relief aspects of watersheds
24. Stream order, drainage density and stream frequency
25. Hydrograph - Components, base flow separation
26. Unit hydrograph theory
27. S-curve
28. Synthetic hydrograph, applications and limitations
29. Flood routing – channel and reservoir routing

30. Flood routing – channel and reservoir routing
31. Hydrology of dry land areas
32. Troll's climatic classification
33. Drought- classification, causes and impacts
34. Drought management strategy

**Practical Schedule**

1. Visit to meteorological observatory and study of different instruments
2. Study of optimal rain gauge network
3. Study of intensity - frequency - duration curves
4. Study of depth - area – duration curve
5. Analysis of rainfall data and estimation of mean rainfall by different methods
6. Analysis of frequency of hydrologic data and estimation of missing data, test for consistency of rainfall records
7. Computation of infiltration indices
8. Computation of peak runoff and runoff volume by Cook's method and rational formula
9. Computation of runoff volume by SCS curve number method
10. Study of stream gauging instruments - current meter and stage level recorder
11. Study and determination of geomorphic parameters of watersheds
12. Study of runoff hydrograph and separation of base flow and surface flow
13. Study of unit hydrograph
14. Study of synthetic hydrograph
15. Study of flood routing
16. Study of various discharge measuring devices
17. Practical Examination

**Suggested Readings**


1. Chow, V. T., Maidment, D. R. and Mays, L. W. 2010. Applied Hydrology. McGraw Hill, New York.
2. Das, G. 2000. Hydrology and Soil Conservation Engineering. PHI, New Delhi.
3. Garg, S. K. 1998. Hydrology and Water Resources Engineering. Khanna Publishers, Delhi.
4. Jaya Rami Reddy, P. 2011. A Text Book of Hydrology. University Science Press, New Delhi.
5. Linsley, R. K., Kohler, M. A., and Paulhus, J. L. H. 1984. Hydrology for Engineers. McGraw-Hill Publishing Co., Japan.
6. Mutreja, K. N. 1990. Applied Hydrology. Tata McGraw-Hill Publishing Co., New Delhi.
7. Panigrahi, B. and Panigrahi, K. 2016. Engineering Hydrology. New India Publishing Agency, New Delhi.
8. Raghunath, H. M. 2006. Hydrology: Principles Analysis and Design. 2nd Edition, New Age International (P) Limited Publishers, New Delhi.
9. Subramanya, K. 2008. Engineering Hydrology. 3rd Edition, Tata McGraw-Hill, New Delhi.
10. Suresh, R. 2005. Watershed Hydrology. Standard Publishers and Distributors, Delhi.
11. Varshney, R. S. 1986. Engineering Hydrology. Nem Chand and Brothers, Roorkee, U.P.

# SWC 2206 Soil and Water Conservation Engineering 3 (2+1)

**Objective**

To make the students acquainted with the different causes of soil erosion and water loss and the different measures for soil and water conservation.

**Theory**

**Module I** **(7 Hours)**

Soil erosion: Introduction, causes and types - geological and accelerated erosion, agents, factors affecting and effects of erosion. Water erosion: Mechanics and forms- splash, sheet, rill, gully, ravine and stream bank erosion; Gullies: classification, stages of development; Soil loss estimation– Universal soil loss equation (USLE) and modified USLE. Rainfall erosivity- estimation by KE>25 and $EI_{30}$ methods; Soil erodibility- topography, crop management and conservation practice factors; Measurement of soil erosion- Runoff plots, soil samples.

**Module II** **(7 Hours)**

Water erosion control measures: Agronomical measures, contour farming, strip cropping, conservation tillage and mulching; Engineering measures- bunds and terraces, bunds: contour and graded bunds- design and surplussing arrangements; terraces: level and graded broad base terraces, bench terraces - planning, design and layout procedure, contour stone wall and trenching; Gully and ravine reclamation- principles of gully control, vegetative measures, temporary structures, and diversion drains. Grassed waterways and design.

**Module III** **(10 Hours)**

Energy and momentum principles in open channels; specific energy and specific force, hydraulic jump and its application, types of hydraulic jump, energy dissipation due to the jump. Soil erosion control structures- Introduction, classification and functional requirements. Permanent structures for soil conservation and gully control- check dams, drop, chute and drop inlet spillways- design requirements, planning for design, design procedures- hydrologic, hydraulic and structural design and stability analysis.

**Module IV** **(4 Hours)**

Wind erosion: Factors affecting, mechanics, soil loss estimation and control measures - vegetative, mechanical measures, wind breaks and shelter belts and stabilization of sand dunes. Land capability classification, dryland farming; Rate of sedimentation, silt monitoring and storage loss in tanks, control of sedimentation in reservoirs.

**Module V** **( 6 Hours)**

Water harvesting techniques: Classification based on source, storage and use, runoff harvesting- short-term and long-term techniques; Structures- farm ponds - dug-out and embankment reservoir types, tanks and subsurface dykes; Farm pond- components, site selection, design criteria, capacity, embankment, mechanical and emergency spillways, cost estimation and construction; Percolation pond - site selection, design and construction details. Design considerations of nala bunds.

**Practical**

Estimation of soil loss by USLE, computation of rainfall erosivity index, computation of soil erodibility index in soil loss estimation; Determination of length of slope (LS) and cropping practice (CP) factors; Estimation/measuring techniques of soil loss; Study of rainfall simulator for erosion assessment, estimation of sediment rate using Coshocton wheel sampler and multi-slot devisor; Determination of sediment concentration through oven drying method. Calculation of rate of sedimentation and storage loss in tanks; Study on sedimentation of reservoirs; Design and layout of contour bunds and graded bunds; Design and layout of broad base terraces and bench terraces; Design of vegetative waterways; Design of shelter belts and wind breaks for wind erosion control; Farm pond- design, capacity and estimation; Hydraulic design of drop spillway; Determination of uplift force and construction of uplift pressure diagram, structural design and stability analysis of drop spillway; Hydraulic and structural design of chute spillway, design of SAF energy dissipater; Design of drop inlet spillway; Study on components of earth embankments and its design; Design of water harvesting structures; Study on prioritization of watershed; Visit to soil erosion sites and watershed project areas for studying erosion control and water conservation measures; Visit to a watershed.

**Lecture Schedule**

1. Soil erosion: Introduction, causes and types - geological and accelerated erosion, agents, factors affecting and effects of erosion
2. Water erosion: Mechanics and forms- splash, sheet, rill, gully, ravine and stream bank erosion
3. Gullies: classification, stages of development
4. Soil loss estimation – Universal soil loss equation (USLE) and modified USLE. Rainfall erosivity - estimation by KE>25 and EI30 methods
5. Soil erodibility
6. Topography, crop management and conservation practice factors
7. Measurement of soil erosion- Runoff plots, soil samples
8. Water erosion control measures: Agronomical measures, contour farming, strip cropping, conservation tillage and mulching
9. Engineering measures - bunds and terraces, bunds: contour and graded bunds - design and surplussing arrangements
10. Engineering measures- bunds and terraces, bunds: contour and graded bunds - design and surplussing arrangements
11. Terraces: level and graded broad base terraces, bench terraces - planning, design and layout procedure, contour stone wall and trenching
12. Terraces: level and graded broad base terraces, bench terraces - planning, design and layout procedure, contour stone wall and trenching
13. Gully and ravine reclamation - principles of gully control, vegetative measures, temporary structures and diversion drains
14. Grassed waterways and design
15. Energy and momentum principles in open channels; specific energy and specific force
16. Hydraulic jump and its application, types of hydraulic jump, energy dissipation due to the jump
17. Soil erosion control structures - Introduction, classification and functional requirements
18. Classification of permanent gully control structures – check dams, drop spillways, drop inlet spillways and chute spillways

19. Drop spillways - design requirements, planning for design, design procedures - hydrologic, hydraulic, structural design and stability analysis
20. Drop spillways - design requirements, planning for design, design procedures - hydrologic, hydraulic and structural design and stability analysis.
21. Drop inlet spillways - design requirements, planning for design, design procedures - hydrologic, hydraulic and structural design and stability analysis.
22. Drop inlet spillways - design requirements, planning for design, design procedures - hydrologic, hydraulic and structural design and stability analysis.
23. Chute spillways - design requirements, planning for design, design procedures - hydrologic, hydraulic and structural design and stability analysis
24. Chute spillways - design requirements, planning for design, design procedures - hydrologic, hydraulic and structural design and stability analysis
25. Wind erosion: Factors affecting, mechanics
26. Wind erosion - Soil loss estimation and control measures - vegetative, mechanical measures, wind breaks and shelter belts and stabilization of sand dunes
27. Land capability classification
28. Dryland farming; Rate of sedimentation, silt monitoring and storage loss in tanks, control of sedimentation in reservoirs
29. Water harvesting techniques: Classification based on source, storage and use
30. Runoff harvesting- short-term and long-term techniques
31. Structures- farm ponds - dug-out and embankment reservoir types, tanks and subsurface dykes
32. Farm pond - components, site selection, design criteria, capacity, embankment, mechanical and emergency spillways, cost estimation and construction
33. Percolation pond - site selection, design and construction details
34. Design considerations of nala bunds

**Practical Schedule**

1. Estimation of soil loss by USLE, computation of rainfall erosivity index, computation of soil erodibility index in soil loss estimation, Determination of length of slope (LS), cropping practice (CP) factors and Estimation/measuring techniques of soil loss
2. Study of rainfall simulator for erosion assessment
3. Estimation of sediment rate using Coshocton wheel sampler and multi-slot devisor and determination of sediment concentration through oven drying method
4. Calculation of rate of sedimentation and storage loss in tanks and study on sedimentation of reservoirs
5. Design and layout of contour bunds and graded bunds
6. Design and layout of broad base terraces and bench terraces
7. Design of vegetative waterways
8. Design of shelter belts and wind breaks for wind erosion control
9. Farm pond- design, capacity, and estimation
10. Hydraulic design of drop spillway, determination of uplift force and construction of uplift pressure diagram, structural design and stability analysis of drop spillway
11. Hydraulic and structural design of chute spillway, design of SAF energy dissipater
12. Design of drop inlet spillway
13. Study on components of earth embankments and its design
14. Design of water harvesting structures

15. Study on prioritization of watershed
16. Visit to watershed and soil erosion sites and watershed project areas for studying erosion control and water conservation measures
17. Practical examination

**Suggested Readings**


1. Chow, V. T. 1985. Open-Channel Hydraulics. McGraw- Hill Book Company, Inc.
2. Das, G. 2000. Hydrology and Soil Conservation Engineering. Prentice Hall of India Pvt. Ltd, New Delhi.
3. Frevert, R. K., Schwab, G. O., Edminster, T. W. and Barnes, K. K. 2009. Soil and Water Conservation Engineering. 4th Edition, John Wiley and Sons, New York.
4. Mahnot, S. C. 2014. Soil and Water Conservation and Watershed Management. International Books and Periodicals Supply Service, New Delhi.
5. Michael, A. M. and Ojha, T. P. 2003. Principles of Agricultural Engineering. Volume II. 4th Edition, Jain Brothers, New Delhi.
6. Murthy, V. V. N. 2002. Land and Water Management Engineering. 4th Edition, Kalyani Publishers, New Delhi.
7. Norman Hudson. 1985. Soil Conservation. Cornell University Press, Ithaka, New York, USA.
8. Samra, J. S., Sharda, V. N. and Sikka, A. K. 2002. Water Harvesting and Recycling: Indian Experiences. CSWCR & TI, Dehradun, Allied Printers, Dehradun.
9. Sharda, V. N., Juyal, G. P., Prakash, C. and Joshi, B. P. 2007. Training Manual: Soil Conservation and Watershed Management (Vol.-II) – CSWCRTI Publication, Dehradun.
10. Singh, G., Venkataraman, C., Sastry, G. and Joshi, B. P. 1996. Manual of Soil and Water Conservation Practices. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
11. Suresh, R. 2014. Soil and Water Conservation Engineering. Standard Publisher Distributors, New Delhi.
12. USDA. 1964. Engineering Hand Book on Drop Spillways (Section-11). USDA, Soil Conservation Service.


## SWC 4107 Watershed Planning and Management 3 (2+1)

**Objective**

To acquaint the students with different aspects of watershed planning and management including participatory approaches and also on the integrated watershed management practices

**Theory**

**Module I** **(6 Hours)**

Introduction and characteristics of watersheds, Watershed management: concept, objectives, factors affecting watershed planning based on land capability classes, Hydrologic data for watershed planning, Watershed codification, delineation, and prioritization of watersheds, sediment yield index.

**Module II** **(4 Hours)**

Community mobilization and participatory institution building, Participatory watershed management, Roles of watershed associations, user groups, and self-help groups, Participatory

Rural Appraisal (PRA), Understanding gender in relation to agriculture.

**Module III** **(5 Hours)**

Water budgeting in a watershed, Management measures including rainwater conservation technologies (in-situ and ex-situ storage), Water harvesting and recycling, Dry farming techniques - inter-terrace and inter-bund land management.

**Module IV** **(5 Hours)**

Integrated watershed management: concept, components, Management of arable lands (agriculture and horticulture) and non-arable lands (forestry, fishery, and animal husbandry), Effect of cropping systems, land management, and cultural practices on watershed hydrology.

**Module V** **(10 Hours)**

Application of remote sensing and GIS in watershed planning and management, Introduction to Remote Sensing and GIS, Map projections, coordinate systems, spatial data structures (raster and vector), Spatial relationships, topology, delineation of watersheds, generation of stream networks, Preparation of thematic maps, hydrological response unit (HRU), watershed prioritization, watershed characterization, watershed action plan Analytical Hierarchy Process, Watershed evaluation and impact assessment, quantification of surface and groundwater resources, computer models used for hydrologic and watershed modelling (including computer models and Soil water assessment tool (SWAT)), Case studies

**Module VI** **(4 Hours)**

Watershed programme execution, follow-up practices, maintenance, monitoring, and evaluation, Planning and formulation of project proposal for watershed management programme including cost-benefit analysis, financial management and accounting procedure.

**Practical**

Delineation of watersheds using toposheets; Surveying and preparation of watershed map; Quantitative analysis of watershed characteristics and parameters; Investigations on watershed for planning and development including PRA; Analysis of hydrologic data for planning watershed management; Measurement of discharge and sediment in a watershed; Water budgeting of watersheds; Study of thematic maps using remote sensing; Study of watershed action plan using GIS; Prioritization of watersheds based on sediment yield index; Study of functional requirement of watershed development structures; Study on components of earth embankments and its design; Study of watershed management technologies; Study of role of various functionaries in watershed development programs; Study of accounting and financial management systems in watershed entities; Visit to watershed development project areas.

**Lecture Schedule**

1. Introduction to Watersheds
2. Characteristics of Watersheds
3. Watershed Management Concepts and Objectives
4. Factors Affecting Watershed Planning, based on land capability classes
5. Hydrologic Data for Watershed Planning
6. Watershed Codification, Delineation, and Prioritization of Watersheds - sediment yield index

7. Community Mobilization and participatory institution building – participatory watershed management
8. Roles of Watershed Associations, User Groups, and Self-Help Groups (SHGs)
9. Participatory Rural Appraisal (PRA)
10. Understanding Gender in Agriculture and Watershed Management
11. Water Budgeting in watershed
12. Management measures: Rainwater Conservation Technologies (In-situ) storage
13. Management measures: Rainwater Conservation Technologies (Ex-situ) storage
14. Water Harvesting and Recycling
15. Dry Farming Techniques – inter terrace and inter bund land management
16. Introduction to Integrated Watershed Management
17. Components of Integrated Watershed Management
18. Management of Arable Lands (Agriculture and horticulture)
19. Management of Non-Arable Lands (Forestry, Fisheries and Animal Husbandry)
20. Effect of cropping Systems, land management and cultural Practices on watershed hydrology
21. Introduction and application of Remote Sensing and GIS in watershed planning and management
22. Map Projections, Coordinate Systems and Spatial Data Structures – raster and vector
23. Spatial relationships topology
24. Delineation of Watersheds and Generation of stream networks
25. Preparation of Thematic Maps, Hydrological Response Units (HRUs)
26. Watershed Prioritization and Characterization
27. Watershed action plan
28. Analytical Hierarchy Process (AHP)
29. Watershed evaluation and impact assessment, quantification of surface and groundwater resources in watershed, computer models used for hydrology and watershed modelling
30. Soil water assessment tool (SWAT) – case study
31. Execution of Watershed Programmes
32. Follow-Up Practices, maintenance, monitoring and evaluation
33. Planning and Formulation of Project Proposals for watershed management programme including cost benefit analysis
34. Financial Management and Accounting Procedures

**Practical Schedule**

1. Delineation of Watersheds Using Toposheets
2. Surveying and Preparation of Watershed Maps
3. Quantitative Analysis of Watershed Characteristics and Parameters
4. Investigations on Watershed for Planning and Development (including PRA)
5. Analysis of Hydrologic Data for Planning Watershed Management
6. Measurement of Discharge and sediment in a Watershed
7. Water Budgeting of Watersheds
8. Study of Thematic Maps Using Remote Sensing
9. Study of Watershed Action Plan Using GIS
10. Prioritization of Watersheds Based on Sediment Yield Index
11. Study of Functional Requirements of Watershed Development Structures
12. Study on Components of Earth Embankments and Their Design

13. Study of Watershed Management Technologies
14. Study of the Role of Various Functionaries in Watershed Development Programs
15. Study of Accounting and Financial Management Systems in Watershed Entities
16. Visit to Watershed Development Project Areas
17. Practical Examination

**Suggested Readings**


1. Das, G. 2008. Hydrology and Soil Conservation Engineering: Including Watershed Management. 2nd edn. Prentice-Hall of India Learning Pvt. Ltd., New Delhi.
2. Katyal, J. C., Singh, R. P., Sharma, S., Das, S. K., Padmanabhan, M. V. and Mishra, P. K. 1995.Field Manual on Watershed Management. CRIDA, Hyderabad.
3. Mahnot, S. C. 2014. Soil and Water Conservation and Watershed Management. International Books and Periodicals Supply Service. New Delhi.
4. Rajora, R. 2019.Integrated Watershed Management. Rawat Publications, New Delhi.
5. Sharda, V. N., Sikka, A. K. and Juyal, G. P. 2006. Participatory Integrated Watershed Management: A Field Manual. Central Soil and Water Conservation Research and Training Institute, Dehradun.
6. Singh, G. D. and Poonia, T. C. 2003. Fundamentals of Watershed Management Technology. Yash Publishing House, Bikaner.
7. Thomas, C. G. 2010. Land Husbandry and Watershed Management. Kalyani Publishers, Ludhiana.

## Department of Soil and Water Conservation Engineering - Elective Courses

## ESW 4201 Floods and Control Measures 3 (2+1)

**Objective**

To enable the students to understand the flood forecasting and warning systems, different permanent and temporary control measures of flood, and to design of storage structures and dams

**Theory**

**Module I** **(4 Hours)**

Floods - Causes of Flood Occurrence, Flood Classification, Probable Maximum Flood, Standard Project Flood, Design Flood, Flood Estimation: Methods of Estimation

**Module II** **(9 Hours)**

Estimation of Flood Peak: Rational Method, Empirical Methods, Unit Hydrograph Method, Statistics in Hydrology, Flood Frequency Methods: Log Normal Distribution, Gumbel's Extreme Value, Log-Pearson Type-III Distribution, Depth-Area-Duration Analysis, Flood Forecasting.

**Module III** **(4 Hours)**

Flood Routing: Channel Routing, Muskingum Method, Reservoir Routing, Modified Pul's Method.

**Module IV** **(6 Hours)**

Flood Control: History of Flood Control - Structural Measures and Non-Structural Measures, Storage and Detention Reservoirs, Levees, Channel Improvement

**Module V** **(11 Hours)**

Gully Erosion and Control Structures, Design and Implementation, Earthen Embankments, Functions and Classification, Hydraulic Fill and Rolled Fill Dams, Homogeneous, Zoned, and Diaphragm Type, Foundation Requirements, Grouting, Seepage Through Dams, Flow Net and Its Properties, Seepage Pressure, Seepage Line in Composite Earth Embankments, Drainage Filters, Piping and Its Causes, Design and Construction of Earthen Dams, Stability of Earthen Embankments Against Failure, Tension, Overturning, Sliding, Stability of Slopes, Analysis of Failure by Different Methods, Planning of Flood Control Projects and Their Economics

**Practical**

Determination of flood stage-discharge relationship in a watershed; Determination of flood peak-area relationships; Determination of frequency distribution functions for extreme flood values using Gumbel's method; Determination of confidence limits of the flood peak estimates for Gumbel's extreme value distribution; Determination of frequency distribution functions for extreme flood values using log-Pearson Type-III distribution; Determination of probable maximum flood, standard project flood and spillway design flood; Design of levees for flood control; Designing, planning and cost- benefit analysis of a flood control project; Design of earthen dams; Determination of the position of phreatic line in earth dams for various conditions, stability analysis of earthen dams against head water pressure, foundation shear, sudden draw down

condition; Stability of slopes of earth dams by friction circle and other methods; Construction of flow net for isotropic and anisotropic media; Computation of seepage by different methods; Determination of settlement of earth dam; Input-output-storage relationships by reservoir routing; Study of reservoir rule curve; Visit to earthen dam and flood control reservoir.

**Lecture Schedule**

1. Floods - Causes of Flood Occurrence
2. Flood Classification: Probable Maximum Flood, Standard Project Flood and Design Flood
3. Flood Classification: Probable Maximum Flood, Standard Project Flood and Design Flood
4. Flood Estimation: Methods of Estimation
5. Estimation of Flood Peak: Rational Method
6. Estimation of Flood Peak: Empirical Methods
7. Estimation of Flood Peak: Unit Hydrograph Method
8. Statistics in Hydrology
9. Flood Frequency Methods: Log Normal Distribution
10. Flood Frequency Methods: Gumbel's Extreme Value
11. Flood Frequency Methods: Log-Pearson Type-III Distribution
12. Depth-Area-Duration Analysis
13. Flood Forecasting
14. Flood Routing: Channel Routing
15. Flood Routing: Muskingum Method
16. Flood Routing: Reservoir Routing
17. Flood Routing: Modified Pul's Method
18. Flood Control: History of Flood Control
19. Structural Measures of Flood Control
20. Non-Structural Measures of Flood Control
21. Storage and Detention Reservoirs
22. Levees in Flood Control
23. Channel Improvement Techniques
24. Case Studies on Flood Control
25. Gully Erosion and Control Structures - Design and Implementation
26. Earthen Embankments: Functions and Classification
27. Hydraulic Fill and Rolled Fill Dams, Homogeneous, Zoned, and Diaphragm Type
28. Foundation Requirements, Grouting, Seepage Through Dams
29. Flow Net and Its Properties
30. Seepage Pressure, Seepage Line in Composite Earth Embankments
31. Drainage Filters, Piping and Its Causes
32. Design and Construction of Earthen Dams
33. Stability of Earthen Embankments Against Failure, Tension, Overturning, Sliding, Stability of Slopes, Analysis of Failure by Different Methods
34. Planning of Flood Control Projects and Their Economics

**Practical Schedule**

1. Determination of Flood Stage-Discharge Relationship in a Watershed
2. Determination of Flood Peak-Area Relationships
3. Determination of Frequency Distribution Functions for Extreme Flood Values Using

Gumbel's Method and Confidence Limits of Flood Peak Estimates for Gumbel's extreme value distribution
4. Determination of Frequency Distribution Functions for Extreme Flood Values Using Log-Pearson Type-III Distribution
5. Determination of Probable Maximum Flood, Standard Project Flood, and Spillway Design Flood
6. Design and planning of Levees for Flood Control and Cost-Benefit Analysis of a Flood Control Project
7. Design of Earthen Dams and determination of the Position of Phreatic Line in Earth Dams for Various Conditions
8. Stability Analysis of Earthen Dams Against Head Water Pressure and Foundation Shear
9. Stability Analysis of Earthen Dams Under Sudden Draw Down Condition
10. Stability of Slopes of Earth Dams by Friction Circle and Other Methods
11. Construction of Flow Net for Isotropic and Anisotropic Media
12. Computation of Seepage by Different Methods
13. Determination of Settlement of Earth Dam
14. Input-Output-Storage Relationships by Reservoir Routing
15. Study of Reservoir Rule Curve
16. Visit to Earthen Dam and Flood Control Reservoir
17. Practical Examination

**Suggested Readings**


1. Arora, K. R. 2014. Soil Mechanics and Foundation Engineering (Geotechnical Engineering). Standard Publishers Distributors, Delhi.
2. Bureau of Reclamation. 1987. Design of Small Dams. US Department of Interior, Washington DC, USA.
3. Garg, S. K. 2014. Soil Mechanics and Foundation Engineering. Khanna Publishers, Delhi.
4. Garg, S. K. 2018. Irrigation Engineering and Hydraulic Structures. Khanna Publishers, Delhi
5. Michael, A, M. and Ojha, T. P. 2003. Principles of Agricultural Engineering. Volume II. 4th Edition, Jain Brothers, New Delhi.
6. Modi, P. N. 2010. Irrigation and Water Power Engineering. Standard Publishers Distributors, Delhi.
7. Murthy, V. V. N. 2010. Land and Water Management Engineering. 4th Edition, Kalyani Publishers, New Delhi.
8. Mutreja, K. N. 1990. Applied Hydrology. Tata McGraw-Hill Publishing Co., New York, Delhi.
9. Stephens, Tim. 2010. Manual on Small Earth Dams - A Guide to Siting, Design and Construction. Food and Agriculture Organization of the United Nations, Rome.
10. Subramanya, K. 2008. Engineering Hydrology. 3rd edn, Tata McGraw-Hill Publishing Co., New Delhi.
11. Suresh, R. 2014. Soil and Water Conservation Engineering. Standard Publisher Distributors, New Delhi.

# ESW 4202 Remote Sensing and GIS Applications 3 (2+1)

**Objective**

To enable the students to know about the remote sensing methods and applications in NRM, digital image processing and concepts of GIS and data management

**Theory**

**Module I** **(8 Hours)**

Introduction to Remote Sensing – Basic Components; Advantages and limitations of Remote Sensing, possible use of RS techniques in assessment and monitoring of land and water resources; electromagnetic spectrum, energy interactions in the atmosphere and with the Earth's surface; major atmospheric windows, principal applications of different wavelength regions, typical spectral reflectance curve for vegetation, soil and water; spectral signatures, different types of sensors and platforms; contrast ratio and possible causes of low contrast.

**Module II** **(9 Hours)**

Aerial photography; Types of aerial photographs, scale of aerial photographs, planning aerial photography- end lap and side lap, stereoscopic vision, requirements of stereoscopic photographs; Air-photo interpretation - interpretation elements; Photogrammetry - measurements on a single vertical aerial photograph, measurements on a stereo - pair- vertical measurement by the parallax method; Ground control for aerial photography; satellite remote sensing, multispectral scanner - whiskbroom and push-broom scanner; Different types of resolutions.

**Module III** **(8 Hours)**

Digital Image Processing - analysis of digital data- image restoration; image enhancement; Information extraction; Image classification - unsupervised classification, supervised classification, important consideration in the identification of training areas; vegetation indices; Microwave remote sensing.

**Module IV** **(9 Hours)**

GIS and basic components, different sources of spatial data, basic spatial entities, major components of spatial data; Basic classes of map projections and their properties; Methods of data input into GIS, data editing, spatial data models and structures, attribute data management, integrating data (map overlay) in GIS; Application of remote sensing and GIS for the management of land and water resources.

**Practical**

Familiarization with remote sensing and GIS hardware; Use of software for image interpretation; Interpretation of aerial photographs and satellite imagery; Basic GIS operations such as image display; Study of various features of GIS software package; Scanning, digitization of maps and data editing; Data base query and map algebra; GIS supported case studies in water resources management.

**Lecture Schedule**

1. Introduction to Remote Sensing – Basic Components, Advantages and limitations of Remote Sensing and use of RS techniques in land and water resource assessment and monitoring

2. Electromagnetic Spectrum – Introduction and Overview
3. Energy interactions in the atmosphere and with Earth's Surface
4. Major Atmospheric Windows and Principal Applications of Wavelength Regions
5. Typical spectral Reflectance Curves for Vegetation, Soil, and Water
6. Spectral Signatures and Their Importance in RS
7. Types of Sensors and Platforms in RS
8. Contrast ratio and possible causes of low contrast
9. Introduction to aerial photography – Types and Scales
10. Planning Aerial Photography – End Lap, Side Lap, and Stereoscopic Vision, requirements of stereoscopic photographs
11. Air-photo Interpretation – Elements and Techniques
12. Photogrammetry - Measurements on a Single Vertical Aerial Photograph
13. Measurements on a Stereo Pair – Parallax Method for Vertical Measurement
14. Ground Control for Aerial Photography
15. Satellite RS and Multispectral Scanners
16. Whiskbroom and Push-broom Scanners
17. Different Types of Resolutions in RS
18. Digital image processing - Analysis of digital data, Image Restoration Techniques in RS
19. Image Enhancement Techniques
20. Information Extraction from Remote Sensing Data
21. Image classification - Unsupervised Classification Techniques in RS
22. Supervised Classification Techniques in RS
23. Considerations for Identifying Training Areas in Image Classification
24. Vegetation Indices and their Applications in RS
25. Introduction to Microwave RS
26. GIS – Fundamentals, components, and applications
27. Different Sources of Geospatial Data
28. Basic Spatial Entities and their representation, major components of spatial data
29. Basic Map Projections and Their Properties
30. Data Input Methods in GIS
31. Data Editing and Management in GIS, attribute data management
32. Spatial Data Models and Structures in GIS
33. Integrating Data in GIS – Map Overlays and Applications
34. Application of RS and GIS in Land and Water Resource Management

**Practical Schedule**

1. Familiarization with Remote Sensing and GIS hardware
2. Introduction to image interpretation software
3. Aerial photograph interpretation - Identifying key features; landforms, water bodies, vegetation, and man-made structures
4. Satellite imagery interpretation
5. Introduction to GIS software interfaces, Basic GIS operations such as image display; Study of various features of GIS software package
6. Loading and displaying raster and vector data, Basic operations - zooming, panning, and querying data
7. Georeferencing of basemap – toposheet
8. Scanning and Digitization of Toposheet and vector data generation

9. Scanning and Digitization of Toposheet and vector data generation
10. Data Editing
11. Conversion between Raster and Vector Data
12. Map projections
13. Database Queries and Map Algebra
14. Digital Elevation Models
15. GIS-Supported Case Study in Water Resources Management
16. GIS-Supported Case Study in Water Resources Management
17. Practical examination

**Suggested Readings**


1. Chang, K. T. 2014. Introduction to Geographic Information System, McGraw Hill.
2. Elangovan, K. 2006. GIS Fundamentals Applications and Implementations. New India Publication Agency, New Delhi.
3. George, J. 2005. Fundamentals of Remote Sensing. 2nd Edn. Universities Press (India) Private Limited, Hyderabad.
4. Jensen, J. R. 2013. Remote Sensing of the Environment: An Earth Resource Perspective. Pearson Education Limited, UK.
5. Lillesand, T., Kiefer, R. W. and Chipman, J. 2015. Remote Sensing and Image Interpretation. 7th Edition, John Wiley and Sons Singapore Pvt. Ltd., Singapore.
6. Reddy, A. M. 2006. Textbook of Remote Sensing and Geographical Information Systems. BS Publications, Hyderabad.
7. Sabins, F. F. 2007. Remote Sensing: Principles and Interpretation. Third Edition, Waveland Press Inc., Illinois, USA.
8. Sahu, K. C. 2008. Text Book of Remote Sensing and Geographic Information Systems. Atlantic Publishers and Distributors (P) Ltd., New Delhi.
9. Shultz, G. A. and Engman, E. T. 2000. Remote Sensing in Hydrology and Water Management. Springer, New York.


## ESW 4203 Information Technology for Land and Water Management 3 (2+1)

**Objective**

To enable the students to understand the application of IT natural resources management and design and application of decision support system and expert systems for NRM.

**Theory**

**Module I** **(9 Hours)**

Concept of Information Technology (IT) and its application potential, role of IT in natural resources management; Existing system of information generation and organizations involved in the field of land and water management; Application and production of multimedia, internet application tools and web technology, networking system of information, problems and prospects of new information and communication technology.

**Module II** **(10 Hours)**

Development of database concept for effective natural resources management; Application of remote sensing, geographic information system (GIS) and GPS; integration of Remote sensing,

GIS and GPS for land and water management applications, Modelling using GPS data, RS, GIS.

**Module III** **(6 Hours)**

Rational data base management system, object-oriented approaches; Information system, decision support systems and expert systems.

**Module IV** **(9 Hours)**

Agricultural information management systems - use of mathematical models and programs; Application of decision support systems, multi sensor data loggers and overview of software packages in natural resource management. Video-conferencing of scientific information. Artificial Intelligence in Natural Resource Management.

**Practical**

Multimedia production; Internet applications: E-mail, voice mail, web tools and technologies; Handling and maintenance of new information technologies and exploiting their potentials; Exercises on database management using database and spreadsheet programs; Usage of remote sensing, GIS and GPS survey in information generation and processing; Exercises on running computer software packages dealing with water balance, crop production, land development, land and water allocation, watershed analysis etc.; Exercises on simple decision support and expert systems for management of natural resources; Multimedia production using different softwares; Exercises on development of information system on selected theme(s); Video-conferencing of scientific information.

**Lecture Schedule**

1. Concept of Information Technology (IT) and Its Application Potential
2. Role of IT in Natural Resource Management
3. Existing system of information generation and organizations involved in the field of land and water management
4. Existing system of information generation and organizations involved in the field of land and water management
5. Application and production of multimedia
6. Internet Application Tools and Web Technology
7. Internet Application Tools and Web Technology
8. Networking Systems of Information
9. Problems and Prospects of New Information and Communication Technology
10. Database Concept for Effective Natural Resource Management
11. Development of Databases for Effective Natural Resource Manage
12. Development of Databases for Effective Natural Resource Manage
13. Introduction to Remote Sensing
14. Application of Remote Sensing in Natural Resource Management
15. Geographic Information System (GIS) in land and water management
16. GPS technology and its application
17. Integration of Remote Sensing, GIS, and GPS
18. Modelling using GIS, RS and GPS
19. Modelling using GIS, RS and GPS
20. Database Management System (DBMS) and its types
21. Rational Database Management Systems

22. Object-Oriented Approaches in DBMS
23. Information Systems for Natural Resource Management
24. Decision Support Systems (DSS) and expert systems and its application
25. Decision Support Systems (DSS) and expert systems and its application
26. Agricultural Information Management Systems
27. Mathematical model – their classification
28. Use of Mathematical Models and Programs for LWR management
29. Use of Mathematical Models and Programs for LWR management
30. Multi-Sensor Data Loggers and its application
31. Overview of Software Packages for Natural Resource Management
32. Overview of Software Packages for Natural Resource Management
33. Role of Video-Conferencing in Scientific Information
34. Artificial Intelligence in Natural Resource Management

**Practical Schedule**

1. Introduction to Multimedia Production
2. Internet Applications: E-mail, voice mail, web tools and technologies
3. Handling and maintenance of new information technologies and exploiting their potentials
4. Exercises on Database Management Using Database and Spreadsheet Programs
5. Remote Sensing for Information Generation and Processing
6. GIS for Information Generation and Processing
7. GPS survey for Information Generation and Processing
8. Exercises on Running Software Packages for Water Balance Modelling
9. Crop Production Modelling Using Software
10. Land Development, land and water allocation Software
11. Watershed Analysis Using GIS
12. Exercises on simple decision support and expert systems for management of natural resources
13. Multimedia production using different software
14. Exercises on development of information system on selected theme(s)
15. Exercises on development of information system on selected theme(s)
16. Video-conferencing of scientific information.
17. Practical examination

**Suggested Readings**


1. Bian F and Xie Y (Eds.). 2015. *Geo-Informatics in Resource Management and Sustainable Ecosystem*. Springer, New York
2. De, D. and Basavaprabhu, J. (Eds). 2010. Communication Support for Sustainable Development. Ganga Kaveri Publishing House, Varanasi.
3. FAO. 1998. Land and Water Resources Information Systems. FAO Land and Water Bulletin 7, Rome.
4. FAO. 2013. Climate-Smart Agriculture- Source Book. FAO, Rome.
5. ICFAI Business School (IBS). 2012. Information Technology and Systems. IBS Centre for Management Research, Hyderabad.
6. Loucks, D. P. and Beek, E. V. 2005. Water Resources Systems Planning and Management - An Introduction to Methods, Models and Applications. UNESCO, Paris.
7. Malliva, R. and Thomas, M. 2012. Arid Lands Water Evaluation and Management. Environmental Science. Springer, New York.

8. Sarvanan, R. 2011. Information and Communication Technology for Agriculture and Rural Development. New India Publishing Agency, New Delhi.
9. Soam, S. K., Sreekanth, P. D. and Rao, N. H. (Eds). 2013. Geospatial Technologies for Natural Resources Management. New India Publishing Agency, Delhi.

## ESW 4204 Wasteland Development 3 (2+1)

**Objective**

- To enable the students to plan for wasteland development keeping in view of agro-climatic conditions, development options, contingency plans, conservation measures, water harvesting and recycling methods in consideration
- To know the different land reclamation and rehabilitation measures for wasteland development and use of micro-irrigation for sustainable wasteland development against adverse situations like drought and water-scarce situations

**Theory**

**Module I** **(7 Hours)**

Land degradation: concept, classification, arid, semiarid, humid, and sub-humid regions, Troll's climatic classification, denuded rangeland and marginal lands, wastelands: factors causing wastelands, classification, and mapping of wastelands, planning of wasteland development: constraints, agro-climatic conditions, development options, contingency plans.

**Module II** **(8 Hours)**

Conservation structures: gully stabilization, ravine rehabilitation, sand dune stabilization, water harvesting and recycling methods, afforestation: agro-horti-forestry, silvipasture methods, forage and fuel crops, socioeconomic constraints in afforestation

**Module III** **(7 Hours)**

Shifting cultivation, optimal land use options, wasteland development: hills, semi-arid, coastal areas, water-scarce areas, reclamation of waterlogged and salt-affected lands

**Module IV** **(6 Hours)**

Mine spoils: impact, land degradation, and reclamation, rehabilitation and slope stabilization, mine environment management, micro-irrigation in wasteland development, sustainable wasteland development in drought situations, socio-economic perspectives in sustainable wasteland development

**Module V** **(6 Hours)**

Participatory approach in wasteland management, preparation of proposal for wasteland development, benefit-cost analysis of wasteland development projects

**Practical**

Mapping and classification of wastelands; Identification of factors causing wastelands; Estimation of vegetation density and classification; Planning and design of engineering measures for

reclamation of wastelands; Design and estimation of different soil and water conservation structures under arid, semi-arid and humid conditions; Planning and design of micro-irrigation in wasteland development; Study on utilization of fly-ash in hydraulic structures; Study on mine spoil areas by plantation; Study on mine spoil areas by back filling of fly-ash; Study on environmental impact assessment (EIA) of mine spoil areas; Cost estimation of the various wasteland development measures; Study on PRA exercise on wasteland management; Preparation of DPR of wasteland development projects; Visit to wasteland development project sites.

**Lecture Schedule**

1. Land degradation: concept, classification
2. Arid, semiarid, humid, and sub-humid regions
3. Troll's climatic classification
4. Denuded rangeland and marginal lands
5. Wastelands: factors causing wastelands
6. Classification and mapping of wastelands
7. Planning of wasteland development: constraints, agro-climatic conditions, development options, contingency plans
8. Conservation structures: gully stabilization
9. Ravine rehabilitation
10. Sand dune stabilization
11. Water harvesting methods
12. Water recycling methods
13. Afforestation: agro-horti-forestry methods
14. Silvipasture methods, forage and fuel crops
15. Socioeconomic constraints in afforestation
16. Shifting cultivation
17. Optimal land use options
18. Wasteland development: hills
19. Wasteland development: semi-arid areas
20. Wasteland development: coastal areas and water scarce areas
21. Wasteland development: coastal areas and water scarce areas
22. Reclamation of waterlogged and salt-affected lands
23. Mine spoils: impact, land degradation, and reclamation
24. Rehabilitation and slope stabilization
25. Mine environment management
26. Micro-irrigation in wasteland development
27. Sustainable wasteland development in drought situations
28. Socio-economic perspectives in sustainable wasteland development
29. Analysis of drought situations
30. Socio-economic considerations in development
31. Participatory approach in wasteland management
32. Preparation of proposal for wasteland development
33. Preparation of proposal for wasteland development
34. Benefit-cost analysis of wasteland development projects

**Practical Schedule**

1. Mapping and classification of wastelands
2. Identification of factors causing wastelands
3. Estimation of vegetation density and classification
4. Planning and design of engineering measures for reclamation of wastelands
5. Design and estimation of different soil and water conservation structures under arid conditions
6. Design and estimation of different soil and water conservation structures under semi-arid conditions
7. Design and estimation of different soil and water conservation structures under humid conditions
8. Planning and design of micro-irrigation in wasteland development
9. Study on utilization of fly-ash in hydraulic structures
10. Study on mine spoil areas by plantation
11. Study on mine spoil areas by backfilling of fly-ash
12. Study on environmental impact assessment (EIA) of mine spoil areas
13. Cost estimation of the various wasteland development measures
14. Study on Participatory Rural Appraisal (PRA) exercise on wasteland management
15. Preparation of Detailed Project Report (DPR) of wasteland development projects
16. Visit to wasteland development project sites
17. Practical examination

**Suggested Readings**


1. Abrol, I. P. and Dhruvanarayana, V. V. 1998. Technologies for Wasteland Development. ICAR, New Delhi.
2. Ambast, S. K., Gupta, S. K. and Singh, G. (Eds). 2007. Agricultural Land Drainage - Reclamation of Waterlogged Saline Lands. Central Soil Salinity Research Institute, Karnal, Haryana.
3. Karthikeyan, C., Thangaraja, K., Fernandez, C. C. and Chandrakandon, K. 2009. Dryland Agriculture and Wasteland Management. Atlantic Publishers and Distributors Pvt. Ltd., New Delhi.
4. Lal, R. and Stewart, B. A. (Eds). 2015. Soil Management of Smallholder Agriculture. Volume 21 of Advances in Soil Science. CRC Press, USA.
5. Malliva, R. and Missimer, T. 2012. Arid Lands Water Evaluation and Management. Springer Heidelberg, New York.
6. Pachauri, R. K. and Sridharan, P. V. (Eds) 2003. Looking Back to Think Ahead Green India 2047. TERI, New Delhi.
7. Swaminathan, M. S. 2010. Science and Integrated Rural Development. Concept Publishing Company (P) Ltd., Delhi.
8. Virmani, S. M (Ed.). 2010. Degraded and Wastelands of India: Status and Spatial Distribution. ICAR, New Delhi.
9. Yadav, H. R. 2013. Management of Wastelands. Concept Publishing Company. New Delhi

## ESW 4205 Application of Plastics in Agriculture 3 (2+1)

**Objective**

To enable the students to understand the applications in moisture conservation, canal and pond lining, use of plastic pipes in irrigation and drainage; know about soil solarisation, mulching, covering materials in green houses, shade houses, poly houses, surface covered cultivation, plastic fencing, nets for insects, birds etc. and in food grain structures, packaging materials, aquaculture, etc.

**Theory**

**Module I** **(6 Hours)**

Introduction of plasticulture - types and quality of plastics used in soil and water conservation, production agriculture and post-harvest management, present status and future prospective of plasticulture in India, quality control measures.

**Module II** **(11 Hours)**

Water management - use of plastics in in-situ moisture conservation and rain water harvesting. Plastic film lining in canal, pond and reservoir, plastic pipes for irrigation water management, bore-well casing and subsurface drainage, drip and sprinkler irrigation systems, use of polymers in control of percolation losses in fields; Soil conditioning - soil solarisation, effects of different colour plastic mulching in surface covered cultivation.

**Module III** **(12 Hours)**

Nursery management - use of plastics in nursery raising, nursery bags, trays, etc.; Controlled environmental cultivation - plastics as cladding material, green/poly/shade net houses, wind breaks, poly tunnels and crop covers; Plastic nets for crop protection- anti insect nets, bird protection nets, plastic fencing. Plastics in drying, preservation, handling and storage of agricultural produce, innovative plastic packaging solutions for processed food products, Plastic CAP covers for storage of food grains in open; Use of plastics as alternate material for manufacturing farm equipment and machinery.

**Module IV** **(5 Hours)**

Plastics for aquacultural engineering and animal husbandry - animal shelters, vermi-beds and inland fisheries; Silage film technique for fodder preservation; Agencies involved in the promotion of plasticulture in agriculture at national and state level. Human resource development in plasticulture applications.

**Practical**

Design, estimation and laying of plastic films in lining of canal, reservoir and water harvesting ponds; Study of plastic components of drip and sprinkler irrigation systems, laying and flushing of laterals; Study of components of subsurface drainage system; Study of different colour plastic mulch laying; Design, estimation and installation of green, poly and shade net houses, low tunnels, etc; Study on CAP device for food grain storage; Study of innovative packaging solutions - leno bags, crates, bins, boxes, vacuum packing, unit packaging, CAS and MAP; Study on use of plastics in nursery, plant protection, inland fisheries, animal shelters; Preparation of vermi-bed and silage film for fodder preservation; Study of plastic parts in making farm machinery; Visits to nearby manufacturing units/ dealers of PVC pipes, drip and sprinkler irrigation systems, greenhouse/ poly-

house/ shade-house/ net-house etc; Visits to farmers' fields with these installations.

**Lecture Schedule**

1. Introduction to Plasticulture
2. Types and quality of plastics used in soil and water conservation, production agriculture and post-harvest management
3. Types and quality of plastics used in soil and water conservation, production agriculture and post-harvest management
4. Present status and future prospective of plasticulture in India
5. Quality control measures
6. Quality control measures
7. Water management: Plastics for in-situ moisture conservation
8. Water management: Plastics for in-situ moisture conservation
9. Water management: Use of plastics in rainwater harvesting
10. Plastic film lining in canals, ponds, and reservoirs
11. Plastic pipes for irrigation water management
12. Bore-well casing and subsurface drainage using plastics
13. Drip and sprinkler irrigation systems: Use of plastics and benefits
14. Use of polymers in controlling percolation losses in agricultural fields
15. Introduction to soil conditioning techniques with plastics – soil solarization
16. Plastic mulching in surface-covered cultivation: Types, colours, and effects
17. Plastic mulching in surface-covered cultivation: Types, colours, and effects
18. Nursery management with plastics: Use of nursery bags, trays, etc.
19. Controlled environment cultivation with plastics as cladding material: Greenhouses, polyhouses, and shade nets
20. Controlled environment cultivation with plastics as cladding material: Greenhouses, polyhouses, and shade nets
21. Use of plastics in wind breaks
22. Poly tunnels and crop covers: Use of plastics in protected cultivation
23. Plastic nets for crop protection: Anti-insect nets and bird protection nets
24. Plastic fencing for crop protection
25. Plastics in drying, preservation, handling, and storage of agricultural produce
26. Plastics in drying, preservation, handling, and storage of agricultural produce
27. Innovative plastic packaging solutions for processed food products
28. Plastic CAP covers for storage of food grains in open
29. Use of plastics as alternative material in manufacturing farm equipment and machinery
30. Plastics in aquacultural engineering - inland fisheries
31. Plastics in animal husbandry: Use in animal shelters and vermi-beds and
32. Silage film technique for fodder preservation
33. National and state level agencies involved in the promotion of plasticulture in agriculture
34. Human resource development in plasticulture applications

**Practical Schedule**

1. Design, estimation, and laying of plastic films for canal lining
2. Design, estimation, and laying of plastic films in reservoirs and water harvesting ponds
3. Study of plastic components of drip irrigation systems: Laying and flushing of laterals
4. Study of plastic components of sprinkler irrigation systems and their installation

5. Study of components of subsurface drainage system
6. Study and laying of different coloured plastic mulch in crop fields
7. Design, estimation, and installation of greenhouses and polyhouses
8. Design, estimation, and installation of shade net houses and low tunnels
9. Study of CAP device for food grain storage
10. Study of innovative plastic packaging solutions: Leno bags, crates, boxes, and bins
11. Study of innovative plastic packaging: Boxes, vacuum packing, CAS (Controlled Atmosphere Storage) and MAP (Modified Atmosphere Packaging), unit packaging
12. Study of plastic usage in nurseries, plant protection, animal shelters and inland fisheries
13. Preparation and installation of vermi-bed and silage film for fodder preservation
14. Study of plastic parts used in farm machinery
15. Visit to nearby manufacturing units or dealers of PVC pipes and irrigation systems
16. Visits to farmers' fields with drip, sprinkler, and greenhouse installations
17. Practical examination

**Suggested Readings**


1. Brown, R. P. 2004. Polymers in Agriculture and Horticulture. RAPRA Review Reports: Vol. 15, No. 2, RAPRA Technology Limited, U.K.
2. Central Pollution Control Board. 2012. Material on Plastic Waste Management. Parivesh Bhawan, East Arjun Nagar, Delhi.
3. Chanda, M. and Roy, S. K. 2008. Plastics Fundamentals, Properties, and Testing. CRC Press.
4. Charles A. Harper. 2006. Handbook of Plastics Technologies. The Complete Guide to Properties and Performance. McGraw-Hill, New Delhi.
5. Dubois. 1978. Plastics in Agriculture. Applied Science Publishers Limited, Essex, England.
6. Ojha, T. P. and Michael, A. M. 2012. Principles of Agricultural Engineering - I. Jain Brothers, Karol Bagh, New Delhi.
7. Pandey, P. H. 2014. Principles and Practices of Agricultural Structures and Environmental Control. Kalyani Publishers, Ludhiana, India.
8. Shankar, A. N. 2014. Integrated Horticulture Development in Eastern Himalayas. Plasticulture in Agri-Horticulture Systems, 241-247.
9. Singh, Brahma, Singh, B., Sabir, N. and Hasan, M. 2014. Advances in Protected Cultivation. New India Publishing Agency, New Delhi.
10. Srivastava, R. K., Maheswari, R. C., Ojha, T. P. and Alam, A. 1988. Plastics in Agriculture. Jain Brothers, Karol Bagh, New Delhi.


## ESW 4206 Precision Farming Techniques for Protected Cultivation 3 (2+1)

**Objectives**

- To enable the students to design and construction of green houses in different agro-climatic zones, greenhouse cooling and1 heating systems, environmental parameter and control, ventilation systems
- To assess different root media, micro-irrigation, fertigation, planting techniques in green house cultivation and to know about hydroponics, post-harvest management, pest management and economic aspects of a green house

**Theory**

**Module I** **(7 Hours)**

Protected cultivation: introduction, history, origin, development, national and international scenario. Types of green houses, components of green house, cladding materials, plant environment interactions, principles of limiting factors, solar radiation and transpiration, greenhouse effect, light, temperature, relative humidity, carbon dioxide enrichment.

**Module II** **(15 Hours)**

Design and construction of greenhouses - site selection, orientation, design, construction, design for ventilation requirement using exhaust fan system, selection of equipment; Greenhouse cooling system - methods, ventilation with roof and side ventilators, evaporative cooling, different shading materials, fogging, combined fogging and fan-pad cooling system, design of cooling system, maintenance of cooling and ventilation systems, pad care, etc. green house heating, components, methods, design of heating system, root media, types, soil and soilless media, composition, estimation, preparation and disinfection, bed preparation.

**Module III** **(5 Hours)**

Planting techniques in green house cultivation; Irrigation in greenhouse and net house- water quality, types of irrigation system, components, design, installation and material requirement; Fogging system for greenhouses and net houses - introduction, benefits, design, installation and material requirement; Maintenance of irrigation and fogging systems.

**Module IV** **(7 Hours)**

Fertilization - nutrient deficiency symptoms and functions of essential nutrient elements, principles of selection of proper application of fertilizers, fertilizer scheduling, rate of application of fertilizers, methods, automated fertilizer application. Greenhouse climate measurement, control and management; Insect and disease management in greenhouse and net houses; Selection of crops for greenhouse cultivation, major crops in greenhouse- irrigation requirement, fertilizer management, cultivation, harvesting and post-harvest techniques; Economic analysis.

**Practical**

Estimation of material requirement for construction of greenhouse; Determination of fertilization schedule and rate of application for various crops; Estimation of material requirement for preparation of root media; Root media preparation, bed preparation and disinfections; Study of different planting techniques; Design and installation of irrigation system; Design and installation of fogging system; Study of different greenhouse environment control instruments; Study of operation, maintenance and fault detection in irrigation system; Study of operation, maintenance and fault detection in fogging system; Economic analysis of greenhouses and net houses; Visit to greenhouses.

**Lecture Schedule**

1. Introduction to Protected Cultivation: Concept, History, Origin and development
2. Protected Cultivation: National and International Scenario
3. Greenhouses – Components, types and Uses
4. Cladding Materials, Plant-Environment Interactions in Greenhouses
5. Principles of Limiting Factors in Greenhouse Cultivation, Solar Radiation and Transpiration

6. Greenhouse Effect, Light and Temperature, Relative Humidity, Carbon Dioxide Enrichment
7. Greenhouse Effect, Light and Temperature, Relative Humidity, Carbon Dioxide Enrichment
8. Design and construction of Greenhouses: Site Selection and Orientation
9. Design and construction of Greenhouse: Planning, Design Considerations
10. Design for Ventilation Requirements using Exhaust Fan Systems
11. Selection of Equipment for Greenhouse Design and Construction
12. Greenhouse Cooling Systems: necessity and Methods
13. Ventilation in Greenhouses: Roof and Side Ventilators
14. Evaporative Cooling in Greenhouses
15. Shading Materials in Greenhouses
16. Fogging Systems in Greenhouses
17. Combined Fogging and Fan-Pad Cooling System
18. Design of cooling system, Maintenance of Cooling and Ventilation Systems, pad care in Greenhouses
19. Design of cooling system, Maintenance of Cooling and Ventilation Systems, pad care in Greenhouses
20. Greenhouse Heating: Components and Methods
21. Design of Heating Systems for Greenhouses
22. Root Media: Types, Soil and Soilless Media - Composition, Estimation, Preparation, disinfection, and bed preparation
23. Planting Techniques in Greenhouse Cultivation
24. Irrigation Systems in Greenhouses and Net Houses: water quality, types of irrigation system, components, design, installation, and material requirement
25. Irrigation Systems in Greenhouses and Net Houses: water quality, types of irrigation system, components, design, installation and material requirement
26. Fogging Systems for Greenhouses and Net Houses: introduction, benefits, design, installation and material requirement
27. Maintenance of irrigation and fogging systems
28. Fertilization in Greenhouses: Nutrient Deficiency Symptoms and Solutions, functions of essential nutrient elements
29. Principles of selection of proper application of fertilizers, fertilizer scheduling, rate of application of fertilizers
30. Methods of fertilization, automated fertilizer application
31. Greenhouse Climate Measurement, Control and Management
32. Insect and disease management in greenhouse and net houses
33. Selection of crops for greenhouse cultivation, major crops in greenhouse - irrigation requirement, fertilizer management, cultivation, harvesting and post-harvest techniques and economic analysis
34. Selection of crops for greenhouse cultivation, major crops in greenhouse- irrigation requirement, fertilizer management, cultivation, harvesting and post-harvest techniques and economic analysis

**Practical Schedule**

1. Estimation of material requirement for construction of greenhouse
2. Determination of fertilization schedule and rate of application for various crops
3. Estimation of material requirement for preparation of root media
4. Root media preparation, bed preparation and disinfections

5. Root media preparation, bed preparation and disinfections
6. Study of different planting techniques
7. Design and installation of irrigation system
8. Design and installation of irrigation system
9. Design and installation of fogging system
10. Design and installation of fogging system
11. Study of different greenhouse environment control instruments
12. Study of operation, maintenance, and fault detection in irrigation system
13. Study of operation, maintenance and fault detection in fogging system
14. Economic analysis of greenhouses and net houses
15. Economic analysis of greenhouses and net houses
16. Visit to greenhouses
17. Practical Examination

**Suggested Readings**


1. Ernst van Heurn and Kees Van der Post. 2004. Protected Cultivation. Digigrafi, Wageningan, The Netherlands.
2. Peter, K.V. and Sing D.K. 2013. Protected Cultivation of Horticulture Crops, New India Publishing Company.
3. Reddy P.P. 2016.Sustainable Crop Protection under Protected Cultivation. Springer Singapore.
4. Sharma P. 2007.Precision Farming. Daya Publishing House New Delhi
5. Singh Brahma and Balraj Singh. 2014. Advances in protected cultivation, New India Publishing Company.


## ESW 4207 Quantity Surveying and Valuation 3 (2+1)

**Objective**

To make the students acquainted with the calculation of quantities, preparation of estimates, and to have a thorough idea regarding the quality and quantity of materials and labours required for a construction project.

**Theory**

**Module I** **(7 Hours)**

Estimation, basic terms and types of estimates - revised estimate, supplementary estimate, maintenance estimate, approximate estimate. Technical sanction and administrative sanction. Different types of plans of buildings. Methods of estimate preparation- plinth area method, cubic rate method, unit rate method, bay method, approximate quantity from bill method, comparison method, cost from materials and labour. Schedule of rates.

**Module II** **(15 Hours)**

Preparation of detailed estimate for buildings - centre line method and ‘long wall-short wall’ method. Preparation detailed estimate for sanitary and water supply works, road, irrigation works, steel structures, doors and windows. Preparation of detailed estimate for RCC Structures, Preparation of bar bending schedule.

**Module III** **(6 Hours)**

Detailed specifications for common building materials and items of work as per I.S specifications, preparation of conveyance statement, calculation of quantities of materials, analysis of rates and preparation of abstract of estimate of agricultural engineering works, Measurement books, Use of PRICE software.

**Module IV** **(6 Hours)**

Valuation, Purpose and principles of valuation. Definition of various terms related to valuation - depreciation, obsolescence, sinking fund, obsolescence, salvage and scrap value, market value, fair rent, year's purchase etc. Methods for calculating depreciation - straight line method, constant percentage method, sinking fund method. Methods of valuation - Replacement cost method, Rental return method, Profit based method and Depreciation method. Valuation of land - belting method, development method, hypothecated building scheme method, rent calculation, lease and leasehold property.

**Practical**

Study of different types of estimates. Preparation of detailed estimate for buildings. Preparation of detailed estimate for irrigation works. Preparation of detailed estimate for greenhouses. Preparation of detailed estimate for water supply works. Preparation of detailed estimate for Roads. Preparation of detailed estimate for drainage works. Preparation of detailed estimate for check dams. Preparation of detailed estimates for water harvesting structures. Preparation of detailed estimate for the dairy barn. Preparation of detailed estimates for storage structures. Methods of measurements of different items of work. Analysis of rate for items of works required for agricultural engineering works. Preparation of abstract of estimate. Measurement and writing measurement book.

**Lecture Schedule**

1. Introduction estimation and costing – basic terms
2. Types of estimates - revised estimate, supplementary estimate, maintenance estimate, approximate estimate
3. Technical sanction and administrative sanction
4. Different types of plans of buildings
5. Methods of estimate preparation - plinth area method, cubic rate method, unit rate method, bay method
6. Methods of estimate preparation - approximate quantity from bill method, comparison method, cost from materials and labour
7. Schedule of rates
8. Preparation of detailed estimate for buildings - centre line method
9. Preparation of detailed estimate for buildings - 'long wall - short wall' method
10. Methods of measurements of different items of work
11. Preparation detailed estimate for irrigation works
12. Preparation of detailed estimate for greenhouses
13. Preparation detailed estimate for sanitary and water supply works
14. Preparation detailed estimate for roads
15. Preparation detailed estimate for drainage works
16. Preparation of detailed estimate for dairy barn

17. Preparation of detailed estimate for check dams
18. Preparation detailed estimate for steel structures
19. Preparation of detailed estimate for storage structures
20. Preparation detailed estimate for doors and windows
21. Preparation detailed estimate for R. C. C. Structures
22. Preparation of bar bending schedule
23. Detailed specifications for common building materials and items of work as per I.S specifications
24. Preparation of conveyance statemen
25. Calculation of quantities of materials for items of work
26. Analysis of rate for items of works required for agricultural engineering works
27. Preparation of abstract of estimate of agricultural engineering works.
28. Measurement books and use of PRICE software
29. Valuation – definitions - sinking fund, years purchase
30. Salvage and scrap value, market value, fair rent
31. Depreciation and obsolescenc
32. Methods for calculating depreciation - straight line method, constant percentage method, sinking fund method
33. Valuation of real property - rental method - profit based method - depreciation method
34. Valuation of land - belting method, development method, hypothecated building scheme method - rent calculation - lease and leasehold property

**Practical Schedule**

1. Study of different types of estimates and preparation of detailed estimate using centre line method and long wall-short wall method.
2. Preparation of detailed estimate for buildings.
3. Preparation of detailed estimate for irrigation works.
4. Preparation of detailed estimate for greenhouses.
5. Preparation of detailed estimate for water supply works.
6. Preparation of detailed estimate for Roads.
7. Preparation of detailed estimate for drainage works.
8. Preparation of detailed estimate for check dams.
9. Preparation of detailed estimate for water harvesting structures.
10. Preparation of detailed estimate for dairy barn.
11. Preparation of detailed estimate for storage structures.
12. Preparation of Bar bending Schedule.
13. Use of PRICE software.
14. Analysis of rate for items of works required for agricultural engineering works.
15. Preparation of abstract of estimate.
16. Measurement and writing in measurement book.
17. Practical examination.

**Suggested Readings**

1. Chakraborthi, M. 1992. Estimating costing & Specification in Civil Engineering. M. Chakraborti Publication.

2. Dutta, B.N. 2007. Estimating and costing in civil engineering. USB publishers' distributors, New Delhi.
3. Rangawala, S.C. 1974. Valuation of real properties. Charotar Publishing House Pvt. Limited.

## ESW 4208 Natural Fibre Applications in Agriculture 3 (2+1)

**Objectives**

To enable the students to

- Know the different applications of natural fibres such as in soil and water conservation, packaging, energy production and soil less farming, etc.
- Understand the economics of using natural fibres for these applications

**Theory**

**Module I** **(7 Hours)**

Natural Fibre based Agrotextiles, characterization and their application: overview of Agrotextile, Technical Textile, Non-woven technology, Design principles for Natural Fibre based Agrotextiles, Tensile and Hydro-physical properties, Estimation techniques, Application as crop mulch, Effect on soil properties, Measurement of soil hydrothermal regime, Effects on crop yield, Effects on soil moisture retention and weed population, Application as shade net, Biodegradability, Life cycle and environmental impact, Economic evaluation. Natural Fibre based Geotextiles, Characterization, and their application: Overview of Geotextile in soil and water conservation.

**Module II** **(10 Hours)**

Woven technology, Design principles for Natural Fibre based Geotextiles (Coir, jute, bamboo etc), Blended Geotextiles its application and case studies, Tensile and Hydro-physical properties, Estimation techniques, Application as soil saver, Effect on soil degradation properties, Factors affecting soil erosion, Rainfall erosivity and indices, Wischmeir's equation for its prediction, isoerodent map of India, Soil erodibility and its measurement, Method of soil loss estimation and measurement (USLE and RUSLE), Water erosion prediction programme (WEPP), sediment transport equations, runoff measurement, sediment measurement (multislot divisor), Concept of integrated watershed management and role of RS and GIS.

**Module III** **(11 Hours)**

Bioengineering, Role of jute, coir and bamboo-based geotextile in soil conservation, Reinforcement, Biodegradability, Life cycle and environmental impact, Economic evaluation. Natural Fibre based sustainable packaging for Agricultural/Horticultural produce: Overview of the packaging industry and current packaging materials, Principle behind packaging of perishable crop produce, Characteristics and properties of natural fibers suitable for packaging, Natural fibre based Green composite and their role in packaging, Design principles for natural fiber-based packaging, natural fibre-based reaper binder, Advantages and limitations of natural fiber-based packaging compared to synthetic alternatives, Biodegradable plastics for packaging agricultural produce. Life cycle assessment and environmental impact analysis, Government policies and regulations related to sustainable packaging.

**Module IV** **(6 Hours)**

Potential of natural fibers as a source of renewable energy: Characteristics of natural fibers and

their suitability as a source of renewable energy, Methods of converting natural fibers into energy, such as combustion and gasification, Economic and environmental analysis of natural fiber-based renewable energy systems, Comparison of natural fiber-based energy systems with other renewable energy sources, Government policies and incentives related to renewable energy (Bioethanol). Role of Natural Fibre in Organic and Soilless Farming: Overview of organic and natural farming, soilless farming, natural fibre waste, characterization of waste, different methods of compost preparation, role of fibre waste as compost, Characteristics of natural fibers and their suitability as a source of soilless media, Effect on crop yield, Biodegradability, Life cycle and environmental impact, Economic evaluation.

**Practical**

Preparation of woven and nonwoven fabrics; Estimation of different mechanical and hydro-physical properties; Agro-textile field trial/experiment; Natural fibre-based Packaging; Production of energy from natural fibres.

**Lecture Schedule**

1. Agrotextiles and Technical Textiles, Natural Fibre based Agrotextiles, Characterization and their application
2. Non-woven technology, Design principles for Natural Fibre based Agrotextiles
3. Tensile and Hydro-physical properties, Estimation techniques
4. Application of Agrotextiles as crop mulch, effect of Natural fiber Agrotextiles on soil properties
5. Measurement of soil hydrothermal regime under Agrotextiles~~,~~, Effects on crop yield, Effects on soil moisture retention and weed population~~,~~
6. Application as shade net, Biodegradability, Life cycle and environmental impact, Economic evaluation
7. Natural Fibre based Geotextiles, Characterization and their application, Overview of Geotextile in soil and water conservation
8. Introduction to Woven Technology for Natural Fibre-based Geotextiles
9. Design principles for Natural Fibre based Geotextiles (Coir, jute, bamboo etc.)
10. Blended Geotextiles and its application and case studies
11. Tensile and Hydro-physical properties, Estimation techniques
12. Application as soil saver and its effect on soil degradation properties
13. Factors affecting soil erosion, rainfall erosivity and indices
14. Wischmeir's equation for its prediction, isoerodent map of India, Soil erodibility and its measurement, method of soil loss estimation and measurement (USLE and RUSLE)
15. Water erosion prediction programme (WEPP), sediment transport equations
16. Runoff measurement, sediment measurement (multislot divisor)
17. Concept of integrated watershed management and role of RS and GIS
18. Bioengineering - Role of jute, coir and bamboo-based geotextile in soil conservation,
19. Reinforcement, and Biodegradability
20. Life cycle and environmental impact
21. Economic evaluation
22. Natural Fibre based sustainable packaging for Agricultural/Horticultural produce
23. Overview of the packaging industry and current packaging materials
24. Principle behind packaging of perishable crop produce
25. Characteristics and properties of natural fibers suitable for packaging

26. Natural fibre based green composite and their role in packaging
27. Design principles for natural fiber-based packaging, natural fibre-based reaper binder, Advantages and limitations of natural fiber-based packaging compared to synthetic alternatives, Biodegradable plastics for packaging agricultural produce
28. Life cycle assessment and environmental impact analysis, Government policies and regulations related to sustainable packaging
29. Potential of natural fibers as a source of renewable energy: Characteristics of natural fibers and their suitability as a source of renewable energy
30. Methods of converting natural fibers into energy, such as combustion and gasification, Economic and environmental analysis of natural fiber-based renewable energy systems
31. Comparison of natural fiber-based energy systems with other renewable energy sources, Government policies and incentives related to renewable energy (Bioethanol)
32. Role of Natural Fibre in Organic and Soilless Farming: Overview of organic and natural farming, soilless farming, natural fibre waste, characterization of waste
33. Different methods of compost preparation, role of fibre waste as compost
34. Characteristics of natural fibers and their suitability as a source of soilless media, Effect on crop yield, Biodegradability, life cycle and environmental impact, Economic evaluation.

**Practical Schedule**

1. Preparation of Woven Fabrics using Natural Fibres
2. Preparation of Woven Fabrics using Natural Fibres
3. Preparation of Nonwoven Fabrics using Natural Fibres
4. Preparation of Nonwoven Fabrics using Natural Fibres
5. Estimation of different mechanical properties of Woven Fabrics
6. Estimation of different mechanical properties of Nonwoven Fabrics
7. Estimation of different mechanical properties of Nonwoven Fabrics
8. Estimation of different Hydro physical properties of Woven Fabrics
9. Estimation of different hydro physical properties of Woven Fabrics
10. Estimation of different hydro physical properties of Nonwoven Fabrics
11. Estimation of different hydro physical properties of Nonwoven Fabrics
12. Agro-textile Field Trial: Application of Natural Fibre Fabrics as Crop Mulch
13. Agro-textile Field Experiment: Impact on Soil Moisture Retention Using Natural Fibre Fabrics
14. Agro-textile Field Experiment: Effect of Fabrics on Weed Control and Crop Yield
15. Study on Natural Fibre based packaging
16. Production of Energy from Natural Fibres: Gasification Method and Combustion Method
17. Practical Examination

**Suggested Readings**


1. Blackburn, R. S. (Ed). 2009. Sustainable Textiles: Life Cycle and Environmental Impact. Woodhead Publishing. ISBN 978-1-84569-453-1.
2. Cheng, H. N., Byron, A. E. and Okos, M. R. (Eds). 2017. Sustainable Fiber-Based Packaging. John Wiley & Sons. ISBN: 978-1-119-17306-4.
3. Fangueiro, R. and Rana, S. (Eds). 2016. Natural Fibre Composites in Geotextiles: Design and Applications. Woodhead Publishing. ISBN: 978-0-08-100215-7
4. Hakeem, K. R., Jawaid, M., and Alothman, O. Y. (Eds). 2019. Biomass and Bioenergy: Processing and Properties. Springer. ISBN: 978-981-13-8562-2.

5. Hardin, M. R. (Ed.). 2007. Natural and Artificial Fiber Nonwoven Textiles. CRC Press. ISBN: 978-0-8493-6454-9.
6. Kozłowski, Ryszard M. (Ed). 2012. Handbook of natural fibres. Volume 2: Processing and applications. Woodhead Publishing Limited. ISBN 978-1-84569-698-6.
7. Tripathy, R.P. and Singh, H.P. (Eds). 1993. Soil Erosion and Conservation. New Age International (P) Limited, Publishers. ISBN: 81-224-0305-0.

## ESW 4209 Water Harvesting and Soil Conservation Structures 3 (2+1)

**Objectives**

- To familiriarise the water harvesting techniques based on source, storage and use and also introduce the soil and water conservation structures.
- To impart awareness on the design requirements, planning for design, design procedures such as hydrologic, hydraulic and structural design and stability analysis of different structures.

**Theory**

**Module I** **(3 Hours)**

Water harvesting -principles, importance and issues. Water harvesting techniques – classification based on source, storage and use. Runoff harvesting – short-term and long-term techniques.

**Module II** **(6 Hours)**

Structures Farm pond - components, site selection, design criteria, capacity,embankment, mechanical and emergency spillways, cost estimation and construction. Percolation pond – site selection, design and construction details. Design considerations of nala bunds.

**Module III** **(12 Hours)**

Soil erosion control structures - introduction, classification and functional requirements. Permanent structures for soil conservation and gully control - check dams, drop, chute and drop inlet spillways - design requirements, planning for design, design procedures - hydrologic, hydraulic and structural design and stability analysis. Drop spillway - applicability, types – straight drop, box-type inlet spillways - description, functional use, advantages and disadvantages, straight apron and stilling basin outlet, structural components and functions.

**Module IV** **(10 Hours)**

Hydraulic jump and its application. Loads on head wall, variables affecting equivalent fluidpressure, triangular load diagram for various flow conditions, creep line theory, uplift pressure estimation, safety against sliding, overturning, crushing and tension.

**Module V** **(3 Hours)**

Chute spillway - description, components, energy dissipaters, design criteria of Saint Antony Falls (SAF) stilling basin and its limitations. Drop inlet spillway - description, functional use and design criteria. Design of Diversions.

**Practical**

Study of different types of farm ponds.Computation of storage capacity of embankment type of farm ponds.Design of dugout farm ponds.Design of percolation pond and nala bunds. Exercise on

hydraulic jump. Exercise on energy dissipation in water flow. Hydrologic, hydraulic and structural design of drop spillway and stability analysis.Design of SAF stilling basins in chute spillway.Hydrologic, hydraulic and structural design of drop inlet spillway. Design of small earthen embankment structures. Practice on software for design of soil and water conservation structures. Field visit to watershed project areas treated with soil and water conservation measures/structures.

**Lecture Schedule**

1. Water harvesting - principles, importance, and issues
2. Water harvesting techniques - classification based on source, storage and use
3. Runoff harvesting – short-term and long-term techniques
4. Structures: Farm pond – general description and its components, different types, site selection
5. Farm pond- design criteria and storage capacity of embankment type farm ponds
6. Mechanical and emergency spillways-cost estimation and construction
7. Percolation pond - site selection, design and construction details
8. Percolation pond - Design problems
9. Design considerations of nala bunds
10. Soil erosion control structures - introduction, classification and functional requirements
11. Permanent structures for soil conservation and gully control –different types
12. Check dams, - design requirements, planning for design, design procedures
13. Check dams, - hydrologic, hydraulic and structural design and stability analysis
14. Drop spillways - design requirements, planning for design, design procedures
15. Drop spillways - hydrologic, hydraulic and structural design and stability analysis
16. Chute spillways- design requirements, planning for design, design procedures
17. Chute spillways- hydrologic, hydraulic and structural design and stability analysis
18. Drop inlet spillways - design requirements, planning for design, design procedures
19. Drop inlet spillways - hydrologic, hydraulic and structural design and stability analysis
20. Drop spillway - applicability, types - advantages and disadvantages,
21. Straight apron and stilling basin outlet, structural components and functions
22. Hydraulic jump and its application, type of hydraulic jump
23. Hydraulic jump and its application, type of hydraulic jump
24. Energy dissipation due to hydraulic jump, jump efficiency, relative loss of energy
25. Straight drop spillways, box-type inlet spillways - description, functional use
26. Straight drop spillways, box-type inlet spillways - description, functional use
27. Drop spillway structural design- Loads on head wall, Variables affecting equivalent fluid pressure
28. Drop spillway structural design- Loads on head wall, Variables affecting equivalent fluid pressure
29. Triangular load diagram for various flow conditions, creep line theory
30. Uplift pressure estimation, safety against sliding
31. Overturning, crushing and tension
32. Chute spillway - description, components, Hydraulic design, Energy dissipaters. Design criteria of Saint Antony Falls (SAF) stilling basin and its limitations
33. Drop inlet spillway - description, functional use and design criteria
34. Diversions structures – general description, Design of Diversions

**Practical Schedule**

1. Study of different types of farm ponds.
2. Computation of storage capacity of embankment type of farm ponds.
3. Design of dugout farm ponds.
4. Design of percolation pond and nala bunds.
5. Exercise on hydraulic jump.
6. Problems
7. Exercise on energy dissipation in water flow.
8. Hydrologic, hydraulic and structural design of drop spillway
9. Stability analysis of design of drop spillway.
10. Design of SAF stilling basins in chute spillway.
11. Stability analysis of design of chute spillway
12. Hydrologic, hydraulic and structural design of drop inlet spillway.
13. Design of small earthen embankment structures.
14. Design of small earthen embankment structures.
15. Practice on software for design of soil and water conservation structures II.
16. Field visit to watershed project areas treated with soil and water conservation measures structures.
17. Practical Examination

**Suggested Readings**


1. Michael, A.M. and T.P. Ojha. 2003. Principles of Agricultural Engineering. Volume II.4thEdition, Jain Brothers, New Delhi.
2. Murthy, V.V.N. 2002.Land and Water Management Engineering. 4th Edition, KalyaniPublishers, New Delhi.
3. Samra, J.S., V.N. Sharda and A.K. Sikka. 2002. Water Harvesting and Recycling: Indian Experiences. CSWCR&TI, Dehradun, Allied Printers, Dehradun.
4. Schwab, G.O., D.D. Fangmeier, W.J. Elliot, R.K. Frevert. 1993. Soil and Water Conservation Engineering.4th Edition, John Wiley and Sons Inc. New York.
5. Singh Gurmel, C. Venkataraman, G. Sastry and B.P. Joshi. 1996. Manual of Soil and Water Conservation Practices. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
6. Studer Rima Mekdaschi and HanspeterLiniger. 2013. Water Harvesting - Guidelines to Good Practice. Centre for Development and Environment, University of Bern, Switzerland.
7. Suresh, R. 2014. Soil and Water Conservation Engineering. Standard Publisher Distributors, New Delhi.
8. Theib Y. Oweis, Dieter Prinz and Ahmed Y. Hachum. 2012. Rainwater Harvesting forAgriculture in the Dry Areas. CRC Press, Taylor and Francis Group, London.

# Department of Soil and Water Conservation Engineering - Skill Enhancement Modules

## Application of Remote Sensing and GIS for Agricultural Water Management 2 (0+2)

- Basics of remote sensing
- Remote sensing sensors and platforms
- Introduction to GIS
- Types of projection systems
- Study of Image resolutions and coordinate system
- Source of remote sensing data and accessibility
- Operations in Google earth platform
- Introduction to basic modules of ArcGIS
- Introduction to basic modules of QGIS
- Georeferencing, rectification, digitization and shape file creation
- Basic raster/vector data operations
- Map projection and re-projection
- Preparation of contour maps and rainfall Thiessen polygons
- Map layout and styling
- Preparation of various vegetation index maps
- Preparation of various wetness index maps
- Delineation of watershed and derivation of morphological parameters

## Operation and Maintenance of Hydro-meteorological Instruments 2 (0+2)

- Study and operation of Weather Monitoring Instruments: Thermometer, Barometer, Hygrometer; Anemometer, Pyranometer and others
- Components of an automatic weather station (AWS)
- Installation of AWS and its maintenance
- Calibration and installation of Tipping bucket raingauge
- Installation of open pan evaporimeter and periodic maintenance
- Study of infiltration process using ring infiltrometer
- Measurement of flow in open channels using various methods
- Study of different weirs and flumes for flow measurement
- Installation of weirs and flumes in the channel
- Measurement of soil moisture using gravimetric method
- In-situ measurement of soil moisture using different soil moisture sensors
- Installation of digital water level recorder (DWLR)
- Measurement of groundwater level using ground water level recorder
- Study of multi-slot divisor and Coshocton wheel silt sampler for measurement of soil loss
- Measurement of flow velocity using digital current meter
- Procedure for recording field observations

- Troubleshooting of hydro-meteorological instruments

## Installation and Maintenance of Rooftop Rainwater Harvesting System 2 (0+2)

- Survey and site selection for RRWH
- Computation of rooftop RWH potential and runoff coefficient
- Study of components of RWH system
- Catchments: grading and plastering of rooftop
- Coarse mesh, gutters; roofing materials
- Conduit: material, size of conveyance pipe
- Types of filter system used in RWH system
- Study of storage tank: capacity, overflow pipe
- Study of suitable recharge structure for groundwater
- Study of constructional details of recharge pits, recharge trench
- Types of contaminants in RWH system
- Hand pumps and its application in RWH system
- Preparation of Detail Project Report

## Operation and Maintenance of Soil Conservation Structure 2 (0+2)

- Survey for slope, stream order and land use/land cover
- Site selection of soil conservation structures based on survey
- Ground truthing of various structures
- Study of different types of soil conservation structures
- Trenching and diversions structures
- Study of types bunding and its features
- Study of types of terracing and its features
- Study of drop spill way: components, function, site suitability
- Study of drop inlet spillway: components, function, site suitability
- Study of chute spillway: components, function, site suitability
- Study of check dams- construction, site suitability
- Study of construction materials of different structures
- Cost estimation of different conservation structures
- Preparation of Detail Project Report

## Department of Processing and Food Engineering- Core courses

## PFE 2101 Engineering Properties of Agricultural Produce and Food Science 3 (2+1)

**Objective**

To make the students acquainted with different engineering properties of agricultural produce and to help them understand the importance of these properties in handling, processing and storage of agricultural commodities.

**Theory**

**Module I** **(9 Hours)**

Engineering properties of food and their importance, application of engineering properties in handling, processing and storage; Physical properties-shape, size, roundness, sphericity, volume, density, porosity, specific gravity, surface area; Colour properties, CIE colour model; Thermal properties-heat capacity, specific heat, thermal conductivity, thermal diffusivity, heat of respiration, co-efficient of thermal expansion; Electrical and dielectric properties-resistance, capacitance, dielectric loss factor, loss tangent, and dielectric constant.

**Module II** **(10 Hours)**

Frictional properties-static friction, kinetic friction, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials; Aero-dynamic characteristics-drag coefficient, terminal velocity; Rheological characteristics of food-elastic, plastic and viscous behaviour, visco-elasticity, rheological models to explain food characteristics; Fluid behaviour-Newtonian, non-Newtonian, pseudo-plastic, dilatant, thixotropic, rheopectic and Bingham plastic; Textural characteristics of foods.

**Module III** **(4 Hours)**

Non-destructive methods of quality determination of foods; Principles of machine vision systems, spectroscopy, hyperspectral imaging and acoustic techniques.

**Module IV** **(11 Hours)**

Introduction to food science and food technology, biochemical reactions involved in food processing and storage, food spoilage agents, general methods for food preservation-physical, chemical and biological methods; Food microbiology-Classification of microorganisms, multiplication of bacteria, various beneficial and harmful microorganisms in relation to food preservation and spoilage, industrial bacteriology and food fermentation.

**Practical**

Determination of the size of grains, fruits and vegetables using measuring instruments and using projection system, Determination of the shape (sphericity and roundness), Determination of the bulk and particle volume, bulk and particle density, specific gravity and porosity of grains, Determination of the volume, density and specific gravity of large individual objects (F and V), Determination of the surface area of the F and V, Determination of angle of repose, co-efficient of friction of different grains on different surfaces and angle of internal friction, To study the terminal

velocity of grains and separating behaviour of grains in a vertical wind tunnel, Determination of specific heat and thermal conductivity of some food grains, Determination of electrical properties of food materials, Determination of hardness of food materials, Determination of viscosity of food, Study and comparison of colour of food materials, Determination of carbohydrates, Determination of total nitrogen, Determination of oil content, Determination of ash content, Study of different types of microorganisms and microbiological examination of food products.

**Lecture Schedule**

1. Introduction-engineering properties of food-classification and importance.
2. Application of engineering properties in handling, processing and storage.
3. Physical properties-shape-size-roundness-sphericity-application.
4. Physical properties-volume-density-porosity-specific gravity-surface area of grains and fruits-application.
5. Colour properties-CIE colour model.
6. Thermal properties-heat capacity-specific heat-thermal conductivity-thermal diffusivity-application.
7. Thermal properties-heat of respiration-co-efficient of thermal expansion.
8. Electrical properties-electrical resistance-capacitance.
9. Electrical properties-dielectric loss factor-loss tangent-dielectric constant.
10. Frictional properties-static friction-kinetic friction-rolling resistance.
11. Angle of internal friction-angle of repose-application.
12. Flow of bulk granular materials.
13. Aero-dynamic properties- drag coefficient-terminal velocity.
14. Rheological properties-Force-deformation-stress-strain-elastic, plastic and viscous behaviour – ideal classical bodies in rheology.
15. Rheological models-Kelvin model-generalized Kelvin model.
16. Rheological models-Maxwell model-generalized Maxwell model-application.
17. Fluid behaviour-Newtonian fluids-non-Newtonian fluids-visco-elasticity.
18. Pseudo-plastic-dilatant-thixotropic-rheopectic-Bingham plastic foods.
19. Textural characteristics of foods.
20. Non-destructive methods of quality determination of foods.
21. Non-destructive methods-principles of machine vision systems.
22. Non-destructive methods-spectroscopy-hyperspectral imaging
23. Non-destructive methods-acoustic techniques.
24. Introduction to food science and food technology.
25. Biochemical reactions involved in food processing and storage.
26. Food spoilage agents.
27. General methods for food preservation-physical methods.
28. General methods for food preservation-chemical methods.
29. General methods for food preservation- biological methods.
30. Introduction to food microbiology-classification of microorganisms.
31. Multiplication of bacteria -various beneficial and harmful microorganism.
32. Microbial examination of food-bacterial, yeast and mould count-isolation and identification of food borne pathogens.
33. Industrial bacteriology-principles-applications.
34. Food fermentation-principles-applications.

**Practical Schedule**

1. Determination of shape and size of grains, fruits and vegetables.
2. Determination of bulk density, particle density and porosity of solid grains.
3. Determination of specific gravity of grains.
4. Determination of the surface area of fruits and vegetables.
5. Determination of angle of repose.
6. Determination of co-efficient of friction and angle of internal friction.
7. Determination of terminal velocity of grains.
8. Study of separating behaviour of grains in a vertical wind tunnel.
9. Determination of specific heat of food.
10. Determination of thermal conductivity of food grains.
11. Determination of electrical properties of food materials.
12. Determination of hardness and colour of food materials.
13. Determination of viscosity of liquid food
14. Determination of carbohydrates, total nitrogen, oil content and ash content
15. Study of different types of microorganisms and microbiological examination of food products.
16. Industrial visit
17. Practical examination

**Suggested Readings**


1. Mohesin, N. N. 1980. *Physical Properties of Plants & Animals*. Gordon & Breach SciencePublishers, New York.
2. Rao, M. A. and Rizvi, S. H. 1995. *Engineering Properties of Foods*. Marcel Dekker Inc. New York.
3. Ray, B. and Bhunia, A. 2008. *Fundamental Food Microbiology*, 4th edn., CRC press,
4. Taylor and Francis Group, USA.
5. Sahay, K. M. and Singh, K. K. 1994. *Unit Operations of Agricultural Processing*. Vikas Publishing House Pvt. Ltd, New Delhi.
6. Serpil, S. and Servet, G. S. 2005. *Physical Properties of Foods*. Springer Science+Business Media, LLC, 233 Spring Street, New York.
7. Singhal, O. P. and Samuel, D. V. K. 2003. *Engineering Properties of Biological Materials*. Saroj Prakasan, New Delhi.


## PFE 2202 Post-Harvest Engineering of Cereals, Pulses and Oilseeds 3 (2+1)

**Objective**

To make the students acquainted with the different unit operations in processing of major cereals, pulses and oilseeds, and the different equipment for the operations

**Theory**

**Module I** **(6 Hours)**

Unit operations in agricultural processing, structure and composition of cereals, pulses and oil seeds, cleaning and grading, aspiration, scalping, size separators, screens, sieve analysis, capacity and effectiveness of screens, various types of separators, specific gravity, magnetic, disc, spiral, pneumatic, inclined draper, velvet roll, colour sorters, cyclone, shape graders.

**Module II** **(11 Hours)**

Drying: Moisture content and water activity, free moisture, bound moisture and equilibrium moisture content, isotherm, hysteresis effect, EMC determination; Psychrometric chart and its use in drying; Drying principles and theory, thin layer and deep bed drying analysis, falling rate and constant rate drying periods, maximum and decreasing drying rate periods, drying equations, mass and energy balance, Shedd's equation; drying methods (conduction, convection, radiation, batch, continuous); Different types of grain dryers (bin, flat bed, LSU, columnar, RPEC, fluidized, rotary and tray), tempering during drying; dryer performance.

**Module III** **(9 Hours)**

Principles of grain storage; different types of grain storage structures; deep bin and shallow bin; design of a silo, structural and functional requirements of a grain storage go-down. Size reduction: Principle; Bond's law, Kick's law, Rittinger's law; Sieve analysis; Different classifications of size reduction machines; description of jaw crusher, hammer mill, attrition mill and ball mill; Material handling: Basic parts of different types of conveyors and elevators, viz. belt, roller, chain, screw, and bucket elevator, cranes and hoists, pneumatic conveying, power requirement for conveying and elevating.

**Module IV** **(8 Hours)**

Milling of rice: Parboiling- merits and demerits, changes during parboiling of rice, parboiling methods, viz. traditional methods, CFTRI method, Jadavpur method, pressure parboiling; different unit operations and equipment involved in traditional and modern rice milling methods; Preparation of rice products as rice flakes and puffed rice. Milling of wheat: Unit operations and equipment; milling of corn: unit operations and equipment in dry and wet milling methods. Milling of pulses: pre-conditioning, dry milling and wet milling methods, CFTRI and Pantnagar methods, pulse milling machines; Milling of oilseeds: preconditioning of oilseeds, mechanical expression, screw press, hydraulic press, solvent extraction method, refining of oil, stabilization of rice bran.

**Practical**

Study of different types of screens and study of screen effectiveness; Study of construction and operation of different types of cleaners and separators; Measurement of moisture content: dry basis and wet basis; Study on drying characteristics of grains and determination of drying constant; Determination of EMC (static and dynamic method); Study of psychrometric chart; Study of various types of dryers; Study of different size reduction machines; Sieve analysis, determination of fineness modulus and uniformity index; Study of different unit operations and machineries in rice mills; Study of different unit operations and machineries in pulse mills; Study of different unit operations and machineries in oil mills; Study of different unit operations and machineries in wheat/ flour mills; Study of different unit operations and machineries in corn processing units; Study of extrusion process; Study of different types of conveying and elevating equipment.

**Lecture Schedule**

1. Introduction-Unit operations in agricultural processing-Importance of unit operations
2. Structure and composition of cereals-pulses-oilseeds- cleaning and grading
3. Aspiration-scalping-types of screen-sieve analysis-capacity-effectiveness of screen
4. Equipment for cleaning and grading-air screen cleaners-rotary screen cleaner- shape graders

5. Various types of separators-specific gravity separator-magnetic separator-disk separator-indented cylinder separator-spiral separator
6. Separators-inclined draper-velvet roll separator-pneumatic separator-colour sorter-cyclone separators
7. Drying- Moisture content and water activity-free moisture-bound and unbound moisture.
8. Moisture content determination-Equilibrium moisture content-isotherm-hysteresis effect
9. EMC determination-static and dynamic methods
10. Psychrometry-psychometric chart-applications in drying.
11. Drying-principles and theory-thin layer and deep bed drying
12. Falling rate and constant rate drying periods-critical moisture content-maximum and decreasing drying rate periods
13. Drying equations-mass and energy balance-Shedd's equation.
14. Drying methods-conduction-convection-radiation-batch and continuous drying process.
15. Types of grain dryers-bin dryer- flat bed dryer-deep bed drying.
16. LSU dryer-columnar dryer.
17. RPEC dryer-fluidized bed dryer-vacuum dryer.
18. Rotary dryer-tray dryer-tempering during drying-dryer performance.
19. Principles of grain storage-Types of grain storage structures.
20. Deep bin-shallow bin-design of a silo.
21. Grain storage godowns-structural and functional requirements.
22. Size reduction-Principle-Bond's law-Kick's law-Rittinger's law.
23. Sieve analysis-size reduction procedures-crushing-impact-cutting-shearing.
24. Size reduction machinery-jaw crusher-hammer mill-attrition mill-ball mill-rubber roll sheller.
25. Material handling-basic parts-conveyors-elevators-belt conveyor-screw conveyor-roller conveyor.
26. Bucket elevator-chain conveyor-cranes and hoists-Pneumatic conveying-power requirement for conveying and elevating.
27. Rice milling-parboiling-advantages and disadvantages of parboiling-changes during parboiling of rice.
28. Parboiling methods-traditional method-CFTRI method of parboiling-Pressure parboiling-Jadavpur method.
29. Unit operations and equipment involved in traditional and modern rice milling methods-machineries for rice milling - engleberg huller- rubber roll sheller- polishing- vertical cone polisher-preparation of rice products-rice flakes-puffed rice.
30. Wheat milling-Unit operations and equipment.
31. Milling of corn-unit operations and equipment-dry and wet milling methods.
32. Milling of pulses-pre-conditioning-dry milling and wet milling methods-CFTRI and Pantnagar methods of pulse milling-pulse milling machines.
33. Milling of oilseeds-preconditioning-mechanical expression-screw press-hydraulic press.
34. Solvent extraction method-refining of oil-stabilization of rice bran.

**Practical Schedule**

1. Study of different types of screens
2. Determination of screen effectiveness.
3. Study of construction and operation of different types of cleaners and separators
4. Measurement of moisture content: dry basis and wet basis.

5. Study on drying characteristics of grains and determination of drying constant.
6. Determination of EMC (static and dynamic method).
7. Study of psychrometric chart.
8. Study of various types of dryers.
9. Study of different size reduction machines.
10. Sieve analysis, determination of fineness modulus and uniformity index.
11. Study of different unit operations and machineries in rice mills.
12. Study of different unit operations and machineries in pulse and oil mills.
13. Study of different unit operations and machineries in wheat/ flour mills.
14. Study of different unit operations and machineries in corn processing units.
15. Study of extrusion process.
16. Study of different types of conveying and elevating equipment
17. Practical examination

**Suggested Readings**


1. Chakraverty, A. 1999. *Post-harvest Technology of Cereals, Pulses and Oilseeds*. Oxford & IBH publishing Co. Ltd, New Delhi.
2. Dash, S. K., Bebartta, J. P. and Kar, A. 2012. *Rice Processing and Allied Operations*. Kalyani Publishers, New Delhi.
3. Geankoplis, C. J. 2002. *Transport Processes and Unit Operations*. Prentice Hall of India Pvt. Ltd, New Delhi.
4. Mangaraj, S., Dash, S. K., Swain, S. and Ali, N. 2016. *Agricultural Process Engineering*. Vol II. Kalyani Publishers, New Delhi.
5. McCabe, W. L., Smith, J. C. and Harriott, P. 1993. *Unit Operations of Chemical Engineering*. McGraw Hill.
6. Sahay, K. M. and Singh, K. K. 1994. *Unit Operations of Agricultural Processing*. Vikas Publishing House Pvt. Ltd, New Delhi.
7. Swain, S., Dash, S. K., Mangaraj, S. and Ali, N. 2016. Agricultural Process Engineering. Vol I. Kalyani Publishers, New Delhi.


## PFE 3103 Food and Dairy Engineering 4 (3+1)

**Objectives**

- To make the students acquainted with the different unit operations in processing and value addition of different dairy and food products
- To make them understand the different types of equipment and their working principles used for these.

**Theory**

**Module 1** **(12 Hours)**

Introduction to different unit operations in food processing; Process flow charts for preparation of various food products; Mass and energy balance. Dehydration of foods; dryers for solid foods, construction and operation of direct and indirect type solar dryers, tray dryer, tunnel dryer, vacuum dryer, microwave dryer, freeze dryer, etc.; dryers for liquid foods, construction and operation of

drum dryer, spray dryer and vacuum band dryer; Evaporation of food products: principle, different types of evaporators, factors affecting steam economy, multiple effect evaporation, vapour recompression

**Module II** **(13 Hours)**

Thermal processing: thermobacteriology, D value, Z value, reaction quotient, process time, different types of retorts and continuous sterilizers, canning process, aseptic processing, Principles and applications of different non-thermal processing methods as vacuum processing, high pressure processing, PEF processing, Ultrasonication, radiation processing; Principles and applications of novel heating methods, viz. ohmic, infrared and dielectric heating

**Module III** **(13 Hours)**

Mixing: Theory of mixing of solids and pastes, mixing index, mixers for solids, liquid foods and pastes, viz. tumbling mixer, screw mixer, ribbon mixer, liquid mixers, sigma-blade mixer, anchor and gate agitator; Separation processes: principle and equipment for sedimentation of solids in liquid and solids in air; Principle and operation of tubular bowl centrifuge and disc bowl centrifuge; Filtration: principle, construction and working principles of different types of filters as plate and frame filter press, shell and leaf filter, centrifugal filter, rotary drum filter, continuous belt filter; Membrane separation: principle, characteristics and applications of reverse osmosis, nanofiltration, ultra-filtration and macro-filtration; membrane modules; Extrusion cooking: principle, factors affecting extrusion cooking, single and twin screw extruders.

**Module IV** **(13 Hours)**

Unit operations in milk processing: Engineering, thermal and chemical properties of milk and milk products; Principles and equipment related to receiving of milk, pasteurization, sterilization, homogenization, cream separation, preparation of butter, cheese, paneer and ice cream. Filling and packaging: Selection of different types of packaging materials for different types of food products; Equipment for filling and packaging of liquid foods such as gravity filler, filling. by metering-FFS system, piston type filler, metering cup filler, filling of pastes, filling of powders; aseptic filling of pouches and bottles. Nanotechnology and its applications in food industry; Basics of food plant design and layout; Plant utilities.

**Practical**

Preparation of flow charts for different food processing industries; Study of different parts of retort and canning process; Study of different types of evaporators and multiple effect evaporation system; Study of drum dryer and spray dryer and comparison of product qualities; Study of different types of mixers for solids and liquids; determination of mixing effectiveness and mixing index; Study of settling and sedimentation process in a tank; Study of different types of filters; Study of membrane modules and different types of membranes; Study of measurement of different properties of milk and milk products; Study of milk pasteurizer, sterilizer and homogenizer; Study on preparation of cream and butter; Study of preparation of cheese, paneer and ice cream; Study of different types of packaging materials; Study of different types of filling machines for liquids and powder/ granules; Study of layout of a food processing plant; Visit to food processing industries and dairy plants to study the plant layout and unit operations.

**Lecture Schedule**

1. Introduction to different unit operations in food processing

2. Process flow charts for preparation of various food products
3. Mass and energy balance.
4. Dehydration of foods; dryers for solid foods, construction and operation of direct and indirect type solar dryers, tray dryer, tunnel dryer
5. Vacuum dryer, microwave dryer, freeze dryer, etc.
6. Dryers for liquid foods, construction and operation of drum dryer
7. Construction and operation of spray dryer and vacuum band dryer
8. Evaporation of food products: principle, different types of evaporators
9. Factors affecting steam economy, multiple effect evaporation, vapour recompression
10. Thermal processing: thermobacteriology
11. D value-Z value-F value-reaction quotient, process time
12. Different types of retorts and continuous sterilizers
13. Canning process-principle and process flow chart
14. Aseptic processing – principle and process flow chart
15. Principles and applications of different non-thermal processing methods as vacuum processing
16. Principles and applications of High-pressure processing-UHT pasteurization and its application
17. Principles and applications of PEF Processing
18. Principles and applications of Ultrasonication
19. Principles and applications of Radiation Processing
20. Principles and applications of novel heating methods,
21. Principles and applications of ohmic heating
22. Principles and applications of infrared heating
23. Principles and applications of dielectric heating
24. Mixing: Theory of mixing of solids and pastes- mixing index
25. Different types of mixers for solids, liquid foods and pastes
26. Tumbling mixer, screw mixer, ribbon mixer
27. Liquid mixers, sigma-blade mixer, anchor and gate agitator
28. Separation processes: principle and equipment for sedimentation of solids in liquid and solids in air
29. Principle and operation of tubular bowl centrifuge and disc bowl centrifuge
30. Filtration: principle, construction and working principles of different types of filters
31. Principle and operation of Plate and frame filter press, shell and leaf filter
32. Principle and operation of centrifugal filter, rotary drum filter, continuous belt filter
33. Membrane separation: principle, characteristics and applications of reverse osmosis, nanofiltration,
34. Principle, characteristics and applications of ultra-filtration and macro-filtration
35. Membrane modules
36. Extrusion cooking: principle, factors affecting extrusion cooking
37. Single and twin screw extruders
38. Unit operations in milk processing
39. Engineering, thermal and chemical properties of milk and milk products
40. Principles and equipment related to receiving of milk, pasteurization, UHT pasteurisation-sterilization
41. Principles and equipment related to homogenization

42. Principles and equipment related to cream separation
43. Principles and equipment related to preparation of butter and cheese
44. Principles and equipment related to preparation of paneer and ice cream
45. Filling and packaging: Selection of different types of packaging materials for different types of food products
46. Equipment for filling and packaging of liquid foods such as gravity filler, filling by metering-FFS system
47. Piston type filler, metering cup filler, filling of pastes, filling of powders
48. Aseptic filling of pouches and bottles.
49. Nanotechnology and its applications in food industry.
50. Basics of food plant design and layout
51. Basics of plant utilities.

**Practical Schedule**

1. Study of different parts of retort and canning process
2. Study of different types of evaporators
3. Study of multiple effect evaporation systems
4. Study of drum dryer and spray dryer
5. Study of different types of mixers for solids and liquids, mixing effectiveness and mixing index
6. Study of settling and sedimentation process in a tank
7. Study of different types of filters
8. Study of membrane modules and different types of membranes
9. Study of measurement of different properties of milk and milk products
10. Study of milk pasteurizer, sterilizer, and homogenizer
11. Study on preparation of cream and butter
12. Study of preparation of cheese, paneer, and ice cream
13. Study of different types of packaging materials
14. Study of different types of filling machines for liquids and powder/granules
15. Study of layout of a food processing plant
16. Visit to food processing industries and dairy plants to study the plant layout and unit operations
17. Practical examination

**Suggested Reading**


1. Ahmed, T. 1997. Dairy Plant Engineering and Management. Kitab Mahal.
2. Dash, S. K., Chandra, P. and Kar, A. 2024. Food Engineering Principles and Practice. CRC Press, Boca Raton, USA
3. McCabe, W. L., Smith, J. C. and Harriott. 1999. Unit Operations of Chemical Engineering. McGraw Hill.
4. Rao, D. G. 2009. Fundamentals of Food Engineering. PHI learning Pvt. Ltd, New Delhi.
5. Singh, R. P. and Heldman, D. R. 1993. Introduction to Food Engineering. Academic Press.
6. Toledo, R. T. 1997. Fundamentals of Food Process Engineering. CBS Publishers

## PFE 3204 Agricultural Structures and Environmental Control 3 (2+1)

**Objectives**

- To make the students acquainted with the different types of agricultural structures
- To enable them to prepare plan and estimate for different farm structures and environment control measures.

**Theory**

**Module I** **(7 Hours)**

Farm and farmstead, farmstead planning and lay out; Environmental control- scope, importance and need, physiological reaction of livestock, environmental control, systems and design, control of temperature, humidity and air ventilation; BIS standards for dairy, piggery and other farm structures.

**Module II** **(10 Hours)**

Farm structures- design, construction and cost estimation of farm structures, animal shelters, compost pit, fodder silo, farm fencing, implement shed, barn for cows, buffalo, poultry etc.; Greenhouses- types, poly houses /shed nets, cladding materials, plant environment interactions, design and construction of greenhouses, site selection, orientation, design for ventilation requirement using exhaust fan system, selection of equipment, greenhouse cooling and heating system.

**Module III** **(8 Hours)**

Grain storage structures- grain storage methods, moisture and temperature change in grain bins, traditional storage structures and their improvement, improved storage structures (CAP, hermitage storage, Pusa bin, RCC ring bin), design consideration for grain storage go-down, bag storage structure, shallow and deep bins, calculation of pressure in bins; Storage of seeds.

**Module IV** **(9 Hours)**

Rural housing and development; Farm roads- types of roads in the farm, construction methods, repair and maintenance of rural roads; Water supply and sanitation- sources of water supply for human beings and animals, drinking water standards, water treatment for rural community, site selection and orientation of buildings for sanitation; Sewage system and design, maintenance, septic tank for small family. Rural electrification- estimate of domestic power requirement, sources of power supply, electrification for rural housing.

**Practical**

Measurement of environmental parameters, Temp, RH, wind velocity, cooling load; Design and layout of a dairy farm; Design and layout of a poultry house; Design and layout of a goat/sheep house; Design and layout of a farm fencing system; Design and layout of a feed/fodder system; Design and layout of a greenhouse; Design and layout of a grain storage structure; Design and layout of a bag storage structure; Performance of domestic storage structure; Design layout of a threshing floor.

**Lecture Schedule**

1. Farmstead – location of farm stead – size and arrangement
2. Planning of farmstead and farm house

3. Physiological reaction of livestock to solar radiation and environmental factors
4. Environment control systems and their design
5. Control of temperature, Humidity and other factors by ventilation and others methods
6. BIS- introduction- objectives- importance- standards for dairy
7. BIS Standards for dairy, piggery, poultry and other farm structures.
8. Design, construction and cost estimation of farm fencing systems- fencing posts
9. Compost pit – mechanism of composting-types of composting
10. Design, construction and cost estimation of compost pit
11. Fodder silo – types - Design construction and cost estimation of fodder silo.
12. Design, construction and cost estimation of implement shed
13. Dairy barns – types – design parameters
14. Design, construction and cost estimation of dairy barns – types
15. Design and construction of deep litter and wire floored poultry houses
16. Cage housing system – poultry equipment
17. Green houses- types- polyhouses, shed nets, and cladding materials.
18. Design and construction of greenhouses- site selection, orientation, and ventilation using exhaust fan systems.
19. Equipment selection for greenhouse cooling and heating systems.
20. Storage of grains- methods- moisture and temperature changes in stored grains – moisture movement
21. Traditional storage structures-their improvement
22. Improved storage structures- CAP, hermetic storage, Pusa bin, RCC ring bins
23. Grain storage silo – deep bin – shallow bin – plain of rupture
24. Calculation of pressure inside bin – grain pressure theories
25. Design and layout of bag storage structures- grain godowns
26. Constructional details of grain godowns- storage of seeds
27. Rural roads – types - construction
28. Maintenance and repair of rural roads
29. Sources of water supply, norms of water supply for human being and animals, drinking water standards
30. Water treatment suitable to rural community
31. Sewage system and its design, cost and maintenance
32. Design of septic tank for small family – Soak pit.
33. Source of power supply and electrification of rural housing power requirement.
34. Estimation of domestic power requirement.

**Practical Schedule**

1. Estimation of cooling load of a farm building
2. Measurement of environmental parameters, Temp, RH, wind velocity
3. Design and layout of a dairy barn
4. Design and layout of a poultry house
5. Design and layout of a goat house/sheep house
6. Design of a farm fencing system
7. Design of a feed/fodder storage structures
8. Design and layout of green house
9. Design of grain storage structures – Grain bin
10. Design and layout of bag storage structure – Grain godown

11. Study and performance evaluation of different domestic storage structure
12. Design, layout and cost estimation of a farm fencing
13. Design layout of a threshing floor
14. Design and layout of a septic tank
15. Design and layout of a rural road
16. Design and layout of compost pit
17. Practical examination

**Suggested Readings**


1. Banerjee, G. C. 2007. *A Text Book of Animal Husbandry*. Oxford IBH Publishing Co, New Delhi.
2. Dutta, B. N. 2016. *Estimating and Costing in Civil Engineering*. Dutta & Co, Lucknow.
3. Garg, S. K. 2010. *Water Supply Engineering*. Khanna Publishers, New Delhi.
4. Khanna, P. N. 1958. *Indian Practical Civil Engineer's Hand Book*. Engineer's Publishers, New Delhi.
5. Nathonson, J. A. 1996. *Basic Environmental Technology*. Prentice Hall of India, New Delhi.
6. Ojha, T. P. and Michael, A. M. 1966. *Principles of Agricultural Engineering*. Vol. I. Jain Brothers, Karol Bag, New Delhi.
7. Pandey, P. H. 2004. *Principles and Practices of Agricultural Structures and Environmental Control*. Kalyani Publishers, Ludhiana.
8. Rao, P. V. 2012. *Text Book of Environmental Engineering*. Prentice Hall of India, New Delhi.
9. Sahay, K. M. and Singh, K. K. 2004. *Unit Operations of Agricultural Processing*. Vikas Publishing Pvt. Ltd, Noida.


## PFE 3205 Post-Harvest Engineering of Horticultural Crops 2 (1+1)

**Objective**

To make the students acquainted with unit operations in processing of major horticultural crops and working principles of different machineries for these.

**Theory**

**Module I** **(6 Hours)**

Importance of processing of fruits and vegetables, spices, condiments; characteristics and properties of horticultural crops important for processing; General methods of preservation of fruits and vegetables and their relative advantages and disadvantages; Flowcharts for preparation of different finished products. Sorting and grading methods specific to fruits and vegetables, shape and size sorting, weight sorting, image processing, colour sorting, sorting effectiveness; Peeling: different peeling methods and devices (manual, mechanical, chemical and thermal peeling).

**Module II** **(7 Hours)**

Minimal processing and pack house activities; Size reduction and juice extraction: equipment for slicing, shredding, crushing, chopping, juice extraction; Blanching: importance and objectives; effects on food (nutrition, colour, pigment, texture); blanching methods and equipment. Drying: Dryers for fruits and vegetables, osmo-dehydration, foam mat drying; advanced drying techniques; quality deterioration during drying of fruits and vegetables; Canning of fruits and vegetables:

methods and equipment, types of cans, failures of cans; Chilling and freezing: Chilling requirements of different fruits and vegetables; Freezing of food, freezing time calculations, slow and fast freezing; Equipment for chilling and freezing (mechanical and cryogenic); Cold chain logistics and reefer containers; Cold storage heat load calculations and selection of matching equipment; Design of cold stores.

**Module III** **(4 Hours)**

Post-harvest management and equipment for spices; Post-harvest management and equipment for flowers; Packaging and storage: packaging requirements (for containment, protection and other purposes); Characteristics of different packaging materials used for raw and processed fruits and vegetables products; bulk and retail packages; Modified atmosphere packaging, smart packaging; Packaging machines; Shrink packaging; Storage methods as low temperature storage, evaporative cooled storage and controlled atmospheric storage.

**Practical**

Preparation of different processed horticultural products; Study of fruit graders; Study of different types of peelers and slicers; Study of juicer and pulper; Study of minimal processing of vegetables; Study of blanching equipment, testing the adequacy of blanching; Study of different dryers for fruits and vegetables; Study of foam mat drying and osmotic dehydration processes; Study of different activities in pack house; Cold storage heat load calculations and design; Study of different types of packaging materials; Study of CAS and MAP of vegetables; Study of shrink packaging of foods; Study of hammer mill, pulveriser for grinding of spices to powder; Visit to fruit and vegetable processing/ spice processing plant.

**Lecture Schedule**

1. Horticultural crops-introduction-classification-importance-status of production and export value
2. Characteristics and properties of horticultural crops important for processing
3. Preservation Technology- general methods of preservation of fruits and vegetables-its advantages and disadvantages.
4. Flowcharts for preparation of different finished products.
5. Sorting and Grading methods of fruits and vegetables
6. Peeling and slicing of horticultural crops- Different methods and equipments used.
7. Principles of processing and preservation: blanching- types-Canning-bottling-surface coatings-chemical dips-thermal processing of food.
8. Minimal processing-fruits and vegetables-methods and principles.
9. Size reduction and juice extraction-equipments for slicing, shredding, chopping, crushing etc.
10. Drying and dehydration-importance-water activity-pre treatments before drying-drying curve-shrinkage, case hardening.
11. Advanced drying techniques-quality deterioration during drying of fruits and vegetables-types of driers
12. Thermo plasticity-chemical changes during drying-osmotic dehydration-osmo vac dehydration and osmo air drying of fruits.
13. Freezing – chilling – types - freezing time calculation - refrigeration- cold storage – design of cold storage structure – cooling load calculation
14. Packaging of horticultural commodities- materials-basic requirements of packaging materials-transportation – smart and shrink packaging.

15. Handling and storage-refrigerated storage-evaporative cooled storage- Modified and Controlled atmosphere storage
16. Post harvest management and equipment for spices and flowers.
17. Quality control in Fruit and vegetable processing industry-Food supply chain.

**Practical Schedule**

1. Preparation of different processed horticultural products.
2. Study of fruit graders.
3. Study of different types of peelers and slicers.
4. Study of juicer and pulper.
5. Study of minimal processing of vegetables.
6. Study of blanching equipments
7. Experiments on testing the adequacy of blanching
8. Study of different dryers for fruits and vegetables.
9. Study of foam mat drying and osmotic dehydration processes.
10. Study of different activities in pack house.
11. Cold storage heat load calculations and design.
12. Study of different types of packaging materials.
13. Study of CAS and MAP of vegetables.
14. Study of shrink packaging of foods.
15. Study of hammer mill, pulveriser for grinding of spices to powder.
16. Visit to fruit and vegetable processing/ spice processing plant.
17. Practical examination.

**Suggested Readings**


1. Dash, S. K., Chandra, P. and Kar, A. 2024. *Food Engineering Principles and Practice*. CRC Press, Boca Raton, USA
2. Fellows, P. J. 2008. *Food Processing Technology Principles and Practices*. Woodhead Publishing.
3. Lal, G., Siddappa, G. S. and Tondon, G. L. 2009. *Preservation of Fruits and Vegetables*. ICAR, New Delhi.
4. Mangaraj, S., Ali, N., Swain, S. and Dash, S. K. 2016. *Agricultural Process Engineering Vol. III.*
5. Pandey, P. H. 1997. *Post-harvest Technology of Fruits and Vegetables* (Principles and practices). Saroj Prakashan, Allahabad.
6. Srivastava, R. P. and Kumar, S. 2019. *Fruit and Vegetable Preservation: Principles and Practices*. Kalyani Publishers, New Delhi.
7. Sudheer, K. P. and Indira, V. 2007. *Post-Harvest Engineering of Horticultural Crops*. New India Publishing House.


## PFE 4106 Food Quality and Safety 3 (2+1)

**Objective**

To enable the student to know about the concept and aim of food quality and safety, food quality characteristics – physical, chemical and biological properties, different hazards and their

prevention, different methods for measuring food quality as well as the food safety management system

**Theory**

**Module I** **(8 Hours)**

Basics of food quality, safety and food analysis; Concept, objectives and need of food quality; definition, objective measurement of quality and safety indices. Quality control, quality control tools, statistical quality control; Sampling (Chemical and Microbiological): purpose, sampling techniques, sampling procedures for liquid, powdered and granular materials

**Module II** **(10 Hours)**

Instrumental method for testing food quality, measurement of colour, flavour, consistency, viscosity, texture and their relationship with food quality and composition. Non-destructive methods for evaluation of food quality. NIR, FTIR and chemometrics theory and application in food quality prediction. Theory and application of X-ray, CT, MRI, Ultrasound for internal quality inspection of fruits and vegetables. Sorting grading using external image analysis, internal biochemical analysis using spectroscopy.

**Module III** **(8 Hours)**

Sensory evaluation methods, panel selection methods, Interpretation of sensory results. Food hazards and food safety, Food borne infections, contaminants (physical, chemical, biological), adulteration, food safety strategies- Food Safety Management Systems, GAP, GHP, GMP, TQM, TQC; Hazards and HACCP,

**Module IV** **(8 Hours)**

Sanitation in food industry (SSOP); Food Laws and Regulations, BIS, AGMARK, FSSAI; International Food standards (ISO-22000, CAC); Food Recall, Traceability; Bio safety and Bioterrorism; Sanitation in food industry.

**Practical**

Study of statistical process control in food processing industry; Study of sampling techniques, tools and protocols used in different types of from food handling, processing and marketing establishments; Study of registration process and licensing procedure under FSSAI; Examination of cereals, oilseeds and pulses from go-downs and market shops in relation to specifications provided by standardization techniques; Detection of adulteration and examination of ghee for various standards of Agmark/ FSSAI; Detection of adulteration and examination of spices for Agmark/ FSSAI standards; Detection of adulteration and examination of milk and milk products for FSSAI standards; Detection of adulteration in fruit products such as jam, jelly, marmalades as per FSSAI specification; Visit to a professional quality control laboratory; Visit to food processing laboratory in an industry and study of records and reports maintained by food processing laboratory.

**Lecture Schedule**

1. Introduction to food quality and safety
2. Basics of food safety and food analysis, concept, objectives and need of food quality.
3. Quality and safety indices - definition, objective measurement

4. Quality control and quality control tools
5. Statistical tool for quality control, methods of quality control
6. Food safety- sampling plans (Chemical and Microbiological) and criteria for microbial assessments in foods
7. Sampling- purpose, sampling techniques, sampling procedures for liquid
8. Sampling procedures for powdered and granular materials.
9. Instrumental method for testing food quality; measurement of colour, and its relationship with food safety and quality aspects
10. Measurement of flavour, consistency, and their relationship with food safety and quality aspects
11. Measurement of texture, viscosity and their relationship with food quality food safety and quality aspects
12. Non-destructive methods for evaluation of food quality
13. NIR, FTIR and chemometrics theory and application in food quality prediction.
14. NIR, FTIR and chemometrics theory and application in food quality prediction.
15. Theory and application of X-ray, CT for internal quality inspection of fruits and vegetables.
16. Theory and application of MRI, Ultrasound for internal quality inspection of fruits and vegetables
17. Sorting grading using external image analysis, internal biochemical analysis using spectroscopy.
18. Sensory evaluation methods, panel selection methods
19. Interpretation of sensory results.
20. Food hazards, food safety and food borne infections
21. Food contaminants – physical, biological and chemical contaminants
22. Food adulteration and food safety.
23. Food Safety Management Systems- TQM and TQC
24. Food Safety Management Systems GAP, GHP, GMP
25. Hazards and HACCP (Hazard analysis and critical control point)- principles.
26. Preparation of HACCP plan, Development of HACCP plan for food industries
27. Sanitation in food industry (SSOP) – principles, applications in food industry
28. Food Laws and Regulations in India- FSSAI,
29. Food Laws and Regulations in India- FSSAI,
30. AGMARK and BIS standards for food products
31. International standards - ISO 22,000
32. Codex Alimentarius Commission Standards (CAC)
33. Food Recall, traceability
34. Bio safety and Bioterrorism

**Practical Schedule**

1. Study of statistical process control in food processing industry
2. Study of statistical process control in food processing industry
3. Study of sampling techniques, tools and protocols used in different types of food handling, processing establishments
4. Study of sampling techniques, tools and protocols used in different types of food marketing establishments
5. Study of FSSAI functions
6. Study of registration process and licensing procedure under FSSAI

7. Examination of cereals oilseeds & pulses from one of go-downs in relation to FPO and BIS specifications
8. Examination of cereals & pulses from one of market shops in relation to FPO and BIS Specifications
9. Detection of adulteration and examination of ghee for various standards of AGMARK/ FSSAI standards
10. Detection of adulteration and examination of spices for Agmark/ FSSAI standards
11. Detection of adulteration and examination of milk and milk products for FSSAI standards
12. Detection of adulteration in fruit products such as jam and jelly as per FSSAI specification
13. Detection of adulteration in fruit product like marmalades as per FSSAI specification
14. Visit to a quality control laboratory
15. Visit to food processing laboratory
16. Study of records and reports maintained by food processing laboratory
17. Practical examination

**Suggested Reading**


1. Acharya, K. T. 2017. Everyday Indian Processed foods. National Book Trust.
2. Gupta, V. (Ed.). 2006. The Food Safety and Standards Act along with Rules & Regulations. Commercial Law Publishers (India) Pvt. Ltd.
3. Jha, S. N. 2015. Rapid Detection of Food Adulterants and Contaminants: Theory and Practice. Elsevier, USA (ISBN 9780124200845), p266.
4. Jha, S. N. (Ed.). 2010. Nondestructive Evaluation of Food Quality: Theory and Practice. Springer Verlag GmbH Berlin Heidelberg, Germany, ISBN 978-3-642-15795-0, doi 10.1007/978-3- 642-15796-7: 288p.
5. Mudambi, S. R., Rao, S. M. and Rajgopal, M. V. 2006. Food Science. New Age International Publishers.
6. Negi, H. P. S., Sharma, S. and Sekhon, K. S. 2007. Hand book of Cereal Technology. Kalyani Publishers, New Delhi.
7. Potter, N. N. and Hotchikss, J. H. 1995. Food Science. Chapman and Hall Pub.
8. Raj, D., Sharma, R. and Joshi, V. K. 2011. Quality for Value Addition in Food Processing. New India Publishing Agency, New Delhi
9. Ranganna, S. 1986. Hand book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill Education.
10. Sharma, A. 2017. A Textbook of Food Science and Technology. CBS Publishers & Distributors.
11. Srivastava, R. P. and Kumar, S. 2017. Fruit and Vegetable Preservation: Principles and Practices. International Book Distributing Company.

## Department of Processing and Food Engineering- Elective Courses

## EPF 4201 Development of Processed Food Products 3 (2+1)

**Objectives**

To enable the students to know about the

- Unit operations and equipment used for different food processing operations
- Processing technologies for value addition of cereals, pulses, oilseeds, vegetables, fruits, milk, fish, meat and poultry products

**Theory**

**Module I** **(8 Hours)**

Process of new product development; Process flow chart with mass and energy balance; Unit operations and equipment for processing; Technologies for value addition of cereals, pulses and oil seeds- milled, puffed, flaked, roasted and malted products, bakery products, snack food, extruded products

**Module II** **(8 Hours)**

Technologies for value added products from fruits, vegetables and spices as canned foods, frozen foods, dried foods, fried foods, fruit juices, sauce, sugar-based confectionery, candy, fermented products, spice extract

**Module III** **(10 Hours)**

Technologies for value addition of liquid foods such as milk, sugarcane juice, etc.; Technologies for value addition of forest produce as mahua and tamarind; Technology for processing of animal produce, viz. meat, poultry, fish, egg products

**Module IV** **(8 Hours)**

Technologies for preparation of health foods, nutraceuticals and functional food; Organic food processing.

**Practical**

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

**Lecture Schedule**

1. Process of new product development
2. Process of new product development
3. Process flow chart with mass and energy balance
4. Unit operations and equipment for processing
5. Technologies for value addition of cereals, pulses and oil seeds- milled, puffed and flaked products
6. Technologies for value addition of cereals, pulses and oil seeds- roasted and malted products
7. Technologies for value addition of cereals, pulses and oil seeds- bakery products

8. Technologies for value addition of cereals, pulses and oil seeds- snack food, extruded products
9. Technologies for value added products from fruits, vegetables and spices as canned foods
10. Technologies for value added products from fruits, vegetables and spices as frozen foods
11. Technologies for value added products from fruits, vegetables and spices as dried foods, fried foods
12. Technologies for value added products from fruits, vegetables and spices as fruit juice
13. Technologies for value added products from fruits, vegetables and spices as sauce
14. Technologies for value added products from fruits, vegetables and spices as sugar-based confectionery, candy
15. Technologies for value added products from fruits, vegetables and spices as fermented products
16. Technologies for value added products from fruits, vegetables and spices as spice extract
17. Technologies for value addition of liquid foods such as milk
18. Technologies for value addition of liquid foods such as sugarcane juice
19. Technologies for value addition of liquid foods such as carbonated beverage
20. Technologies for value addition of liquid foods such as soups
21. Technologies for value addition of forest produce as mahua
22. Technologies for value addition of forest produce as tamarind
23. Technology for processing of animal produce, viz. meat
24. Technology for processing of animal produce, viz. poultry
25. Technology for processing of animal produce, viz. fish
26. Technology for processing of animal produce, viz. egg products
27. Introduction to health foods
28. Technologies for preparation of health foods
29. Introduction to nutraceuticals
30. Technologies for preparation of nutraceuticals
31. Probiotic, prebiotic and symbiotic
32. Introduction to functional food
33. Technologies for preparation of functional food
34. Organic food processing.

**Practical Schedule**

1. Process design and preparation of process flow chart of either milled, puffed, flaked, roasted or malted products, bakery products, snack food or extruded products
2. Process design and preparation of process flow chart of either canned foods, frozen foods, dried foods, fried foods, fruit juices, sauce, sugar-based confectionery, candy, fermented products, or spice extract
3. Process design and preparation of process flow chart of any liquid food
4. Process design and preparation of process flow chart of any forest produce
5. Process design and preparation of process flow chart of any animal produce
6. Process design and preparation of process flow chart of either health foods, nutraceuticals or functional food
7. Preparation of different value-added products of either milled, puffed, flaked, roasted or malted products bakery products, snack food or extruded products
8. Preparation of different value-added products of either canned foods, frozen foods, dried foods, fried foods, fruit juices, sauce, sugar-based confectionery, candy, fermented products, or spice extract

9. Preparation of different value-added products of any liquid food
10. Preparation of different value-added products of any forest produce
11. Preparation of different value-added products of any animal produce
12. Preparation of different value-added products of either health foods, nutraceuticals or functional food
13. Visit to roller flour mill, rice mill, spice grinding mill, milk plant, dhal and oil mill, fruit/ vegetable processing plant, sugar mill and other food processing industries
14. Study of operations and machinery of any milling unit
15. Study of operations and machinery of any vegetable processing unit
16. Study of operations and machinery of any food processing industry
17. Practical examination

**Suggested Readings**


1. Acharya, K. T. 2017. Everyday Indian Processed Foods. National Book Trust.
2. Dash, S. K., Chandra, P. and Kar, A. 2024. Food Engineering Principles and Practice. CRC Press, Boca Raton, USA
3. Mudambi, S. R., Rao, S. M. and Rajgopal, M. V. 2006. Food Science. New Age International Publishers.
4. Negi, H. P. S., Sharma, S. and Sekhon, K. S. 2007. Handbook of Cereal Technology. Kalyani Pub.
5. Potter, N. N. and Hotchkiss, J. H. 1995. Food Science. Chapman and Hall Pub.
6. Rao, D. G. 2009. Fundamentals of Food Engineering. PHI Learning Pvt. Ltd, New Delhi.
7. Srivastava, R. P. and Kumar, S. 2019. Fruit and Vegetable Preservation: Principles and Practices. International Book Distributing Company.


## EPF 4202 Food Packaging Technology 3 (2+1)

**Objectives**

To enable the students to

- Understand the interaction of food, packaging and environment
- Understand the different methods of package development and packaging
- Select the best type and form of packaging of specific food for specific end users

**Theory**

**Module I** **(6 Hours)**

Factors affecting shelf life of food material during storage, interactions of spoilage agents with environmental factors as water, oxygen, light, pH, etc. and general principles of control of the spoilage agents; Difference between food infection, food intoxication and allergy. Packaging of foods, requirement, importance and scope, environmental considerations; Packaging systems, types: flexible and rigid; retail and bulk; levels of packaging.

**Module II** **(13 Hours)**

Different types of packaging materials, their key properties and applications; Metal cans- manufacture of two piece and three piece cans; Plastic packaging- different types of polymers and lamination used in food packaging and their barrier properties; Manufacture of plastic packaging

materials, profile extrusion, blown film/ sheet extrusion, blow molding, extrusion blow molding, injection blow molding, stretch blow molding, injection molding; Glass containers- types of glass used in food packaging, manufacture of glass and glass containers, closures for glass containers; Paper and paper board packaging- paper and paper board manufacture process, modification of barrier properties and characteristics of paper/ boards; Relative advantages and disadvantages of different packaging materials, effect of these materials on packed commodities.

**Module III** **(7 Hours)**

Nutritional labelling on packages; CAS and MAP, shrink and cling packaging, vacuum and gas packaging; Active packaging, Smart packaging; Packaging requirement for raw and processed food and selection of packaging materials; Disposal and recycle of packaging waste.

**Module IV** **(8 Hours)**

Package testing- testing methods for flexible materials, rigid materials and semi rigid materials, tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.), plastic film and laminates (thickness, tensile strength, gloss, haze, burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.), glass containers (visual defects, colour, dimensions, impact strength, etc.), metal containers (pressure test, product compatibility, etc.).

**Practical**

Identification of different types of packaging materials; Determination of tensile/ compressive strength of given material/ package; To perform different destructive and non-destructive test for glass containers; Vacuum packaging of agricultural produces; Determination of tearing strength of paper board; Measurement of thickness of packaging materials; To perform grease-resistance test in plastic pouches; Determination of bursting strength of packaging material; Determination of water vapour transmission rate; Shrink wrapping of various horticultural produce; Testing of chemical resistance of packaging materials; Determination of drop test of food package and visit to relevant industries.

**Lecture Schedule**

1. Introduction to packaging- application in food industry
2. Factors affecting shelf life of food material during storage-Interactions of spoilage agents with environmental factors as water- oxygen, light, pH.
3. General principles of control of the spoilage agents
4. Difference between food infection, food intoxication and allergy
5. Packaging of foods-requirement-importance and scope- -environmental considerations.
6. Packaging systems- types- flexible and rigid- retail and bulk- levels of packaging
7. Different types of packaging materials- key properties- applications
8. Metal cans- types.
9. Metal cans- manufacture of two piece and three-piece cans
10. Plastic packaging- different types of polymers used in food packaging - barrier
11. Properties
12. Different types of laminations used in food packaging
13. Manufacture of plastic packaging materials- profile extrusion- blown film/ sheet
14. Manufacture of plastic packaging materials-extrusion blow moulding- injection blow
15. moulding

16. Manufacture of plastic packaging materials - stretch blow moulding- injection moulding.
17. Glass containers- types of glass used in food packaging
18. Manufacture of glass and glass containers- closures for glass containers.
19. Paper and paper board packaging- paper and paper board manufacture process
20. Modification of barrier properties - characteristics of paper/ boards.
21. Relative advantages and disadvantages of different packaging materials
22. Nutritional labelling on packages
23. CAS and MAP
24. Shrink and cling packaging
25. Vacuum and gas packaging
26. Active packaging- Smart packaging
27. Packaging requirement for raw and processed foods- selection of packaging materials
28. Disposal and recycle of packaging waste
29. Package testing- methods for flexible materials- rigid materials and semi rigid materials
30. Package testing -Tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.)
31. Package testing -Tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.)
32. Package testing-plastic film and laminates (thickness, tensile strength, gloss, haze,
33. burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.)
34. Package testing-plastic film and laminates (thickness, tensile strength, gloss, haze,
35. burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.)
36. Package testing-glass containers (visual defects, colour, dimensions, impact strength,etc.), metal containers (pressure test, product compatibility, etc.)
37. Package testing-glass containers (visual defects, colour, dimensions, impact strength, etc.)
38. Package testing metal containers (pressure test, product compatibility, etc.)

**Practical Schedule**

1. Identification of different types of packaging materials
2. Determination of tensile/ compressive strength of given material/ package
3. To perform different destructive tests for glass containers
4. To perform different non-destructive tests for glass containers
5. Vacuum packaging of agricultural produces
6. Measurement of basic weight and grammage of paper and paperboards
7. Measurement of water absorption of paper, paper boards
8. Determination of tearing strength of paper board
9. Measurement of thickness of packaging materials
10. To perform grease-resistance test in plastic pouches
11. Determination of bursting strength of packaging material
12. Determination of water vapour transmission rate
13. Shrink wrapping of various horticultural produce
14. Testing of chemical resistance of packaging materials
15. Determination of drop test of food package
16. Visit to relevant food processing industries
17. Practical examination

**Suggested Readings**


1. Coles, R., McDowell, D. and Kirwan, M. J. 2003. Food Packaging Technology. Blackwell Publishing Co.
2. Gosby, N. T. 2001. Food Packaging Materials. Applied Science Publication
3. John, P. J. 2008. A Handbook on Food Packaging. Narendra Publishing House.
4. Mahadevia, M. and Gowramma, R. V. 2007. Food Packaging Materials. Tata McGraw Hill.
5. Robertson, G. L. 2001. Food Packaging and Shelf life: A Practical Guide. Narendra Publishing House.
6. Robertson, G. L. 2005. Food Packaging: Principles and Practice. Second Edition. Taylor and Francis.


## EPF 4203 Food Plant and Equipment Design 3 (2+1)

**Objectives**

To enable the students to

- Understand the managerial aspects of food processing plant
- Understand Govt. policy on small and medium scale food processing enterprise
- Understand the procedure of obtaining license and registration for operating food processing business

**Theory**

**Module I** **(7 Hours)**

Food plant location, selection criteria for plant location; Selection of processes and plant capacity; Requirements of plant building and its components, flow diagrams; Selection of equipment, process and controls; Objectives and principles of food plant layout; Different types of plant layout

**Module II** **(8 Hours )**

Consideration of salient features of processing plants for cereals, pulses, oilseeds, horticultural and vegetable crops, poultry, fish and meat products, milk and milk products for equipment selection and layout.

**Module III** **(9 Hours)**

Application of design engineering for processing equipment; Design parameters and general design procedure; Material specification, types of material for process equipment; Design codes, pressure vessel design; Design of cleaners; Design of tubular heat exchanger, shell and tube heat exchanger and plate heat exchanger;

**Module IV** **(10 Hours)**

Design of belt conveyer, screw conveyer and bucket elevator; Design of grain dryers; Design of milling equipment; Optimization of design with respect to process efficiency, energy and cost; Computer Aided Design.

**Practical**

Study of salient features and layout of pre processing house; Study of salient features, design and layout of different types of food processing industries, viz. milk and milk product plants, modern rice mill, bakery, fruits and vegetables processing unit; Evaluation of given layout; Design of pressure vessel; Design of cleaners; Design of milling equipment; Design of tubular heat exchanger, shell and tube type heat exchanger, plate heat exchanger; Design of grain dryer; Design of belt conveyor, bucket elevator, screw conveyor.

**Lecture Schedule**

1. Food plant location, selection criteria- plant location, location theory
2. Selection of processes, plant capacity, different criteria for plant site selection
3. Requirements of plant building and its components for food processing units
4. Project design, flow diagrams, selection of equipment, process and controls
5. Project design, flow diagrams, selection of equipment, process and controls
6. Plant layout objectives-classical and practical layout
7. Types of plant layout –process, product and layout
8. Fixed position and combination layout
9. Food plant layout - objectives and principles
10. Preparation of layout for fruit and vegetable processing industry
11. Salient features of processing plants for cereals, pulses
12. Salient features of processing plants for oilseeds
13. Salient features of processing plants for horticultural and vegetable crops
14. Salient features of processing plants for poultry, fish and meat products
15. Salient features of processing plants for milk and milk products.
16. Application of engineering principles to design and selection of food processing equipments
17. Introduction ,definition and types of design parameters
18. Material codes : definition ,classification, different types and theories failure
19. Definition, classification and types of Material specification and design codes
20. Construction and design of pressure vessels
21. Construction and design of different types of cleaners
22. Construction and design of tubular heat exchanger and plate heat exchanger
23. Construction and design of shell and tube heat exchanger
24. Introduction , definition , types of conveyors and elevators
25. Construction and design of belt conveyer and screw conveyer
26. Construction and design of bucket elevator
27. Definition, types and design of dryers; tray dryer, tunnel dryer and fluidized bed dryer
28. Definition, types and design of dryers; spray dryer, vacuum dryer and microwave dryer
29. Definition, types and methods of milling equipments,
30. Construction and design of rubber roll Sheller and hammer mill
31. Construction and design of attrition mill and ball mill
32. Optimization of design with respect to process efficiency
33. Energy and cost economics of different design equipments
34. Introduction, definition and classification of computer aided design

**Practical Schedule**

1. Study of salient features and layout of pre-processing house.

2. Study of salient features and layout of Milk and Milk product plants
3. Salient features, design and layout of modern rice mill.
4. Salient features, design and layout of fruit processing unit.
5. Salient features, design and layout of canning unit for vegetable processing.
6. Salient features, design and layout of Bakery and related product plant
7. Evaluation of given layout.
8. Design of pressure vessel
9. Design of cleaners.
10. Design of rubber roll Sheller
11. Design of hammer and ball mill
12. Design of tubular heat exchanger and plate heat exchanger
13. Design of shell and tube heat exchanger
14. Design of grain dryers
15. Design of belt conveyor and screw conveyor
16. Design of bucket elevator
17. Practical examination

**Suggested Reading**


1. Bhattacharyya, B. C. 2008. Introduction to Chemical Equipment Design. CBS Publishers and Distributors.
2. Dawande, S. D. 1999. Process Design of Equipment. Central Techno Publication, Nagpur.
3. Geankoplis, C. J. 1993. Transport Processes and Unit Operations. Prentice-Hall.
4. Hall, H. S. and Rosen, Y. S. 1963. Milk Plant Layout. FAO Publication, Rome.
5. López Antonio Gómez. 2005. Food Plant Design. T&F India.
6. Mahajan, M. 2016. Operations Research. Dhanpat Rai and Company Private Limited, Delhi.
7. Mahajani, V. V. and Umarji, S. B. 2009. Process Equipment Design. Macmillan.
8. Maroulis, Z. B. and Saravacos, G. D. 2007. Food Plant Economics. Taylor and Francis, LLC.
9. Maroulis, Z. B. 2003. Food Process Design. Marcel Dekker, Inc, Cimarron Road, Monticello, New York 12701, USA.
10. Robberts Theunis, C. 2016. Food Plant Engineering Systems. CRC Press, Washington.


## EPF 4204 Emerging Technologies in Food Processing 3(2+1)

**Objective**

To enable the students to:

1. know about various emerging technologies in food processing.
2. know the practical applications of various emerging technologies in food processing.

**Theory**

**Module I** **(12 Hours)**

Fundamentals of food preservation-methods of food preservation-introduction, type and sources of radiation, dosimetry, mode of action of ionizing radiation –direct and indirect effect, radiation effect on food constituents, dose requirement for different products and regulations. Hurdle technology – Ozone – its role in food industry – generation – application.

**Module II** **(12 Hours)**

Pulsed electrified sterilization - application. Pulsed light processing - High pressure technology – application, Oscillating magnetic field sterilization, Ultra sound – application in food industry.

**Module III** **(5 Hours)**

Nano Technology: History, tools and techniques nanomaterials, applications in food packaging and products, implications, environmental impact of nanomaterials and their potential effects on global economics, Enzyme Technology: importance and significance, Effect of Enzyme Technology and its application in food industries.

**Module IV** **(5 Hours)**

Ohmic heating-fundamentals-UV-sterilization - microwave heating – Microwave assisted process in food processing- Radio Frequency heating- cold plasma technique.

**Lecture Schedule**

1. Fundamentals of food preservation-methods of food preservation.
2. Introduction, scope of emerging food preservation methods.
3. Radiation- sources and types of radiation in food industries.
4. Dosimetry - mode of action of ionizing radiation, Radiation effect on food constituents direct and indirect effect.
5. Radiation dose requirement for different products-Regulations involved in the application of radiation-Equipments.
6. Hurdle technology – introduction and importance.
7. Different types of hurdles occur in food spoilage-Hurdle effect – examples.
8. Homeostasis – multi target preservation- metabolic exhaustion.
9. Different types of hazards, physical, chemical and biological hazards.
10. Ozone – introduction and its role in food industry-advantages.
11. Generation of Ozone and its application.
12. Different levels of ozone in preservation.
13. Pulsed electric field sterilization – definition and significance-theory.
14. Generation of pulsed electric fields- treatment chamber design.
15. Electric field strength- treatment time temperature – pulse geometry.
16. Application of Pulsed electrified sterilization in food industries.
17. Pulsed light processing- theory-generation.
18. Applications of Pulsed light processing.
19. High pressure technology - importance and significance-Theory.
20. HPP-equipment- effect of high-pressure technology – Applications in food processing.
21. Oscillating magnetic field sterilization- importance and significance- theory.
22. Equipment for generation of magnetic field pulses - Effect of Oscillating magnetic field sterilization.
23. Ultra sound - importance and significance- theory.
24. Ultrasonic processing equipment- Application of ultrasound in food industries.
25. Nano Technology - importance and significance.
26. Nano materials - Effect of Nano Technology and its impact in global scenario.
27. Application of nano technology in food processing.
28. Enzyme Technology- mode of action - importance and significance.
29. Major enzymes and potential food applications.

30. Ohmic, UV, microwave and radio frequency heating of food – theory and applications
31. Ohmic, UV, microwave and radio frequency heating of food – theory and applications.
32. Ohmic, UV, microwave and radio frequency heating of food – theory and applications.
33. Cold plasma technique – fundamentals.
34. Cold plasma technique-applications in food processing.

**Practical Schedule**

1. Experiments on microwave heating.
2. Study of irradiation process.
3. Study of hurdle technology.
4. Experiments on ozone processing.
5. Study of pulsed electric field processing.
6. Study of pulsed light technology.
7. Experiments on ultrasound processing.
8. Study of high-pressure processing.
9. Study of ohmic heating.
10. Study of nanotechnology.
11. Study of reverse osmosis.
12. Study of cold plasma technique.
13. Study of radio frequency heating.
14. Study of enzyme technology.
15. Study on oscillating magnetic field sterilization.
16. Study of membrane separation process.
17. Practical examination.

**Suggested Readings**


1. Fellows, P.J.2001. Food Processing Technology.
2. Leninger, H.A. and Beverlod, W.A. Food Process Engineering, D.Reicle Pub. Corp.
3. Peter Zeuthen and Leif Bogh- Sorensen. Food Preservation Techniques, Wood head Publishing Ltd. Cambridge.
4. Marcus Karel and Daryl B.Lund. Physical Principles of Food Preservation. Marcel Dekkaer Inc. New York.


## EPF 4205 Processing of Livestock, Fish and Marine Products 3 (2+1)

**Objectives**

To enable the students to

- Learn various processes and methods for processing of livestock, fish and marine products
- Understand the livestock and marine product processing and its applications in industries

**Theory**

**Module I** **(9 Hours)**

Production, economics, and processing scenario of meat, fish, and poultry; Processing and preservation of eggs, production of egg yolk and egg yellow powder; Poultry processing: Unit operations for various poultry products

**Module II** **(10 Hours)**

Fish processing: Unit operations for various fish products; Preservation of meat by dehydration, freezing, pickling, curing, cooking and smoking; preservation of meat using ionizing radiation; preservation of meat using antibiotics and chemical additives

**Module III** **(10 Hours)**

Eating quality of meat and discoloration; water-holding capacity and juiciness in cooked and uncooked meat; Meat texture and tenderness: measurement, factors affecting texture and tenderness, artificial tenderizing

**Module IV** **(5 Hours)**

Abattoir design and layout, meat plant sanitation and safety; By-products utilization

**Practical**

Hands on exercise on the processing of fish, meat and egg and preparation of value-added products; Visit to processing plants.

**Lecture Schedule**

1. Introduction to meat fish and poultry
2. Production, economics, and processing scenario of meat
3. Production, economics, and processing scenario of fish
4. Production, economics, and processing scenario of poultry
5. Processing and preservation of eggs
6. Structure of egg
7. Production of egg yolk and egg yellow powder
8. Poultry processing: Unit operations for various poultry products
9. Processed products of poultry
10. Fish processing: Unit operations for various fish products
11. Processed fish products
12. Preservation of meat by dehydration method
13. Preservation of meat by freezing method
14. Preservation of meat by pickling method
15. Preservation of meat by curing method
16. Preservation of meat by cooking and smoking method
17. Preservation of meat using ionizing radiation
18. Preservation of meat using antibiotics
19. Preservation of meat using chemical additives
20. Eating quality of meat
21. Discoloration of meat
22. Impact of discoloration on eating quality
23. Water-holding capacity in cooked and uncooked meat
24. Juiciness in cooked and uncooked meat and its relation to Water holding capacity
25. Meat texture and tenderness: Introduction
26. Objective measurement methods of meat texture and tenderness
27. Subjective measurement methods of meat texture and tenderness
28. Factors affecting texture and tenderness
29. Artificial tenderizing

30. Abattoir design and layout- Introduction, Considerations
31. Abattoir design and layout- Sections
32. Meat plant sanitation and safety
33. By-products utilization-Edible
34. By-products utilization-Inedible

**Practical Schedule**

1. Hands on exercise on the processing of fish
2. Quality testing of fish
3. Hands on exercise on the processing of meat
4. Quality testing of meat
5. Hands on exercise on the processing of egg
6. Production egg yolk powder
7. Quality testing of egg
8. Preparation of value-added products from fish-I
9. Preparation of value-added products from fish-II
10. Preparation of value-added products from meat-I
11. Preparation of value-added products from meat-II
12. Preparation of value-added products from egg-I
13. Preservation of meat by pickling method
14. Preservation of meat by curing method
15. Preservation of meat by cooking and smoking method
16. Visit to processing plants.
17. Practical examination

**Suggested Readings**


1. Bechtel, P.J. Muscle as Food. Academic Press.
2. Hui, Y. H. Handbook of Meat and Meat Processing. CRC Press.
3. Lawrie, R. A. and Ledward, D. Lawrie's Meat Science. Woodhead Publishing.
4. Stadelmen, W. J. and Cotterill, O.J. Egg Science and Technology. CRC press.


## EPF 4206 Processing of Spices and Plantation Crops 3 (2+1)

**Objectives**

- Learn processing technology of different spices
- Understand post-harvest technology of tea, coffee, cocoa etc.

**Theory**

**Module I** **(2 Hours)**

Production and processing scenario of spice, flavour and plantation crops and its scope; Major spices: Post harvest technology, composition.

**Module II** **(15 Hours )**

Processed products of spices: Ginger, chilli, turmeric, onion and garlic, pepper, cardamom. Equipment for cryogenic grinding; Minor spices: Herbs, leaves and spartan seasonings and their processing and utilization; All spice, Annie seed, sweet basil; Caraway seed, cassia, cinnamon;

Clove, coriander, cumin, dill seed; Fennel seed, nutmeg, mace, mint marjoram; Rosemary, saffron, sage; Savory, thyme, ajowan; Asafetida, curry leaves.

**Module III** **(8 Hours)**

Postharvest technology for Tea, coffee, cocoa, Vanilla and annatto processing; post-harvest technology and processing of areca nut, cashew nut, oil palm, coconut. Flavours of minor spices; Flavour of major spices.

**Module IV** **(9 Hours)**

Spice oil and oleoresins: Extraction techniques; Super critical fluid extraction of spices. Standard specification of spices; Standards like ESA, ASTA, FSSAI and maintenance of quality by fumigation, CAS and ETO sterilization. Functional packaging of spices and spice products; By products of plantation crops and spices.

**Practical**

Identification and characterization of flavouring compounds of spices; Valuable oil determination; Extraction of oil from clove, pepper, cardamom, chilli; Extraction of oleoresins: Turmeric, ginger, pepper, clove; Peperine estimation in pepper oleoresin; Steam distillation of spices; Determination of curcumin content in turmeric; Chemical analysis of spices: Moisture, valuable oil, specific gravity, refractive index, acid value; Study of standard specification of spices; Packaging study of spices; Preparation of curry powder; Visit to spice industry.

**Lecture Schedule**

1. Production and processing scenario of spice, flavour and plantation crops and its scope.
2. Post harvest technology and composition of major spices
3. Unit operations in spice processing-cleaning, drying, milling, and grading
4. Processing of Ginger -flow chart-various products- processing of chilli- drying-dryers, value added products.
5. Processing of turmeric- boiling and polishing-drying methods-equipments and operation.
6. Processing of onion - drying methods-value added products
7. Processing of garlic
8. Processing of pepper- value added products-flow chart-packaging methods.
9. Processing of cardamom- stages of harvest-cleaning, drying, grading equipments. Equipment for cryogenic grinding
10. Processing and utilization of minor spices-herbs, leaves and spartan seasonings
11. Aniseed, Sweet basil-composition and its utilization.
12. Caraway seed, cassia and cinnamon-composition and its utilization.
13. Processing of Clove-stages of harvest-cleaning, drying, grading equipments
14. Coriander-uses, harvesting, drying.
15. Processing of cumin, dill seed -types, harvesting, drying.
16. Processing of fennel seed and its utilization.
17. Processing of nutmeg and mace.
18. Processing of mint-harvesting, drying, storage.
19. Processing of marjoram and rosemary, saffron-production flow chart.
20. Sage herb, thyme, ajwain, asafoetida, curry leaves-harvesting, drying, preservation, uses.
21. Plantation crops-classification-production & processing-Status and Exports.

22. Processing of Tea-unit operation-flow chart, process and equipments
23. Processing of coffee-dry and wet processing-green and cherry Coffee
24. Unit operation-flow charts-equipments and operation
25. Instant coffee powder-flow chart-byproduct utilization of coffee industry
26. Processing of Cocoa-important unit operation-equipments-chocolate processing-flow charts.
27. Processing of vanilla and annatto-flowchart, utilization.
28. Processing of arecanut-different products-unit operation-flow chart equipment and operation
29. Processing of cashew nut-unit operations-flow chart
30. Processing of oil palm and coconut-unit operations-flow chart
31. Flavour extraction from spices-minor spices and major spices.
32. Extraction of oleoresins and essential oils from medicinal plants and spices-steam distillation and Super critical fluid extraction of spices
33. Standards - ESA, ASTA, FSSAI and maintenance of quality by fumigation, CAS and ETO sterilization
34. Packaging of spices and spice products-materials-methods-packaging equipment; By products of plantation crops and spices

**Practical Schedule**

1. Identification and characterization of flavouring compounds of spices
2. Valuable oil determination
3. Performance evaluation of pepper grader
4. Extraction of oil from clove, pepper, cardamom, chilli.
5. Extraction of oleoresins: Turmeric, ginger, pepper, clove.
6. Peperine estimation in pepper oleoresin
7. Steam distillation of spices
8. Determination of curcumin content in turmeric
9. Determination of Moisture content in spices
10. Determination of refractive index and acid value in spices.
11. Determination of specific gravity of spices.
12. Packaging study of spices
13. Preparation of curry powder
14. Study of standard specification of spices.
15. Microwave assisted extraction of spice oil.
16. Visit to a spice processing industry
17. Practical examination

**Suggested Reading**


1. Gupta, S. Handbook of Spices and Packaging with Formulae. Engineers India Research Institute, New Delhi.
2. Hirasa, K. and Takemasa, M. 1998. Spice Science and Technology. Marcel Dekker, NY, USA.
3. Panda, H. Handbook on Spices and Condiments (Cultivation, Processing and Extraction). Asia Pacific Business Press Inc., New Delhi.
4. Pruthi, J.S. 2001. Spices and Condiments – Major Spices of India. National Book Trust, New Delhi.
5. Pruthi, J.S. 2001. Spices and Condiments – Minor Spices of India. National Book Trust, New Delhi.

6. Purseglave, J.W., Brown, E.G., Green, C.L. and Robins. Spices, Vol. I and II. SRJ Academic Press, New Delhi.
7. Shanmugavelu, K.G. Spices and Plantation Crops. Oxford and IBH Publishing Co., New Delhi.

## EPF 4207 Food Composition and Analysis 3 (2+1)

**Objectives**

This course aims to provide students with a comprehensive understanding of the chemical and biological principles underlying food components as well as their metabolic pathways and implications for nutrition. Additionally, it emphasizes the importance of food analysis techniques and microbiological aspects in ensuring food safety, quality, and preservation.

**Theory**

**Module I** **(8 Hours)**

Carbohydrates: Classification, Structure, properties, and importance, Modification of carbohydrates in Food Processing; Enzymatic and chemical reactions of carbohydrates in food systems.Proteins in Foods: Classification, structure, and properties of proteins.Functional properties of proteins.Processing-induced physical, chemical, and nutritional changes in proteins.Lipids in Foods: Classification, structure, and properties of lipids.Chemical aspects: Lipolysis, auto-oxidation, thermal decomposition, Refining, hydrogenation, and inter-esterification.

**Module II** **(10 Hours)**

Concepts of Food and Nutrition: Functions of food, Basic food groups, nutrients supplied by food, basal metabolism, balanced diets, Malnutrition. Enzyme Action: Introduction to enzymes, Mechanism of enzyme action, and their role in food processing.Carbohydrate Metabolism: Digestion, absorption, assimilation of carbohydrates, Glycolysis, TCA cycle, energy production.Lipid Metabolism: β-oxidation, lipid biosynthesis, ketosis, Breakdown of phospholipids and triglycerides.Protein Metabolism: Transamination, deamination, urea cycle, Nitrogen fixation, and protein turnover.Vitamins: Fat-soluble vitamins, Water-soluble vitamins; functions, absorption, deficiencies. Minerals: Macro & Microminerals.

**Module III** **(10 Hours)**

Principles of Food Analysis: Importance, regulations, and standards, sample preparation. Proximate Analysis: Methods for moisture, protein, fat, crude fiber, and ash content, Total fat analysis, crude fiber determination, and mineral analysis. Spectroscopy in Food Analysis: Principles and applications of UV-visible spectroscopy. Atomic absorption spectroscopy and its use in food analysis.Chromatography: Principles and techniques of adsorption, partition, gel-filtration.Ion-exchange and size-exclusion chromatography.Gas-liquid chromatography (GLC) for food composition analysis. High-performance liquid chromatography (HPLC) for food composition.Food Contaminants: Analysis of pesticide residues, heavy metals, and drug residue in food.

**Module IV** **(6 Hours)**

Food Microbiology: Importance of microorganisms in food science, Spoilage, preservation, and fermentation. Microbial Growth Factors: Intrinsic factors: pH, water activity, nutrients, redox potential, Extrinsic factors: Temperature, humidity, gaseous atmosphere. Microbial profiles in milk, fruits, vegetables.Microbial spoilage in cereals, meats, and seafood. Food borne Pathogens and Toxins: Bacterial toxins (Salmonella, Staphylococcus aureus), Fungal toxins, algal toxins, and foodborne intoxications.Preservation and Shelf-Life: Calculation and determination of shelf-life.

**Lecture Schedule**

1. Carbohydrates: Monosaccharides, disaccharides, and polysaccharides: Structure, properties, and importance, Modification of carbohydrates in food processing;
2. Carbohydrates: Enzymatic and chemical reactions of carbohydrates in food systems.
3. Proteins in Foods: Classification, structure, and properties of proteins.
4. Proteins in Foods: Functional properties of proteins (emulsification, gelation, foaming).
5. Proteins in Foods: Processing-induced physical, chemical, and nutritional changes in proteins.
6. Lipids in Foods: Classification, structure, and properties of lipids.
7. Lipids in Foods: Chemical aspects: Lipolysis, auto-oxidation, thermal decomposition.
8. Lipids in Foods: Refining, hydrogenation, and inter-esterification.
9. Concepts of Food and Nutrition: Functions of food, Basic food groups, nutrients supplied by food, basal metabolism, balanced diets, Malnutrition
10. Enzyme Action: Introduction to enzymes, Mechanism of enzyme action and their role in food processing.
11. Carbohydrate Metabolism: Digestion, absorption, assimilation of carbohydrates.
12. Carbohydrate Metabolism: Glycolysis, TCA cycle, energy production.
13. Lipid Metabolism: β-oxidation, lipid biosynthesis, ketosis.
14. Lipid Metabolism: Breakdown of phospholipids and triglycerides.
15. Protein Metabolism: Transamination, deamination, urea cycle.
16. Protein Metabolism: Nitrogen fixation and protein turnover.
17. Vitamins: Fat-soluble vitamins, Water-soluble vitamins; functions, absorption, deficiencies
18. Minerals: Macro (calcium, phosphorus)&Microminerals (iron, zinc);
19. Principles of Food Analysis: Importance, regulations, and standards, sample preparation.
20. Proximate Analysis: Methods for moisture, protein, fat, crude fiber, and ash content.
21. Proximate Analysis: Total fat analysis, crude fiber determination, mineral analysis.
22. Spectroscopy in Food Analysis: Principles and applications of UV-Visible spectroscopy.
23. Spectroscopy in Food Analysis: Atomic absorption spectroscopy and its use in food analysis.
24. Chromatography: Principles and techniques of adsorption, partition, gel-filtration.
25. Chromatography: Ion-exchange and size-exclusion chromatography.
26. Chromatography: Gas-liquid chromatography (GLC) for food composition analysis.
27. Chromatography: High-performance liquid chromatography (HPLC) for food composition.
28. Food Contaminants: Analysis of pesticide residues, heavy metals, and drug residue in food.

29. Introduction to Food Microbiology: Importance of microorganisms in food science, Spoilage, preservation, and fermentation.
30. Microbial Growth Factors: Intrinsic factors: pH, water activity, nutrients, redox potential, Extrinsic factors: Temperature, humidity, gaseous atmosphere.
31. Normal Microbiological Quality: Microbial profiles in milk, fruits, vegetables.
32. Normal Microbiological Quality: Microbial spoilage in cereals, meats, and seafood.
33. Foodborne Pathogens and Toxins: Bacterial toxins (Salmonella, Staphylococcus aureus), Fungal toxins, algal toxins, and foodborne intoxications.
34. Preservation and Shelf-Life: Calculation and determination of shelf-life.

**Practical Schedule**

1. Determination of moisture content in food samples.
2. Determination of crude protein using the Kjeldahl method.
3. Estimation of lipid quality: Acid value, saponification value, and iodine number.
4. Qualitative and quantitative determination of carbohydrates.
5. Qualitative and quantitative determination of proteins.
6. Estimation of Vitamin C using the dye method.
7. Measurement of energy using bomb calorimetry.
8. Estimation of total sugars using spectrophotometry.
9. Fatty acid profiling using gas chromatography (GC).
10. Analysis of heavy metals using atomic absorption spectroscopy.
11. Isolation and identification of bacteria from food samples.
12. Isolation and identification of molds from food samples.
13. Enumeration of coliforms using the MPN method.
14. Detection of Salmonella in food samples.
15. Detection of Staphylococcus aureus in food samples.
16. Practical examination

**Suggested Readings**


1. Brady, J.W. 2013. Introductory Food Chemistry. Comstock Publishing Associates, CornellUniversity Press, Ithaca, USA.
2. Belitz, H. D., Grosch, W. and Schieberle, P. 2009. Food Chemistry, 4th edn. Springer-VerlagBerlin Heidelberg.
3. Fennema, O.R. 1996. Food Chemistry, 3rd edn. Marcel Dekker, Inc., New York, USA.
4. Meyer, L.H. 1974. Food Chemistry. The AVI Publishing Co Inc., Connecticut, MA, USA.
5. Berdanier, C.D., Feldman, E.B. and Dwyer, J. 2008. Handbook of Nutrition and Food, 2nd edn.CRC Press, Boca Raton, FL, USA.
6. Berg, J.M., Tymoczko, J.L., Stryer, L. and Gatto Jr., G.J. 2002. Biochemistry, 7th edn. W.H. Freeman and Company, NY, USA.
7. Buchanan, B.B., Gruissem W. and Jones, R.L. 2002. Biochemistry and Molecular Biology of Plants. John Wiley and Sons, Inc., NY, USA

8. Nieisen, S.S. 2010. Food Analysis Laboratory Manual, 2nd edn. Springer, NY, USA.
9. Nieisen, S.S. 2003. Food Analysis, 3rd edn. Kluwer Academic, New York, USA.
10. Ötles, S. 2009. Handbook of Food Analysis Instruments. CRC Press, Boca Raton, FL, USA.
11. Adams, M.R. and Moss, M.O. 2008. Food Microbiology, 3rd edn, The Royal Society of Chemistry,Cambridge, UK.
12. Banwart, G.J. 1989. Basic Food Microbiology, 2nd edn. Chapman and Hall, New York, USA.
13. Frazier, W.C. and Westfoff, D.C. 1987. Food Microbiology, 4th edn. Tata McGraw-Hill, Education, New Delhi.

# Department of Processing and Food Engineering-Skill Enhancement Modules

## Agro Processing methods, equipment operation and maintenance 2 (0+2)

- Acquaintance with different unit operations involved in agro-processing
- Cleaning and grading of agricultural commodities: operation and maintenance of different cleaners, graders and destoners
- Operation and maintenance of dehusker, dehuller, degermer and dryer
- Operation and maintenance of rice milling machineries
- Operation and maintenance of dhal mills and oil mill
- Operation and maintenance of flour mills and pulverisers
- Operation and maintenance of boiler, pasteurizer and sterilizer
- Operation and maintenance of peeler, slicer, pulper and juicer
- Operation and maintenance of canning machineries
- Operation and maintenance of packaging machineries

## Operation and management of multi- Commodity Agro – processing Centre 2 (0+2)

- Acquaintance with different agro-processing models
- Site selection, plant layout and project report preparation
- Manufacturing and management of primary processing centre
- Preparation of grain, pulse and oilseed- based products and acquaintance with operation of different equipment
- Preparation of products using flour mill
- Spice processing and acquaintance with operation of different equipment
- Operation and management of fruit and vegetable pack house
- Preparation of different fruit- based products and acquaintance with operation of different equipment
- Preparation of different vegetable- based products and acquaintance with operation of different equipment
- Manufacturing of snack foods
- Acquaintance with food safety and hygiene, and certifications
- Record keeping, inventory, finance and human resource management for agro-processing

## Primary Processing, Value Addition and Cold Chain Logistics 2 (0+2)

- Primary processing of fruits and vegetables
- Operation and maintenance of washer and graders
- Study of refrigeration system and freezing equipment
- Operation of pre cooling systems
- Operation and maintenance of cold storage and solar cold room
- Operation and maintenance of ripening chamber

- Cool chain logistics and cold transport: chilled transport van, semi chilled transport, refrigerated van system
- Cooling systems/ cold chain technology: Gel pack, dry ice, liquid nitrogen, eutectic plates, reefers, cold chain standards and regulations
- Supply chain management systems planning, sourcing, manufacturing, delivering, returning, types of SCM models
- Supply chain logistics, contract logistics

## Food Grain Godown and Warehouse Management 2 (0+2)

- Conversant with technical terms of grain storage, measurement of temperature, relative humidity, grain sampling and moisture content measurement, grain quality
- Acquaintance with different factors for grain deterioration during storage and main insects of stored commodities
- Acquaintance with warehouse equipment and different storage structures
- Cleaning, drying and aeration of stored products
- Determination of dimension of warehouse for bag storage
- Acquaintance with constructional features, maintenance, sanitation and hygiene of warehouses
- Study on integrated pest management, chemical and non-chemical pest and rodent control measures in grain storage system
- Detection methods of insect infestation in food grains and prevention and control of storage fungi
- Acquaintance with inventory, logistics, and collateral management
- Guideline for procurement and disposal of food grains
- Quality control of food grains

## Post-harvest Value Chain Management Including Logistics 2 (0+2)

- Understanding the concept of post-harvest value chain
- Study of existing supply chain of different commodities
- Case study and analysis of value chain of food grains
- Case study and analysis of value chain of horticultural commodities
- Sourcing and material management
- Handling, packing and storage of agricultural commodities
- Transportation and marketing of agricultural commodities
- Ware house management
- Cold storage management
- Cold chain logistics and supply chain management system
- Quality management and tracking food supply chain

## Department of Basic Engineering & Applied Sciences- Core courses

## BES 1101 Crop Production and Protection Technologies 4 (3+1)

**Objective**

To equip the students with basic idea on crop production and protection practicesto understand the domain of agricultural sciences and to have an idea of the different types of machineries/ equipment that can be adopted for these operations.

**Theory**

**Module I** **(14 Hours)**

Introduction and scope of agronomy; Classification of crops; Effect of different weather parameters on crop growth and development; Principles of tillage, tilth and its characteristics; Crop seasons; Time and method of sowing of major field crops, seed rate for important crops; Methods and time of application of manures and fertilizers, fertigation; Basic principles of natural farming, organic farming and sustainable agriculture.

**Module II** **(8 Hours)**

Soil-water-plant relationship, crop coefficients, water requirement of crops and critical stagesfor irrigation; Weeds and their management in crops; Crop rotation, cropping systems, cropping scheme, relay cropping, mixed cropping and intercropping.

**Module III** **(12 Hours)**

Soil forming processes; Classification and composition of soil, soil taxonomy orders; Importantsoil physical properties and their importance; soil particle distribution; soil inorganic colloids– their composition, properties and origin of charge; ion exchange in soil and nutrient availability; soil organic matter– its composition and decomposition, effect on soil fertility; Soil reaction – acidic, saline and sodic soils; Quality of irrigation water.

**Module IV** **(5 Hours)**

Essential plants nutrients- their functions and deficiency symptoms in plants; Important inorganic fertilizers and their reactions in soils; Gypsum requirement for reclamation of sodic soils and neutralizing RSC; Liquid fertilizers and their solubility and compatibility.

**Module V** **(10 Hours)**

Types of horticultural crops; Sowing and planting times and methods; Seed rate and seed treatment for vegetable crops; Macro and micro propagation methods; Types of plant growing structures; Pruning and training; Water requirements and critical stages; Management of orchard; Major pests and diseases of horticultural crops and their management.

**Practical**

Identification of crops and their varieties, seeds and weeds; Study of different fertilizer application methods and weed control methods; Judging the maturity time for harvesting of crop; Study of seed viability and germination test; Identification of rocks and minerals; Examination of soil profile in the field; Determination of bulk density; particle density and porosity of soil; Determination of organic carbon of soil; Identification of nutrient deficiency symptoms of crops in the field; Determination ofgypsum requirement of sodic soils; Identification and description of important fruits, flowers

and vegetables crops; Study of different garden tools; Preparation of nursery bed; Practices of pruning and training in some important fruit crops; Study of cultural operations for vegetable crops (sowing,fertilizer application, mulching, irrigation and weed control); Seed extraction techniques; Visit to commercial greenhouse/ polyhouse.

**Lecture Schedule**

1. Introduction to agronomy-definition-importance and scope- role in agriculture.
2. Classification of crops.
3. Weather parameters-effect on crop growth and development.
4. Tillage-definition-objectives-advantage and disadvantages.
5. Types-tilth and its characteristics.
6. Crop seasons
7. Time and method of sowing of major field crops.
8. Seed rate for important crops.
9. Manures and fertilizers-types.
10. Manures and fertilizers- Method of application
11. Fertigation- advantages.
12. Natural farming-definition- principles and practices involved.
13. Organic farming- definition- concept-importance- inputs in organic farming.
14. Sustainable agriculture- definition-pillars- components.
15. Soil-water-plant relationship.
16. Crop coefficients and water requirements of crops.
17. Critical stages for irrigation.
18. Weeds-definition-classification.
19. Weed management methods- cultural and chemical methods
20. Weed management methods- mechanical and biological methods.
21. Cropping systems- crop rotation, relay cropping, mixed cropping and intercropping
22. Cropping scheme.
23. Soil – definition- soil forming factors-process.
24. Classification of soil - soil taxonomy orders.
25. Soil physical properties (texture, structure, particle density, bulk density, porosity)
26. Soil particle distribution.
27. Soil inorganic colloids- their composition and properties
28. Origin of charge- ion exchange
29. Nutrient availability in soil.
30. Soil organic matter-composition, decomposition.
31. Effect on soil fertility.
32. Soil reaction – acidic, saline and sodic soils
33. Quality of irrigation water.
34. Quality of irrigation water.
35. Essential plant nutrients
36. Functions and deficiency symptoms of essential plant nutrients
37. Inorganic fertilizers and soil reactions.
38. Gypsum requirement for sodic soils and neutralizing RSC.

39. Liquid fertilizers: solubility and compatibility
40. Horticultural crops- type.
41. Sowing and planting time and method.
42. Seed rate and seed treatment for vegetable crops.
43. Propagation methods- macro, micro
44. Plant growing structures.
45. Pruning and training.
46. Water requirements and critical stages in horticultural crops.
47. Orchard management.
48. Major pest of horticultural crops and their management
49. Major disease of horticultural crops and their management.

**Practical Schedule**

1. Identification of crops and their varieties, seeds and weeds.
2. Study of different fertilizer application methods and weed control methods.
3. Judging the maturity time for harvesting of crop.
4. Study of seed viability and germination test.
5. Identification of rocks and minerals.
6. Examination of soil profile in the field.
7. Determination of bulk density; particle density and porosity of soil.
8. Determination of organic carbon of soil.
9. Identification of nutrient deficiency symptoms of crops in the field.
10. Determination of gypsum requirement of sodic soils.
11. Identification and description of important fruits, flowers, and vegetable crops.
12. Study of different garden tools.
13. Preparation of nursery bed.
14. Practices of pruning and training in some important fruit crops.
15. Study of cultural operations for vegetable crops (sowing, fertilizer application, mulching, irrigation and weed control).
16. Seed extraction techniques.
17. Visit to commercial greenhouse/ polyhouse.

**Suggested Readings**


1. Ahamad S, Anwar Ali and Sharma P K (Eds). 2018. Plant Disease Management in Horticultural Crops. Daya Publishing House, Delhi.
2. Biswas T D and Mukharjee S K. 1987. A Text Book of Soil Science. Tata McGraw-Hill publishing Co. Ltd.
3. Brady N C and Ray R Weill. 2002. The Nature and Properties of Soil. Pearson Education Inc. New Delhi.
4. Chadha K L. 2003. Handbook of Horticulture. ICAR Publication, New Delhi.
5. Das D K. 2020. Introductory to Soil Science. Kalyani publication, Ludhiana.
6. Dey G C. 2013. Fundamentals of Agronomy. Jain Book Depot.
7. Ghildyal B P and Tripathy R P. 1987. Soil Physics. Wiley Eastern Ltd., New Delhi.

8. Hillel D. 1982. Introduction to Soil Physics. Academic Press, New York.
9. Indian Society of soil science. 2002. Fundamentals of Soil Science. ISSC, IARI, New Delhi.
10. Janick J. 1979. Horticultural Science. Surjeet Publications, Delhi.
11. Kumar N. 2017. Introduction to Horticulture. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
12. Muthukrishnan N, Ganapathy N, Nalini R and Rajendran R. 2005. Pest Management in Horticultural Crops. New Madura Publishers, Madurai, Tamil Nadu.
13. Reddy S R. 2020. Principles of Agronomy. Kalyani Publisher.
14. Reddy Yellamanda T and Reddy Shankar G H. 1995. Principles of Agronomy. Kalyani PublishersLudhiana.
15. Sehgal J L. 1996. Soil Pedology. Kalyani publication, Ludhiana.
16. Singh Jitendra. 2018. Fundamentals of Horticulture. Kalyani Publishers, Ludhiana.
17. Singh S S and Singh R. 2013. Principles and practices of Agronomy. Kalyani Publisher.
18. Sudheer K P and Indira V. 2016. Post harvest Technology of Horticultural Crops. New India Publishing Agency, New Delhi.

## BES 1102 Agricultural Informatics and Artificial Intelligence 3 (2+1)

**Objectives**

- To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.
- To provide basic knowledge of computer with applications in Agriculture and to make the students familiar with Agricultural-Informatics, its components and applications in agriculture

**Theory**

**Module I** **(9 Hours)**

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for creating, Editing and Formatting a document, Data presentation, Tabulation and graph creation, Statistical analysis, Mathematical expressions, Database, concepts and types, creating database, Uses of DBMS in Agriculture, Internet and World Wide Web (www): Concepts and components. Computer programming: General concepts, programming languages-machine language, assembly language, high level language- Visual Basic, Java, Fortran, C/ C++, etc. concepts (only introduction).

**Module II** **(13 Hours)**

e-Agriculture, Concepts, design and development; Application of innovative ways to use information and communication technologies (IT) in Agriculture; Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation; IT applications for computation of water and nutrient requirement of crops; Computer-controlled devices (automated systems) for Agri-input management; Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management etc.; Geospatial technology: Concepts, techniques, components and uses for

generating valuable agri-information; Decision support systems: Concepts components and applications in agriculture; Agriculture Expert System; Soil Information Systems etc. for supporting farm decisions. Preparation of contingent crop-planning and crop calendars using IT tools; Digital India and schemes to promote digitalization of agriculture in India.

**Module III** **(9 Hours)**

Introduction to artificial intelligence, background, and applications, Turing test. Control strategies-Breadth-first search, Depth-first search; Heuristics search techniques: Best-first search, A* algorithm (only the concept introduction, a detailed study of algorithm not expected); IoT and Big Data; Use of AI in agriculture for autonomous crop management, and health; monitoring livestock health, intelligent pesticide application, yield mapping and predictive analysis, automatic weeding and harvesting, sorting of produce, and other food processing applications; Concepts of smart agriculture, use of AI in food and nutrition science.

**Practical**

Study of computer components, accessories, practice of important DoS Commands, Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, File Management. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific documents, MS- EXCEL - Creating a spreadsheet, Use of statistical tools, Writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS: Creating Database, preparing queries and reports, Demonstration of Agri- information system, Introduction to World Wide Web(WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

**Lecture Schedule**

1. Introduction to Computers, Anatomy of Computers.
2. Memory Concepts, Units of Memory.
3. Operating System: Definition and types.
4. Applications of MS-Office for creating, Editing, and Formatting a document.
5. Spreadsheet - Data presentation, Tabulation, and graph creation.
6. Spreadsheet- Statistical analysis, Mathematical expressions.
7. Database, concepts, and types, creating database, Uses of DBMS in Agriculture.
8. Internet and World Wide Web (www): Concepts and components.
9. Computer programming: General concepts –programming, language, structural programming. Introduction to Visual Basic, Java, FORTRAN, C/C++ (only introduction, as examples).
10. e-Agriculture, Concepts, design and development.
11. Application of innovative ways to use information and communication technologies (IT) in Agriculture.

12. Computer Models in Agriculture: Statistical, weather analysis.
13. Crop simulation models, concepts, structure, inputs- outputs files, limitations, and advantages.
14. Application of models for understanding plant processes, sensitivity, verification, calibration, and validation.
15. IT applications for computation of water and nutrient requirements of crops.
16. Computer-controlled devices (automated systems) for Agri-input management.
17. Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management.
18. Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information.
19. Decision support systems: Concepts components and applications in agriculture.
20. Agriculture Expert System; Soil Information Systems etc. for supporting farm decisions.
21. Preparation of contingent crop-planning and crop calendars using IT tools.
22. Digital India and schemes to promote digitalization of agriculture in India.
23. Introduction to artificial intelligence, background, and applications, Turing test.
24. Control strategies, Breadth-first search, Depth-first search, Heuristics search techniques: Best-first search, A* algorithm (only concepts expected).
25. IoT and Big Data in agriculture.
26. Use of AI in agriculture for autonomous crop management, intelligent pesticide application.
27. AI in crop health monitoring, and monitoring livestock health.
28. AI in yield mapping and predictive analysis.
29. Automatic weeding and harvesting, sorting of produce, and other food processing applications.
30. Concepts of smart agriculture.
31. Use of AI in food and nutrition science.

**Practical Schedule**

1. Study of computer components, accessories, practice of important DoS Commands.
2. Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, and File Management.
3. Use of MS-WORD for creating, editing and formatting documents.
4. MS PowerPoint for creating, editing, and presenting scientific documents.
5. MS- EXCEL - Creating a spreadsheet, writing expressions, Creating graphs.
6. Analysis of scientific data, Use of statistical tools, Handling macros in Spreadsheet.
7. MS-ACCESS: Creating Database, preparing queries and reports.
8. Demonstration of Agri- information system.
9. Introduction to World Wide Web(WWW) and its components.
10. Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++.
11. Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/Wofost,
12. Preparation of inputs file for CSM and study of model outputs.
13. Computation of water and nutrient requirements of crop using CSM and IT tools.
14. Use of smart phones and other devices in agro-advisory and dissemination of market information.
15. Introduction of Geospatial Technology.
16. Hands-on practice in preparation of Decision Support System.
17. Preparation of contingent crop planning.

18. India Digital Ecosystem of Agriculture (IDEA).

**Suggested Readings**


1. Choudhary K. R. Fundamentals of Artificial Intelligence. Springer
2. Date, C. J. 2000. Introduction to Database Management System. Addison-Wesley.
3. ITL Educations Solutions Ltd. Introduction to Information Technology. Pearson Education.
4. Kumar, E. 2020. Artificial Intelligence. Wiley.
5. Nilson, N.J. 2001. Principles of Artificial Intelligence. Narosa.
6. Rajaraman, V. and Adabala, N. Fundamentals of Computers. PHI Learning Pvt. Ltd, New Delhi.
7. Russell, Stuart. 2013. Artificial Intelligence: A Modern Approach. Pearson Edition.
8. Sethi, D. P. and Pradhan, M. 2017. Concepts and Techniques of Programming in C. I.K. International Publishing House Pvt. Limited.
9. Vanitha, G. 2023. Agro-Informatics. NIPA, New Delhi.


## BES 1203 Computer Programming and Data Structures 2 (0+2)

**Objective**

To make the students conversant on computer programming languages, specifically C language as well as to make him familiar with programming for simple agricultural engineering applications.

**Practical**

Introduction to high level languages; Structural programming, C programming, a simple C programming, execution of a C program, program and instruction; Familiarizing with Turbo C/ANSI C IDE; Building an executable version of C program; Study of different operators such as arithmetic, relational, logical, assignment, increment and decrement, conditional, bitwise and special operators, precedence of arithmetic operators; Debugging a C program; Developing and executing simple programs; Creating programs using decision making statements such as if, go to and switch; Developing program using loop statements while, do and for; Using nested control structures; Familiarizing with one and two dimensional arrays; Using string functions; Creating user defined functions; Developing structures and union; Using local, global and external variables; Using pointers; Developing linked lists in C language; Inserting an item in Linked List; Deleting an item in Linked List; Implementing Stacks; Implementing push/pop functions; Creating queues, Insertion/ Deletion in queues.

**Practical Schedule**

1. Simple C programs using operators and output statements
2. Programs using input statement and mathematical equations
3. Programs with library functions and if statements
4. Development of programs with if statement
5. Development of programs with nested if
6. Programs with switch statements
7. Illustrating type casting, go to statement
8. While loop example programs
9. Do-while loop programs

10. Standard programs in C
11. Nested loops with while, do-while statements
12. Programs with for loops
13. Nested for loop illustration programs
14. Break, continue statements
15. One dimensional array creation and calculations and printing
16. Array sorting – selection sort
17. Searching of array
18. Programs with Two dimensional arrays
19. Matrix addition, Transpose
20. Matrix multiplication
21. String manipulation programs
22. Creating User defined functions with return types
23. Functions of various return types and parameters
24. Programs with structures
25. Programs with unions
26. Programs to illustrate pointers
27. Functions passing parameters by address
28. Functions passing structures as parameters
29. Manipulating arrays with pointers
30. Dynamic memory allocation functions -Self referential structures
31. Linked lists – insertion/deletion of linked lists
32. Stacks- Push/pop operations
33. Queues – insertion deletion operations
34. Practical Examination

**Suggested Readings**


1. Augenstein, L. and Tanenbaum. 2003. Data structures using C and C++. PHI/Pearson Education.
2. Balagurusamy, E. 1990. Programming in 'C'. Tata McGraw Hill Publishing Co. Ltd., 12/4 Asaf Ali Road, New Delhi.
3. Bronson, G. and Menconi, S. 1995. A First Book of 'C' Fundamentals of 'C' Programming. Jaico Publishing House, New Delhi.
4. Drozdek, A. 2012. Data Structures and Algorithms in C++. Vikas Publishing House / Thomson International Student Edition.
5. Goodrich, M T, Tamassia, R and Mount, D. 2011. Data structures and Algorithms in C++. Wiley Student Edition, John Wiley and Sons.
6. Rajaraman, V. 1985. Computer Oriented Numerical Methods. Prentice Hall of India. Pvt. Ltd, New Delhi.
7. Rajaraman, V. 1995. Computer Programming in 'C'. Prentice Hall of India Pvt. Ltd., New Delhi.
8. Sahni, S. 2006. Data Structures, Algorithms and Applications in C++. University Press (India) Pvt. Ltd / Orient Longman Pvt. Ltd.
9. Weiss, M. A. 2007. Data Structures and Algorithm Analysis in C++. Pearson Education.
10. Agarwal, A. 2005. The Complete Reference Guide: Data Structure through C. ISBN: 8178840448; Publisher: Cyber Tech Publications.

# BES 1204 Farming Based Livelihood System 3 (2+1)

**Objectives**

- To make the students aware about farming-based livelihood systems in agriculture.
- To disseminate the knowledge and skill how farming-based systems can be a source of livelihood.

**Theory**

**Module I** **(12 Hours)**

Status of agriculture in India and different states, Income of farmers and rural people in India; Livelihood-Definition, concept and livelihood pattern in urban and rural areas; Different indicators to study livelihood systems. Agricultural livelihood systems (ALS): Meaning, approach, approaches and framework, Definition of farming systems and farming based livelihood systems; Prevalent farming systems in India contributing to livelihood. Types of traditional and modern farming systems.

**Module II** **(12 Hours)**

Components of farming system/ farming-based livelihood systems- Crops and cropping systems, Livestock (dairy, piggery, goatry, poultry, duckry etc.), Horticultural crops, Agro-forestry systems, Aqua culture Duck/Poultry cum Fish, Dairy cum Fish, Piggery cum Fish etc., Small, medium- and large- enterprises including value chains and secondary enterprises as livelihood components for farmers, Factors affecting integration of various enterprises of farming for livelihood.

**Module III** **(4 Hours)**

Feasibility of different farming systems for different agro-climatic zones, Commercial farming-based livelihood models by NABARD, ICAR and other organizations across the country, Case studies on different livelihood enterprises associated with the farming.

**Module IV** **(5 Hours)**

Risk and success factors in farming-based livelihood systems, Schemes and programs by Central and State Government, Public and Private organizations involved in promotion of farming-based livelihood opportunities. Role of farming- based livelihood enterprises in 21$^{st}$ Century in view of circular economy, green economy, climate change, digitalization and changing life style.

**Practical**

Survey of farming systems and agricultural-based livelihood enterprises, Study of components of important farming based livelihood models/ systems in different agro-climatic zones, Study of production and profitability of crop based, livestock based, processing based and integrated farming based livelihood models, Field visit of innovative farming system models. Visit of Agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and study of agri-enterprises involved in industry and service sectors (Value Chain Models), Learning about concept of project formulation on farming-based livelihood systems along with cost and profit analysis, Case study of Start-Ups in agri-sectors.

**Lecture Schedule**

1. Introduction to agriculture in India.
2. Status of agriculture in different states of India.
3. Income of farmers and rural people in India.
4. Livelihood- definitions, concepts, and frameworks.
5. Livelihood patterns in urban and rural areas- a comparative analysis.
6. Indicators for studying livelihood systems.
7. Agricultural Livelihood Systems (ALS): meaning and approaches.
8. Approaches and frameworks of ALS.
9. Definition and importance of farming systems and farming based livelihood systems
10. Prevalent farming systems in India
11. Traditional farming systems in India-types
12. Modern farming systems in India- types
13. Components of farming-based livelihood systems
14. Crop-based livelihood systems
15. Crops and cropping systems: importance in farming livelihoods
16. Livestock-based livelihood systems (dairy, piggery, goatry, poultry, duckry etc.)
17. Horticultural crops in livelihood systems
18. Agro-forestry systems
19. Aqua culture-based systems
20. Duck/poultry cum fish, dairy cum fish, piggery cum fish
21. Small enterprises as livelihood components
22. Medium and large enterprises - value chains and secondary enterprises as livelihood components
23. Medium and large enterprises- value chains and secondary enterprises as livelihood components for farmers
24. Integration of farming and non-farming enterprises- benefits and factors affecting
25. Feasibility of different farming systems for different agro-climatic zones
26. Zone-specific farming systems
27. Commercial farming-based livelihood models (NABARD, ICAR and other organizations).
28. Case studies on different livelihood enterprises across country
29. Risk and success factors in farming-based livelihood systems
30. Schemes and programs by central and state government
31. Schemes and programs by public and private organizations in promotion of farming-based livelihood opportunities
32. Role of farming- based livelihood enterprises in 21$^{st}$ century
33. Role of circular economy, green economy, climate change, digitalization and changing life style.

**Practical Schedule**

1. Survey of farming systems and agricultural-based livelihood enterprises.
2. Survey of farming systems and agricultural-based livelihood enterprises.
3. Study of components of farming-based livelihood models in different agroclimatic zones.
4. Study of components of farming-based livelihood models different agroclimatic zones.
5. Study of production and profitability of crop-based livelihood models.
6. Study of production and profitability of livestock-based livelihood models.

7. Study of production and profitability of processing-based livelihood models.
8. Study of integrated farming-based livelihood models.
9. Field visit to innovative farming system models (Preparation).
10. Reflection and analysis of field visit- group discussion.
11. Field visit- farming system models.
12. Visit to agri-based enterprises.
13. Study the functional aspects of agri-based enterprises for the integration of production, processing and distribution sectors.
14. Study of agri-enterprises involved in industry and service sectors (Value chain models).
15. Learning the concept of project formulation on farming-based livelihood systems.
16. Study of the cost and profit analysis of farming-based livelihood systems.
17. Case study of start-ups in agri-sectors.
18. Case study of start-ups in agri-sectors.

**Suggested Readings**


1. Agarwal, A. and Narain, S. (1989). Towards Green Villages: A strategy for Environmentally, Sound and Participatory Rural Development, Center for Science and Environment, New Delhi, India.
2. Ashley, C., Carney, D. (1999). Sustainable Livelihoods: Lessons from Early Experience; Department for International Development: London, UK; Volume 7.
3. Carloni, A. (2001). Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa, Consultation Document, FAO, Rome, Italy.
4. Dixon, J. and A. Gulliver with D. Gibbon. (2001). Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. FAO and World Bank, Rome, Italy and Washington, DC, USA.
5. Evenson, R.E. (2000). Agricultural Productivity and Production in Developing Countries. In FAO, The State of Food and Agriculture, FAO, Rome, Italy
6. Livelihood Improvement of Underprivileged Farming Community: Some Experiences from Vaishali, Samastipur, Darbhanga and Munger Districts of Bihar by B. P. Bhatt, Abhay Kumar,P.K. Thakur, Amitava Dey Ujjwal Kumar, Sanjeev Kumar, B.K. Jha, Lokendra Kumar, K. N. Pathak, A. Hassan, S. K. Singh, K. K. Singh and K. M. Singh ICAR Research Complex for Eastern Region ICAR Parisar, P.O. Bihar Veterinary College, Patna - 800 014, Bihar.
7. Panwar et al. (2020). Integrated Farming System models for Agricultural Diversification, Enhanced Income and employment, Indian Council of Agricultural Research, New Delhi.
8. Reddy, S.R. (2016). Farming System and Sustainable Agriculture. Kalyani Publishers, New Delhi.
9. Singh, J.P., et al. (2015). Region Specific Integrated Farming System Models, ICAR-Indian Institute of Farming Systems Research, Modipuram.
10. Walia, S. S. and Walia, U. S. (2020). Farming System and Sustainable Agriculture, Scientific Publishers, Jodhpur, Rajasthan.


## BES 1205 Communication Skills 2 (1+1)

**Objective**

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication, and demonstrate positive group communication.

**Theory**

**Module I** **(3 Hours)**

Communication Process: The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature and significance of communication process; Meaning, types, and models of communication; Verbal and non-verbal communication; Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

**Module II** **(5 Hours)**

Basic Communication Skills: Listening, Speaking, Reading and Writing Skills; Precis writing/ Abstracting/Summarizing; Style of technical communication Curriculum vitae/resume writing; Innovative methods to enhance vocabulary, analogy questions.

**Module III** **(10 Hours)**

Structural and Functional Grammar: Sentence structure, modifiers, connecting words and verbals; phrases and clauses; Case: subjective case, possessive case; objective case; Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles; Agreement of verb with the subject: tense, mood, voice; Writing effective sentences; Basic sentence faults.

**Practical**

Listening and note taking; Writing skills: precis writing, summarizing and abstracting; Reading and comprehension (written and oral) of general and technical articles; Micro-presentations and Impromptu Presentations: Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed; Group discussions; Public speaking exercises; vocabulary building exercises; Interview Techniques; organization of events.

**Lecture Schedule**

1. Communication Process: The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature, and significance of communication process.
2. Meaning, types, and models of communication; Verbal and non-verbal communication.
3. Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.
4. Basic Communication Skills: Listening, Speaking, Reading and Writing Skills.
5. Precis writing/ Abstracting/Summarizing.
6. Precis writing/ Abstracting/Summarizing.
7. Style of technical communication Curriculum vitae/resume writing.
8. Innovative methods to enhance vocabulary, analogy questions.
9. Structural and Functional Grammar: Sentence structure.
10. Grammar: modifiers, connecting words and verbals.
11. Grammar: Phrases and clauses.
12. Case: subjective case, possessive case; objective case.
13. Correct usage of nouns, pronouns.
14. Correct usage of antecedents, adjectives, adverbs and articles.
15. Agreement of verb with the subject: tenses.
16. Agreement of verb with the subject: tense, mood, voice.
17. Writing effective sentences.

18. Basic sentence faults.

**Practical Schedule**

1. Listening and note taking.
2. Writing skills: precis writing,.
3. Summarizing and abstracting.
4. Reading and comprehension (written and oral) of general articles.
5. Reading and comprehension (written and oral) of technical articles.
6. Micro-presentations.
7. Micro-presentations.
8. Micro-presentations.
9. Impromptu Presentations.
10. Impromptu Presentations.
11. Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed.
12. Group discussions.
13. Public speaking exercises.
14. Public speaking exercises.
15. Vocabulary building exercises.
16. Vocabulary building exercises
17. Interview Techniques.
18. Organization of events.

**Suggested Readings**


1. Allport, G W, 1937, Personality: A Psychological Interpretation. Holt, New York.
2. Brown Michele and Brandreth, Gyles, 1994, How to Interview and be Interviewed. Sheldon Press, London.
3. Carnegie Dale, 1997, The Quick and Easy Way to Effective Speaking. Pocket Books, New York.
4. Francis Peter S J, 2012, Soft Skills and Professional Communication. Tata McGraw Hill, New Delhi.
5. Kumar S and Pushpa Lata, 2011, Communication Skills. Oxford University Press.
6. Neuliep James W, 2003, Intercultural Communication A Contextual Approach. Houghton Mifflin Co Boston.
7. Pease, Allan, 1998, Body Language. Sudha Publications, Delhi.
8. Raman M and Singh P, 2000, Business Communication. Oxford University Press.
9. Seely J, 2013, Oxford Guide to Effective Writing and Speaking. Oxford University Press.
10. Thomson A J and Martinet A V, 1977, A Practical English Grammar. Oxford University.


## BES 2106 Engineering Mathematics-l (3+0)

**Objective**

To make the students acquainted with the basic mathematics applied in engineering and their applications in solving engineering problems

**Theory**

**Module I** **(10 Hours)**

Differential Equations: First order differential equations, exact and reducible to exact form by integrating factors, linear differential equation and Bernoulli's equation, equations of first order and higher degree, Clairaut's equation.

**Module II** **(10 Hours)**

Higher order differential equations: Methods of finding complementary functions and particular integrals, methods of variation of parameters, Cauchy's and Legendre's linear equations, simultaneous linear differential equations with constant coefficients.

**Module III** **(5 Hours)**

Differential calculus: Functions of two or more variables, Taylor's and Maclaurin's expansions, Maxima and minima.

**Module IV** **(8 Hours)**

Partial differential equations: Partial derivative and total derivative, homogeneous functions and Euler's theorem. Formation of PDE, higher order linear PDE with constant coefficients, solution of non-linear PDE, Charpit's method.

**Module V** **(10 Hours)**

Integral calculus: Double integrals, change of order of integration, triple integrals, application of double and triple integrals to find area and volume.

**Module VI** **(10 Hours)**

Matrices: Elementary transformations, Gauss elimination, Gauss-Jordan method to find the inverse of a matrix. rank of a matrix, solution of linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem- its use to find inverse of the matrix, linear transformation, diagonalization of matrices.

**Lecture Schedule**

1. Introduction to Differential Equations
2. Exact Differential Equations
3. Exact Differential Equations contd.
4. Equations Reducible to Exact Form by Integrating Factors
5. Equations Reducible to Exact Form by Integrating Factors contd.
6. Linear Differential Equations (First Order)
7. Linear Differential Equations (First Order) contd.
8. Bernoulli's Equation
9. Equations of First Order and Higher Degree
10. Clairaut's Equation
11. Introduction to Higher Order Differential Equations
12. Complementary Functions (C.F.)
13. Complementary Functions (C.F.) contd.
14. Particular Integrals (P.I.)

15. Particular Integrals (P.I.) contd.
16. Method of Variation of Parameters
17. Method of Variation of Parameters contd.
18. Cauchy's Linear Equations
19. Legendre's Linear Equations
20. Simultaneous Linear Differential Equations with Constant Coefficients
21. Functions of Two or More Variables
22. Taylor's Expansions for Multivariable Functions
23. Maclaurin's Expansions for Multivariable Functions
24. Maxima and Minima of Functions of Multiple Variables
25. Maxima and Minima of Functions of Multiple Variables contd.
26. Introduction to Partial and Total Derivatives
27. Introduction to Partial and Total Derivatives contd.
28. Homogeneous Functions and Euler's Theorem
29. Homogeneous Functions and Euler's Theorem contd.
30. Formation of Partial Differential Equations (PDE)
31. Higher-order linear PDE with constant coefficients
32. Solution of Non-Linear PDEs
33. Charpit's Method
34. Double Integrals
35. Double Integrals contd.
36. Change of Order of Integration
37. Change of Order of Integration contd.
38. Triple Integrals
39. Triple Integrals contd.
40. Applications of Double Integrals (Finding Area and Volume)
41. Applications of Double Integrals (Finding Area and Volume) contd.
42. Applications of Triple Integrals (Finding Area and Volume)
43. Applications of Triple Integrals (Finding Area and Volume) contd.
44. Elementary Transformations of Matrices
45. Gauss Elimination Method
46. Gauss-Jordan Method to Find Inverse of a Matrix
47. Rank of a Matrix
48. Solution of Linear Equations Using Matrices
49. Solution of Linear Equations Using Matrices contd.
50. Eigenvalues and Eigenvectors
51. Eigenvalues and Eigenvectors contd.
52. Cayley-Hamilton Theorem and Its Applications (Finding Matrix Inverse)
53. Linear Transformation and Diagonalization of Matrices

**Suggested Readings**


1. Grewal, B. S. 2004. Higher Engineering Mathematics. Khanna Publishers Delhi.
2. Narayan, S. 2004. A Text Book of Vector. S. Chand and Co. Ltd. New Delhi.
3. Narayan, S. 2004. Differential Calculus. S. Chand and Co. Ltd. New Delhi.

4. Narayan, S. 2004. Integral Calculus. S. Chand and Co. Ltd. New Delhi.

## BES 2107 Engineering Physics 3 (2+1)

**Objective**

To make the students acquainted with applications of physics in engineering and different physical processes in agricultural engineering

**Theory**

**Module I** **(12 Hours)**

Magnetism: Dia, para and ferro-magnetism- classification; Langevin theory of dia, and para magnetism, adiabatic demagnetization, Weiss molecular field theory; Introduction to quantum mechanics: wave particles duality, de-Broglie concept uncertainty principle, time dependent and time independent Schrodinger equation.

**Module II** **(9 Hours)**

Spectroscopy: Qualitative explanation of Zeeman effect, Stark effect and Paschen back effect, Raman spectroscopy; Solid state physics: statement of Bloch function, bands in solids, effective mass, distinction between metals, insulators and semi-conductors.

**Module III** **(8 Hours)**

Semiconductors: Intrinsic and extrinsic semi-conductors, law of mass action, determination ofenergy gap in semi-conductors, donors and acceptor levels; Superconductivity: super conductivity, critical magnetic field, Meissner effect, isotope effect, Type I and II superconductors, Josephsons effect, DC and AC SQUIDS, introduction to high Tc superconductors.

**Module IV** **(7 Hours)**

LASERS and MASERS: Spontaneous and stimulated emission, Einstein A and B coefficients, population inversion, He, Ne and Ruby lasers, Ammonia and Ruby masers; Holography and optical fibre: optical fibre- physical structure, basic theory, type of modes, characteristics of optical fibre and applications; Illumination: laws of illumination, luminous flux, luminous intensity, candle power, brightness.

**Practical**

To verify law of transverse vibrations along a string using electrical tuning fork; To determine e/m of electron using magnetron valve method; Determine dielectric constant of material using De Sautys bridge; Study the variation of magnetic field with distance along the axis of a current carrying circular coil and to determine the radius of the coil; Determine the energy band gap in a semiconductor using a p-n junction diode; Study the LCR circuit; Find the wavelength of light by using prism and spectrometer; Determine the low resistance using Carey Foster bridge without calibrating the bridge wire.

**Lecture Schedule**

1. Dia-magnetism- classical and quantum theory- para magnetism-
2. Langevin theory of Dia and Para-magnetism.

3. Ferromagnetism- statement of curie-Weiss law-curie point-ferromagnetic domains-ferrites.
4. Anti-ferro magnetism-domain wall-hard and soft magnetic materials.
5. Introduction to quantum mechanics: Electromagnetic waves, The wave equation.
6. Particle Aspect of Radiation, Blackbody Radiation,
7. Photoelectric effect, nature of light, wave particle duality
8. Wave Properties of Particles, de-Broglie concept.
9. Waves of probability -phase velocity & group velocity- particle diffraction-Electron Microscope.
10. Uncertainty principle- position and momentum uncertainty -. Energy & time uncertainty,
11. Schrodinger equation-, time dependent form-Probability and Normalization
12. Time independent Schrodinger equation- steady state form-eigen value equation.
13. Spectroscopy - Regions of Spectrum -Quantization of Energy -orbital and magnetic quantum numbers
14. Zeeman effect-definition-normal and anomalous Zeeman effect
15. Stark effect-explanation.
16. Paschen back effect-explanation of energy levels.
17. Raman effect-classical and quantum theory- applications.
18. Solid state physics-crystalline and amorphous solids-fundamental terms of crystallography
19. Miller indices-simple cubic, face centered cubic and hexagonal closed packed structures.
20. Bloch theorem-Brillouin zone-extended, reduced and periodic zone schemeEffective mass of an electron-
21. Band theory of solids- origin of energy gap- classification of solids based on band theory-Distinction between metals semiconductors and insulators.
22. intrinsic and extrinsic semiconductors-donor and acceptor levels.
23. Free carrier concentration in intrinsic and extrinsic semiconductors- determination of energy gap in semi-conductors
24. Superconductivity-effect of applied magnetic field-persistent current.
25. Meissner effect-London equation-London penetration depth.
26. Thermodynamics of superconducting phase transition-entropy-specific heat capacity.
27. Energy gap-isotope effect-BCS theory-cooper pair- type I and type ii superconductor-Josephson effect-
28. AC and DC Josephson effect-Josephson tunneling.
29. High temp superconductors-SQUIDS-Josephson junction switch-applications
30. Lasers and masers-spontaneous and stimulated emissions-population inversion- Einstein A and B coefficients-
31. coherence –spatial and temporal coherence- Bandwidth-laser broadening-natural-collisional – doppler broadening.
32. Ruby laser-He-Ne laser-ammonia and Ruby maser-application of lasers
33. Holography –hologram-recording-reconstruction of hologram-applications.
34. Optical fibers-numerical aperture-acceptance angle-modes-single and multimode.
35. Step index and graded index fibers-intermodal dispersion-fiber optic communication-applications.
36. Illumination-properties of illumination-important terms-laws of illumination-Inverse square law- Lambert’s cosine law

**Practical Schedule**

1. To study the wavelength of light using Newton's Rings
2. Newton's Rings Refractive Index
3. To verify law of transverse vibrations along a string using electrical tuning fork.
4. To determine e/m of electron using magnetron valve method.
5. Determine dielectric constant of material using De Sautys bridge
6. Study the variation of magnetic field with distance along the axis of a current carrying circular coil and to determine the radius of the coil.
7. To determine the energy band gap in a semiconductor using a p-n Junction diode
8. To find the numerical aperture of optical fiber 198
9. To find the wavelength of light by prism and spectrometer
10. To study the refractive index of the material of the prism using spectrometer
11. Spectrometer-i-d curve
12. Diffraction grating normal incidence method
13. To find the frequency of A C supply using an electrical vibrator
14. To study the variations of thermo emf of a copper-constantan thermo-couple with temperature.
15. Study the LCR circuit
16. Determine the low resistance using Carey Foster bridge without calibrating the bridge wire.

**Suggested Readings**


1. Avadhanulu, M. N. 2013. An Introduction to Lasers theory and applications. S. Chand Publication.
2. Chattopadhyay, D. and Rakshit, P. C. 2011. Electricity and Magnetism. S. Chand Publication.
3. Ghatak, A. K. and Lokanathan, S. 2022. Quantum Mechanics, Theory and Application. Trinity Press.
4. Griffiths, D. J. and Schroeter. 2018. Introduction to Quantum Mechanics. Cambridge University Press.
5. Khandelwal, D. P. 1985. A Laboratory Manual of Physics. Vani Publications.
6. Kittel, C. 2005. Introduction to Solid State Physics. Wiley Eastern Pvt. Ltd.
7. Laud, B. B. 2011. Lasers and Non-linear Optics. New Age International Publishers.
8. Mani, H. S. and Mehta, G. K. 2022. Modern Physics. Affiliated East-West Press.
9. Omar, M. A. 2002. Elementary Solid-State Physics. Pearson.
10. Prakash, S. 2011. Optics. Pragati Prakashan, Meerut.
11. Saraf, B. and Khandelwal, D. P. 1982. Physics through Experiments. Vol. I & II. Vikas Publication, New Delhi.
12. Subramanyam, N., Lal, B. and Avadhanulu, M. N. 2012. A Textbook of Optics. S. Chand.
13. White, H. E. 2019. Introduction to Atomic Spectra. Mc-Graw Hill Publication.
14. Worsnop, B. L. and Flint, H. C. 1951. Advanced Practical Physics. Littlehampton Book Services Ltd.


## BES 2108 Engineering Chemistry 3 (2+1)

**Objective**

To make the students acquainted with applications of chemistry in engineering and different chemical processes in agricultural and food engineering

**Theory**

**Module I** **(8 Hours)**

Phase rule: Phase, component, degree of freedom, application to one component system, viz. water system, sulphur system, two component system, viz. Pb-Ag system, desilverisation of Pb. Colloids: Classification, properties like optical activity-Tyndall effect, Brownian movement, electrical properties –electrophoresis, causes, types and methods of prevention- proper designing. Corrosion: Cathodic protection using pure metal and metal alloys, use of inhibitors.

**Module II** **(16 Hours)**

Water: Temporary and permanent hardness, disadvantages of hard water, scale and sludge formation of boilers, boiler corrosion, basic idea on thermo-gravimetric analysis, polarographic analysis, nuclear radiation, detectors and analytical applications of radio-active materials, discovery of isotopes and new elements, release of atomic energy, radio-active tracer and carbon dating. Fuels: Classifications, calorific value and its determination by bomb calorimeter.

**Module III** **(8 Hours)**

Principles of food chemistry: Lipids, proteins, carbohydrates and their classifications, vitamins and their importance. Enzymes and co-enzymes important in food processing and storage, their use in manufacturing of ethanol and acetic acid by fermentation method. Introduction to food preservatives, definition, types natural and artificial preservative and its use, colouring and flavoring reagents of foods. Lubricants: Classifications, properties-viscosity, flash point and fire point mechanism, thick film, thin film and extreme pressure, neutralization point, saponification number and mechanical stability.

**Module IV** **(4 Hours)**

Type of polymerization with examples (addition, free radical); Different properties of polymers-chemical resistance, crystallinity. Polymers: Effect of heat on polymers, general use, basic principles of determination of molecular weight by viscosity methods, basic principles of determination of molecular weight by light scattering methods. Introduction to IR spectroscopy: Basic principles of spectroscopy, Beer-Lamberts law, types of vibration, symmetric, asymmetric vibration and it type, absorbances of different functional group in IR.

**Practical**

To determine of temporary and permanent hardness of water by EDTA method; To study the different types of fuels and compare their characteristics; To study different types of foods and their ingredients; To study the different types of food preservatives and their active principles; To estimate chloride in water sample; To estimate dissolved oxygen in water sample; To estimate chloride in water samples; To study the different properties of lubricants; To determine λmax and verification of Beer-Lambert law.

**Lecture Schedule**

1. Phase, component, degree of freedom, application to one component system, viz. water system, sulphur system
2. Two component system viz. Pb – Ag system, desilverisation of Pb
3. Colloids -classification of colloids, Colloids-Preparation of colloidal solution - Dispersion and Condensation methods-purification.

4. Colloids - Properties of colloidal solution - electrical double layer, Zeta potential – Cataphoresis, Tyndall effect, Brownian movement, causes, types, method of prevension – proper designing - Origin of charge on colloidal solutions and application of colloids
5. Corrosion - Definition, cause of corrosion, types of corrosion, theories of corrosion
6. Galvanic cell corrosion, concentration cell corrosion, pitting corrosion, stress corrosion, dezincification, microbial corrosion, atmospheric corrosion.
7. Control of corrosion - by purification, alloying, cathodic protection, using inhibitors &passivators, pure metals & metal alloys
8. Protective coating - paint, lacquer, enamel and varnish
9. Sources of water, impurities in water, nature of impurities and their removal.
10. Hardness of water - effect of hardness, determination of hardness.
11. Softening of water - (l)Lime -soda process (2) zeolite method
12. Demineralization, ion exchange method, (l)Process that separate water from salt water - Evaporation/distillation, solvent extraction & reverse osmosis (2) Process that separate salt from saline water - electro dialysis
13. Water treatment - Removal of bacteria and microorganism by sterilization - bleaching power, chlorine, chloramines, ozone and U.V light.
14. Potability of water, Various methods of treatment of industrial waste and radio-active waste
15. Thermo gravimetric analysis, Polarographic analysis.
16. Nuclear radiation, detector and analytical applications of radioactive materials.
17. Discovery of isotopes and new elements, release of atomic energy, radio-active tracer and carbon dating
18. Classification of fuels, calorific values, gross and net calorific values - coal - origin and its classification
19. Proximate and ultimate analysis of coal
20. Determination of calorific value by bomb calorimeter
21. Petroleum- origin, classification, fractionation of petroleum, refining of petrol, knocking property, octane number, knocking and anti knocking agents.
22. Cracking of petrol, synthesis of petrol- Fischer Tropsch processes & Bergius processes
23. Gaseous fuels -manufacture, composition and calorific values of coal gas and biogas
24. Flue gas analysis by Orsat apparatus
25. Chemistry of carbohydrates, classification- mono saccharides, properties of monosaccharides, disaccharides, properties of disaccharides
26. Polysaccharides -properties, cellulose, starch, dextrin, glycogen, gums, pectic substances, hemicellulose.
27. Chemistry of lipids - classification-fat constants and characteristics of fats.
28. Classification of fatty acids, alcohols in fats - properties of fats and fatty acids, simple lipids, phospholipids
29. Chemistry of fat soluble vitamins and water soluble vitamins. Amino acids and proteins.- classification and properties
30. Chemistry of enzymes and co –enzymes, Importance of enzymes and co – enzymes in food processing and storage, use of enzyme in the manufacture of ethanol and acetic acid by fermentation methods.
31. Food preservatives – Definition types – natural and artificial preservatives, its use, colouring and flavouring reagents of foods, Colours –natural and artificial colours

32. Classification, types of lubrication, properties – viscosity, flash point and fire point mechanism, thick film, thin film and extreme pressure, neutralisation point, saponification number and mechanical stability
33. Types of polymerization with examples (addition, free radical), Different properties of polymers - chemical resistance, crystallinity
34. Polymers – Effect of heat on polymers, general use, basic principles of determination of molecular weight by viscosity methods, basic principles of determination of molecular weight by light scattering methods
35. U.V. Spectra - basic principle - verification of Beer-Lambert's Law
36. IR Spectra – basic principle – Types of vibration – symmetric and asymmetric vibration, absorbance's of different functional group in IR

**Practical Schedule**

1. Determination of temporary hardness of water by EDTA method
2. Determination of permanent hardness of water by EDTA method
3. Estimation of chloride in water
4. Estimation of dissolved oxygen in water
5. Estimation of available chlorine in bleaching powder
6. Qualitative test for carbohydrates and proteins
7. Qualitative test for lipids
8. Qualitative test for fats
9. Determination of calorific value of a fuel
10. Determination of viscosity of liquids
11. Determination of surface tension of lubricants
12. Determination of fat constant – saponification values
13. Estimation of Vitamin C
14. Determination iodine value – acid number
15. Determination of Casein in milk
16. Verification of Beer – Lambertz law for $KMnO_4$ colorimetrically
17. Verification of Beer – Lambertz law for $K_2Cr_2O_7$ colorimetrically
18. Practical Examination

**Suggested Readings**


1. Bahl, B. S., Bahl, A. and Tuli, B. D. 2007. *Essentials of Physical Chemistry*. S. Chand and Co. Ltd, Delhi.
2. Finar, I. L. 2002. *Organic Chemistry*. Vol I and II. Pearson.
3. Glasstone, S. *Elements of Physical Chemistry*. The Macmillan Company of India Limited.
4. Jain and Jain. 2016. *Engineering Chemistry*. Dhanpat Rai Publication.
5. Jain, P. L. and Jain, M. 1994. *Engineering Chemistry*. Danpat Rai publishing company Pvt. Ltd, Delhi.
6. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K. 2010. *Organic Chemistry*. Pearson.
7. Sharam, Y. R. 2013. *Elementary Organic Spectroscopy*. S Chand.

# BES 2109 Physical Education, First Aid, Yoga Practice and Meditation 2 (0+2)

## Objectives

- To make the students aware about Physical Education, First Aid and Yoga Practices
- To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general well-being through yoga

## Practical

Physical education; Training and Coaching - Meaning and Concept; Methods of Training; aerobic and aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory and Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to aging and role of regular exercise on aging process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems and its Management; Posture; Postural Deformities; Exercises for good posture. Yoga; History of Yoga, Types of Yoga, Introduction to Yoga. Suryanamskar Pranayama (Definitionand Importance) Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari. Role of yoga in sports. Teaching of Asanas – demonstration, practice, correction and practice. Asanas (Definition and Importance) Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left leg- right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan. Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh Mudras (Definition and Importance) Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra. History of sports and ancient games, Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics.Need and requirement of first aid. First Aid equipment and upkeep. First AID Techniques, First aid related with respiratory system. First aid related with Heart, Blood and Circulation. First aid related with Wounds and Injuries. First aid related with Bones, Joints Muscle related injuries. First aid related with Nervous system and Unconsciousness. First aid related with Gastrointestinal Tract. First aid related with Skin, Burns. First aid related with Poisoning. First aid related with Bites and Stings. First aid related with Sense organs, Handling and transport of injured traumatized persons. Sports injuries and their treatments.

## Practical Schedule

1. Health Related Physical Fitness Test – One mile run, abdominal sit ups – 1 minute, sit and reach, modified pull ups
2. Flexibility components – Speed, Strength, Endurance, Power, Agility, Coordination and Balance
3. Training exercises - Fartlek training, Circuit training

4. First AID Techniques
5. Yoga - Practices
6. Suryanamskar, Pranayama, Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari
7. Teaching of Asanas – demonstration, practice, correction and practice
8. Asanas - Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left leg- right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan
9. Meditation - Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
10. Mudras - Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
11. Coaching and fundamentals of skill developments of major games (any two)
12. Basketball – Dribbling and Holding
13. Basketball - Passing – chest pass, bounce pass, overhead pass
14. Basketball – Shooting – lay ups, free throw, jump shot
15. Basketball – Moves – two man, three man weave, four man and five man running
16. Basketball – Tactics – offences, defence, pivot and screening
17. Volleyball – Stance and Service – under hand, tennis service, jump service
18. Volleyball – Passing – upper hand and under hand
19. Volleyball – Lift – vertical, arch, short
20. Volleyball – Smash and Block
21. Football – Passing and Stopping – instep, inside, back pass, wall pass weaving, long pass
22. Football – Dribbling and Juggling
23. Football – Trapping – foot trapping, chest, thigh and head
24. Badminton – Grip – forehand and backhand, Service, Lob – underhand and overhand, overhead strokes, Drop shot and Smash, Tactics – Singles and Doubles
25. Cricket – Stance – front foot drive, back foot defence, pull shot
26. Cricket – Bowling – spin and fast bowling
27. Table Tennis – Grip - forehand and backhand, Service, Tactics – Singles and Doubles
28. Kabaddi – Tactics - Riding, Defence, Chain holding
29. Kho Kho – Tactics - Riding and Defence
30. Coaching and Tactic development of athletic events – Conditioning (warming up – jogging - freehand exercises – short sprints)
31. Coaching and Tactic development of athletic events – Types of running (sprints – middle distance – long distance)
32. Coaching and Tactic development of athletic events – Start and Finish
33. Coaching and Tactic development of athletic events – Types of Jumps (long jump, high jump, triple jump, pole vault)
34. Coaching and Tactic development of athletic events – Types of Throws (shotput, discuss throw, javelin throw, hammer throw)
35. Coaching and Tactic development of athletic events – Team events (4x100m relay, 4x400m relay) – Combined events (decathlon, heptathlon)
36. Practical Examination

# BES 2210 Engineering Mathematics-II (3+0)

**Objective**

To make the students acquainted with the application of various advanced mathematics such as vector calculus, Fourier series and Laplace transform and applications of numerical methods in engineering.

**Theory**

**Module I** **(14 Hours)**

Vector calculus: Scalar and vector point functions, vector differential operator Del, gradient ofscalar point function, divergence and curl of vector point function and their physical interpretations. Line integral, surface integral, volume integral. Green's theorem, Stock's theorem and Divergence theorem (without proofs).

**Module II** **(7 Hours)**

Complex analysis: Functions of a complex variable, limit, continuity and analytic function, Cauchy-Reimann equations, harmonic functions.

**Module III** **(9 Hours)**

Fourier series: Periodic functions, Fourier series, Euler's formulae, functions having arbitrary period, even and odd functions, half range series expansion, series expansion of functions with finite discontinuity.

**Module IV** **(8 Hours)**

Laplace Transform: rules for Laplace transform and inverse Laplace transform, applications to find solutions of ordinary and simultaneous differential equations.

**Module V** **(15 Hours)**

Numerical methods: Finite difference operators and their relationship, factorial notation. Newton's forward and backward interpolation formulae, Newton's divided difference interpolation formula, Lagrange's interpolation formula, numerical differentiation and integration rule, numerical solutions of ODE by Taylor's series, Euler's and modified Euler's method, Runge-Kutta method oforder four.

**Lecture Schedule**

1. Introduction to vector calculus
2. Scalar and vector point functions
3. Vector differential operator Del, gradient of scalar point function
4. Divergence and curl of vector point function
5. Physical interpretations of divergence and curl
6. Integration of vectors, line integral
7. Line integral
8. Surface integral
9. Surface integral contd.
10. Volume integral
11. Green's theorem

12. Stock's theorem
13. Gauss Divergence theorem
14. Gauss Divergence theorem contd.
15. Introduction to complex analysis
16. Functions of complex variable
17. Limit, continuity, analytic functions
18. Analytic functions
19. Cauchy-Reimann equations
20. Cauchy- Reimann equations contd.
21. Harmonic functions
22. Periodic functions, Euler's formulae
23. Fourier series
24. Fourier series of functions having arbitrary period
25. Fourier series of functions having arbitrary period contd.
26. Fourier series of even andodd functions
27. Fourier series of even andodd functions contd.
28. Half range series expansion
29. Half range series expansion contd.
30. Series expansion of functions with finite discontinuity.
31. Introduction to Laplace transform, definition
32. Laplace transforms of elementary functions
33. Laplace transforms of elementary functions contd.
34. Rules for Laplace transform and inverse Laplace transform
35. Rules for Laplace transform and inverse Laplace transform contd.
36. Applications to find solutions of ordinary differential equations
37. Applications to find solutions of ordinary differential equations contd.
38. Applications to find solutions of simultaneous differential equations.
39. Finite difference operators
40. Relationship between finite difference operators
41. Factorial notation, Newton's forward interpolation formulae
42. Newton's backward interpolation formulae
43. Lagrange's interpolation formula
44. Lagrange's interpolation formula contd.
45. Numerical differentiation rules
46. Numerical differentiation rules contd.
47. Numerical integration rules
48. Numerical integration rules contd
49. Numerical solutions of ODE by Taylor's series method
50. Numerical solutions of ODE by Euler's method
51. Numerical solutions of ODE by modified Euler's method
52. Runge-Kutta method of order four.
53. Runge-Kutta method of order four contd.

**Suggested Readings**


1. Grewal, B. S. 2004. Higher Engineering Mathematics. Khanna Publishers Delhi.
2. Narayan, S. 2004. A Text Book of Vector. S. Chand and Co. Ltd. New Delhi.
3. Narayan, S. 2004. Differential Calculus. S. Chand and Co. Ltd. New Delhi.

4. Narayan, S. 2004. Integral Calculus. S. Chand and Co. Ltd. New Delhi.

## BES 2211 Entrepreneurship Development and Business Management 3 (2+1)

**Objectives**

- To provide the student an insight into the concept and scope of entrepreneurship
- To expose to various aspects of establishment and management of a small business unit
- To enable the student to develop financially viable agribusiness proposal.

**Theory**

**Module I** **(7 Hours)**

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for, and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development.

**Module II** **(7 Hours)**

Environment scanning and opportunity identification, need for scanning – spotting of opportunities – scanning of the environment – identification of product/service – starting a project. Factors influencing the sensing of opportunities. Infrastructure and support systems – good policies, schemes for entrepreneurship development, role of financial institutions, and other agencies in entrepreneurship development.

**Module III** **(8 Hours)**

Steps involved in the functioning of an enterprise. Selection of the product/services, selection of form of ownership, registration, selection of site, capital sources, acquisition of manufacturing know-how, packaging, and distribution. Planning of an enterprise, project identification, selection, and formulation of the project. Project report preparation and enterprise management.

**Module IV** **( 7 Hours)**

Production management – product, levels of products, product mix, quality control, cost of production, production controls. Material management – raw material costing, inventory control. Personal management – manpower planning, labor turnover, wages/salaries.

**Module V** **(7 Hours)**

Financial management/accounting – funds, fixed capital and working capital, costing and pricing, long-term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, and taxation. Marketing management – market, types, marketing assistance, market strategies. Crisis management – raw material, production, leadership, market, finance, natural disasters, etc.

**Practical**

Visit to small scale industries/agro-industries, Interaction with successful entrepreneurs/ agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

**Lecture Schedule**

1. Concept and Definition of Entrepreneurship
2. Evolution and Growth of Entrepreneurship
3. Importance and Role of Entrepreneurs in Economic Development
4. Motivational Factors for Entrepreneurship
5. Characteristics and Traits of Successful Entrepreneurs
6. Entrepreneurial Competencies and Attributes
7. Social and Environmental Factors Affecting Entrepreneurship
8. Need for and Importance of Entrepreneurial Development
9. Objectives of Entrepreneurial Activities
10. Types of Entrepreneurs (e.g., Innovators, Imitators, etc.)
11. Functions of Entrepreneurs
12. Steps in Entrepreneurship Development
13. Environment Scanning for Opportunity Identification
14. Spotting Opportunities and Scanning the Environment
15. Identification of Product/Service for New Ventures
16. Infrastructure for Entrepreneurship Development
17. Role of Financial Institutions in Supporting Entrepreneurs
18. Government Policies and Schemes for Entrepreneurship Development
19. Role of Other Agencies (Incubators, Accelerators, NGOs)
20. Steps in Enterprise Functioning
21. Selection of Product/Service and Form of Ownership
22. Registration, Licensing, and Legal Formalities
23. Site Selection and Capital Sourcing
24. Acquisition of Manufacturing Know-How, Packaging, and Distribution
25. Project Identification and Selection
26. Project Formulation and Report Preparation
27. Enterprise Management and Project Execution
28. Production Management: Product and Quality Control
29. Material Management: Raw Material Costing and Inventory Control
30. Financial Management: Fund Sources, Fixed and Working Capital
31. Accounting Principles: Book Keeping, Journals, Ledgers
32. Accounting- Annual Statements
33. Marketing Management: Market Types, Strategies, Assistance
34. Crisis Management: Raw Material and Production Issues
35. Leadership and Financial Crises
36. Market Crises and Natural Disasters: Managing Entrepreneurial Risk

**Practical Schedule**

1. Visit to Small Scale Industries
2. Motivational Factors for Entrepreneurship-Analyze the various motivational factors that drive individuals to become entrepreneurs. Provide real-life examples to support your analysis.
3. Interaction with Successful Entrepreneurs

4. Visit to Agro-Industries
5. Characteristics of Successful Entrepreneurs- Identify five successful entrepreneurs and evaluate their key characteristics. Compare these traits and explain how they contribute to their success.
6. Interaction with Agric entrepreneurs
7. Environmental Scanning and Opportunity Identification-Conduct an environmental scan for a specific industry (e.g., retail, technology, or agriculture). Identify three potential business opportunities and explain the factors that influenced your choices.
8. Visit to Financial Institutions
9. Infrastructure and Support Systems for Entrepreneurship Development- Research and evaluate the infrastructure and support systems available for entrepreneurs in your country. Discuss the role of government policies, financial institutions, and other support agencies.
10. Visit a local entrepreneurship development agency or incubator.
11. Steps in setting up a Business- Create a detailed step-by-step guide on how to start a business, covering product selection, form of ownership, registration, site selection, and sourcing capital.
12. Preparation of Project Proposal for Funding
13. Project Proposal Preparation- Choose a business idea and prepare a project proposal that includes product identification, market analysis, financial planning, and a marketing strategy. The proposal should be suitable for submission to a financial institution or investor.
14. Production Management and Quality Control- Analyze the production process for a specific product. Discuss how quality control is managed and suggest improvements for efficiency and cost reduction.
15. Financial Management in Entrepreneurship- Prepare a financial plan for a small business. Include fixed capital, working capital, costing, pricing, and short-term and long-term financial planning. Incorporate concepts like bookkeeping, journal entries, and taxation.
16. Crisis Management Strategies - Develop a crisis management plan for a hypothetical business facing a shortage of raw materials, production delays, or market disruptions. Include strategies for leadership, finance, and market crisis management.
17. Market Research for Project Proposal- Conduct market research to analyze customer demand, competitors, and market gaps.

**Suggested Readings**


1. Charantimath P.M. 2009. Entrepreneurship Development and Small Business Enterprises. Pearson Publications, New Delhi.
2. Desai,Vasant. 1997. Small Scale Industries and Entrepreneurship. Himalaya Publ. House
3. Desai V. 2015. Entrepreneurship: Development and Management, Himalaya Publishing House.
4. Grover, Indu. 2008. Handbook on Empowerment and Entrepreneurship. Agrotech Public Academy.
5. Gupta CB. 2001. Management Theory and Practice. Sultan Chand and Sons.
6. Khanka SS. 1999. Entrepreneurial Development. S. Chand and Co.
7. Mehra P. 2016. Business Communication for Managers. Pearson India, New Delhi.
8. Pandey M. and Tewari D. 2010. The Agribusiness Book. IBDC Publishers, Lucknow.

9. Singh D. 1995. Effective Managerial Leadership. Deep and Deep Publ.
10. Singhal R.K. 2013. Entrepreneurship Development and Management, Katson Books.
11. Tripathi PC and Reddy PN. 1991. Principles of Management. Tata McGraw Hill.

## BES 3112 Personality Development 2 (1+1)

**Objective**

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability

**Theory**

**Module I** **( 5 Hours)**

Personality definition, Nature of personality, theories of personality and its types. Thehumanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B Behaviours, personality and Organizational Behaviour.

**Module II** **( 7 Hours)**

Foundations of individual behavior and factors influencing individual behavior, Models of individual behavior, Perception and attributes and factors affecting perception, Attribution theory and case studies on Perception and Attribution. Learning: Meaning and definition, theories and principles of learning, Learning and organizational behavior, Learning and training, learning feedback.

**Module III** **(6 Hours)**

Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational behavior, emotional intelligence. Motivation- theories and principles, Teamwork and group dynamics.

**Practical**

MBTI personality analysis, Learning Styles and Strategies, Motivational needs, Firo-B, Interpersonal Communication, Teamwork and team building, Group Dynamics, Win-win game, Conflict Management, Leadership styles, Case studies on Personality and Organizational Behavior.

**Lecture Schedule**

1. Personality definition, Nature of personality, theories of personality and its types.
2. The humanistic approach - Maslow's self-actualization theory, shaping of personality
3. Determinants of personality, Myers-Briggs Typology Indicator
4. Locus of control and performance
5. Type A and Type B Behaviours, personality and Organizational Behaviour.
6. Foundations of individual behaviour and factors influencing individual behaviour.
7. Models of individual behaviour.
8. Perception and attributes and factors affecting perception.

9. Attribution theory and case studies on Perception and Attribution.
10. Learning: Meaning and definition, theories and principles of learning.
11. Learning and organizational behaviour.
12. Learning and training, learning feedback.
13. Attitude and values, Intelligence- types of Intelligence
14. Theories of intelligence, measurements of intelligence.
15. Factors influencing intelligence.
16. Intelligence and Organizational behaviour, emotional intelligence.
17. Motivation- theories and principles,
18. Teamwork and group dynamics.

**Practical Schedule**

1. MBTI personality analysis
2. MBTI personality analysis
3. Learning Styles and Strategies
4. Motivational needs, exercises
5. Motivational classes from eminent speakers
6. Firo -B Model -puzzles, games
7. Firo-B tools and tests
8. Interpersonal Communication
9. Interpersonal Communication - exercises
10. Teamwork and team building
11. Teamwork and team building activities
12. Group Dynamics - activities
13. Win-win game
14. Conflict Management
15. Leadership styles
16. Case studies on Personality and Organizational Behaviour.
17. Case studies on Personality and Organizational Behaviour.

**Suggested Readings**


1. Andrews, Sudhir. 1988. How to Succeed at Interviews. Tata McGraw-Hill.
2. Heller, Robert. 2002. Effective Leadership. Essential Manager series. Dk Publishing.
3. Hindle, Tim. 2003. Reducing Stress. Essential Manager series. Dk Publishing.
4. Lucas, Stephen. 2001. Art of Public Speaking. New Delhi. Tata - Mc-Graw Hill.
5. Mile, D.J. 2004. Power of Positive Thinking. Delhi. Rohan Book Company.
6. Kumar, Pravesh. 2005. All about Self- Motivation. New Delhi. Goodwill Publishing House.
7. Smith, B. 2004. Body Language. Delhi: Rohan Book Company.
8. Shaffer, D. R. 2009. Social and Personality Development (6th Edition). Belmont, CA: Wadswor.


## BES 3213 Sensors, Artificial Intelligence and Robotics in Agriculture 3 (2+1)

**Objectives**

To enable the student to know the

- Basics and selection of sensors for different agricultural applications

- Application of artificial intelligence and AI programming techniques
- Problem-solving through search and knowledge representation and reasoning with AI
- Use of open-source hardware (Arduino and Raspberry pi); robot programming, controlling algorithm, and basics of neural network

**Theory**

**Module I** **(6 Hours)**

Sensors Fundamentals: Introduction to sensors and transducers; Need for sensors in agriculture; Sensor Classification; Units of measurements; Sensor characteristics, Active and passive sensors– static characteristics, dynamic characteristics- first and second order sensors; Photoelectric effect – Photo dielectric effect – Hall effect – Thermoelectric effect – Piezoresistive effect – Piezoelectric effect – Pyroelectric effect- Magneto mechanical effect (magnetostriction) – Magneto resistive effect. Basics of detector materials/ sensor type (Silicon diode, InGaAs- etc.) and their characteristics. Fundamentals of visual, NIR, IR and FTIR spectroscopy, Remote sensing, data acquisition and their analysis; Training and validation of sensor and its results.

**Module II** **(6 Hours)**

Sensors in different applications: Occupancy and motion detectors; Position, displacement, and level; Velocity and acceleration; Force, strain, and tactile Sensors; Pressure sensors, Temperature sensors, Optical sensors and electromagnetic wave detector. Capacitance sensors; Weather sensors, imaging sensors and their application in agriculture. Principle and working of sensors for soil moisture, soil temperature, chlorophyll meter, coloursensor, spectral sensor, temperature sensor, humidity sensor, wind speed, motion sensors, positionsensor etc. Biosensors, general components of biosensor, biomolecules in biosensors such as enzyme, DNA, antibody, Nanomaterials in biosensors- Quantum dots.

**Module III** **(3 Hours)**

Introduction to Artificial Intelligence: *Overview*- foundations, scope, problems, history and approaches of AI. Intelligent agents: reactive, deliberative, goal driven, utility-driven, and learning agents, AI programming techniques. Classical AI, concept of expert system, conflict resolution, multiple rules, forward chaining, backward chaining; Advantages and limitations of AI systems.

**Module IV** **(7 Hours)**

Problem-solving through Search: Forward and backward, state-space, blind, heuristic, problem reduction, alpha-beta pruning, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms, bidirectional search, heuristic search, problems and examples. Knowledge Representation and Reasoning: Foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications. Planning: planning as search, partial order planning, construction and use of planning graphs.

**Module V** **(8 Hours)**

Robotics: Introduction to Robotics-classification with respect to geometrical configuration (anatomy), selection based on the agriculture application; Hardware for robot, sensors and actuator in robot, control of robot, system interface and integration in robot; Communication- internal

and external communications; Fundamentals of microprocessor architecture; Introduction to use of open source hardware (arduino and raspberry pi); robot programming, controlling algorithm-basic on neural network; Feedback system, safety sensors; Controlled system and chain type: Serial manipulator and Parallel Manipulator. Components of Industrial robotics-precession of movement-resolution, accuracy and Repeatability-Dynamic characteristics- speed of motion, load carrying capacity and speed of response.

**Module VI** **(6 Hours)**

Application in Agriculture: Introduction to precision farming tools for implementation of precision agriculture; site-specific management - nutrient management, agro- chemicals and fertilizer management, weeds management; Application of drone- pesticides/ nutrient spraying, environmental monitoring; Yield monitoring and mapping, soil sampling and analysis; Protected cultivation - smart irrigation system; precision livestock farming, application in food processing; image processing- shape analysis, feature detection and object location; gas and chemical sensor for electronic nose and electronic tongue.

**Practical**

Identify various sensors viz. Proximity sensors, ultrasonic sensors, optical sensors, electrochemical sensors and mechanical sensors; Measurement of displacement, force and pressure using different sensors; Use of load sensor on tractors to predict pulling requirements for ground engaging equipment; Introduction to open source programming languages, advantages and drawbacks of open source programming; Programming in Embedded- C, Concepts of C language; Identify various components in open source hardware (Arduino and Raspberry pi); Using of open source hardware and program for LED blink; Using of open source hardware and program for buzzer; Measurement of distance using ultrasonic sensor and IR sensor using open source hardware and programs; Experiment using moisture, temperature and relative humidity sensors for automatic irrigation and protected cultivation; Detection based spraying system using ultrasound for spraying operation using opens source hardware by programming with sensor and testing; Detection based spraying system using ultrasound for spraying operation – installation on sprayer unit with actuator/sensor and testing; Learning on open source image processing software for shape analysis and object detection; Learning about the different applications of robots in agriculture; Fabrication and integration of sensors; Visit to robot fabrication facilities/workshop.

**Lecture Schedule**

1. Sensors Fundamentals: Introduction to sensors and transducers; Need for sensors in agriculture; Sensor Classification.
2. Units of measurements; Sensor characteristics, Active and passive sensors– static characteristics, dynamic characteristics.
3. First and second order sensors; Photoelectric effect – Photo dielectric effect – Hall effect, Thermoelectric effect.
4. Piezoresistive effect – Piezoelectric effect – Pyroelectric effect, Magneto mechanical effect (magnetostriction) – Magneto resistive effect.
5. Basics of detector materials/ sensor type (Silicon diode, InGaAS- etc.) and their characteristics. Fundamentals of visual, NIR, IR, and FTIR spectroscopy.
6. Remote sensing, data acquisition, and their analysis; Training and validation of sensor and its results.

7. Sensors in different applications: Occupancy and motion detectors; Position, displacement, and level; Velocity and acceleration; Force, strain, and tactile Sensors.
8. Pressure sensors, Temperaturesensors, Optical sensors and electromagnetic wave detector.
9. Capacitance sensors; Weather sensors, imaging sensors and their application in agriculture.
10. Principle and working of sensors for soil moisture, soil temperature, chlorophyll meter, colour sensor, spectral sensor, temperature sensor, humidity sensor.
11. Principle and working of wind speed, motion sensors, position sensor etc.
12. Biosensors, general components of biosensor, biomolecules in biosensors such as enzyme, DNA, antibody, Nanomaterials in biosensors- Quantum dots.
13. Introduction to Artificial Intelligence: *Overview*- foundations, scope, problems, history and approaches of AI.
14. Intelligent agents: reactive, deliberative, goal driven, utility-driven, and learning agents.
15. AI programming techniques. Classical AI, concept of expert system, conflict resolution, multiple rules, Forward chaining, backward chaining; Advantages and limitations of AI systems.
16. Problem-solving through Search: Forward and backward, state-space, blind, heuristic.
17. Problem reduction, alpha-beta pruning, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms.
18. Bidirectional search, heuristic search, problems and examples.
19. Knowledge Representation and Reasoning: Foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space.
20. Predicate logic, situation calculus, description logics.
21. Reasoning with defaults, reasoning about knowledge, sample applications.
22. Planning: planning as search, partial order planning, construction and use of planning graphs.
23. Robotics: Introduction to Robotics-classification with respect to geometrical configuration (anatomy), selection based on the agriculture application.
24. Hardware for robot, sensors, and actuator in robot, control of robot, system interface, and integration in robot.
25. Communication-internal and external communications, Fundamentals of microprocessor architecture.
26. Introduction to the use of open-source hardware (Arduino and Raspberry Pi).
27. Robot programming, controlling algorithm- basics on neural network.
28. Feedback system, safety sensors.
29. Controlled system and chain type: Serial manipulator and Parallel Manipulator.
30. Components of Industrial robotics-precision of movement- resolution, accuracy and Repeatability-Dynamic characteristics- speed of motion, load carrying capacity and speed of response.
31. Robotic application in Agriculture: Introduction to precision farming tools for implementation of precision agriculture.
32. Application of site-specific management - nutrient management, agro- chemicals and fertilizer management, weeds management;
33. Application of drone- pesticides/ nutrient spraying, environmental monitoring; Yield monitoring and mapping, soil sampling and analysis.
34. Protected cultivation - smart irrigation system; precision livestock farming,

35. Application in food processing; image processing- shape analysis, feature detection and object location.
36. Gas and chemical sensor for the electronic nose and electronic tongue.

**Practical Schedule**

1. Identify various sensors - Proximity sensors, ultrasonic sensors, optical sensors, electrochemical sensors, and mechanical sensors;
2. Measurement of displacement, force, and pressure using different sensors.
3. Use of load sensors on tractors to predict pulling requirements for ground-engaging equipment.
4. Introduction to open source programming languages, advantages and drawbacks of open source programming; Programming in Embedded- C, Concepts of C language.
5. Identify various components open-source hardware – Arduino.
6. Identify various components open-source hardware - Raspberry Pi.
7. Experiment using open-source hardware (Aurdino/Raspberry Pi) and program for LED blink.
8. Experiment using open-source hardware (Aurdino/Raspberry Pi) and program for the buzzer.
9. Measurement of distance using ultrasonic sensor and IR sensor.
10. Experiment using moisture, temperature, and relative humidity sensors for automatic irrigation and protected cultivation.
11. Detection-based spraying system using ultrasound for spraying operation using open source hardware by programming with sensor and testing.
12. Detection-based spraying system using ultrasound for spraying operation – installation on sprayer unit with actuator/sensor and testing.
13. Learning about open-source image processing software for shape analysis and object detection.
14. Learning about the different applications of robots in agriculture.
15. Fabrication and integration of sensors.
16. Visit to robot fabrication facilities/workshop.
17. Practical Examination.

**Suggested Readings**


1. Bräunl, T. 2013. Embedded Robotics Mobile Robot Design and Applications with Embedded Systems. Springer Berlin Heidelberg.
2. Craig John, J. 2005. Introduction to Robotics. Pearson Education Inc., Asia, 3rd Edition.
3. Ghoshal, Asitava. 2006. Robotics: Fundamental Concepts and Analysis. Oxford University Press.
4. Gonzalez and Wintz. Digital Image Processing. 3rd edn.
5. Jha, S. N. 2015. Rapid Detection of Food Adulterants and Contaminants: Theory and Practice. Elsevier, USA (ISBN 9780124200845), p266.
6. Jha, S. N. (ed.). 2010. Nondestructive Evaluation of Food Quality: Theory and Practice. Springer
7. Verlag GmbH Berlin Heidelberg, Germany, ISBN 978-3-642-15795-0, doi 10.1007/978-3-642-15796-7: 288p.
8. Nikku, S. B. 2020. Introduction to Robotics – Analysis, Control, Applications. 3rd edition. John Wiley & Sons Ltd., 2020.
9. Nilsson Nils, J. 1980. Principles of Artificial Intelligence. Elsevier.

10. Rich, Knight and Nair. Artificial Intelligence. Tata McGraw Hill.
11. Saha, S. K. 2014. Introduction to Robotics. Tata McGraw Hills Education, 2014.
12. Schilling Robert, J. 1990. Fundamentals of robotics – Analysis and control. Prentice Hall of India.

## BES 4114 Agricultural Statistics and Data Analysis 2 (1+1)

**Objective**

To make the students acquainted with important statistical data analysis tools and application of these for research in agricultural engineering

**Theory**

**Module I** **(1 Hours)**

Introduction to statistics: Definition, advantages and limitations, Data- Types of data, quantitative and qualitative; variable- discrete and continuous; frequency distribution table; construction of frequency distribution table (inclusive and exclusive) - number of classes, length of class, tally-marks, frequency, class midpoint, cumulative frequencies, frequency curve, graphs, and charts.

**Module II** **(4 Hours)**

Measures of central tendency: Definition, characteristics of ideal average, different measures; arithmetic mean, median, mode, geometric mean, and harmonic mean for grouped and ungrouped data, merits and demerits; Measures of dispersion: definition, different measures (absolute and relative); range, quartile deviation, mean deviation, standard deviation (SD), variance and coefficient of variation.

**Module III** **(7 Hours)**

Probability: Definition and concept of probability; Random variable: concept of random variable and expectation; Simple linear correlation: concept, definition, types and its properties; Simple linear regression: concept, definition and its properties; Normal distribution: definition, density function, curve, properties, standard normal distribution (SND), properties including area under the curve (without proof); Binomial distribution: definition, density function and properties; Poisson distribution: definition, density function and properties; Introduction to sampling: definition of statistical population, sample, random sampling, parameter, statistic, sampling distribution, concept of standard error of mean.

**Module IV** **(6 Hours)**

Testing of hypothesis-hypothesis, null hypothesis, types of hypothesis, level of significance, degrees of freedom, statistical errors, Large sample test (Z test), small sample test t-test (one-tailed, two-tailed and paired tests); Testing of significance through variance (F test), Chi-square test: goodness of fit and testing of independence of attributes (2x2 contingency table).

**Lecture Schedule**

1. Introduction to statistics, types of data, frequency distribution, curves
2. Measures of central tendency: mean, median, mode
3. Geometric mean, Harmonic mean

4. Measures of dispersion: range, quartile deviation, mean deviation
5. Standard deviation, coefficient of variation.
6. Probability and expectation
7. Simple linear correlation
8. Simple linear regression
9. Normal distribution
10. Binomial distribution
11. Poisson distribution
12. Sampling theory
13. Testing of hypothesis: basic concepts
14. Large sample test - Z test
15. Small sample test - t-test
16. F test
17. Chi-square test: goodness of fit
18. Independence of attribute, contingency table

**Practical Schedule**

1. Construction of frequency distribution table and frequency curve
2. Measures of central tendency: mean, median, mode
3. Geometric mean, Harmonic mean
4. Measures of dispersion: range, quartile deviation, mean deviation
5. Measures of dispersion – standard deviation, variance and coefficient of variation
6. Computation of binomial distribution
7. Computation of poison distribution
8. Calculation of correlation coefficient
9. Calculation of correlation coefficient
10. Calculation of regression coefficient
11. Z test for single sample mean
12. Z test for two sample mean
13. T-test for single sample mean
14. T-test for two sample mean
15. Paired t-test
16. F-test
17. Chi-square test
18. Practical examination

**Suggested Readings**


1. Agrawal, B. L. 1991. Basic Statistics. Wiley Eastern Ltd. New Age International Ltd.
2. Chandel, S. R. S. 1999. A Handbook of Agricultural Statistics. Achal Prakasan Mandir, Kanpur.
3. Gupta, S. C. and Kapoor, V. K. 1970. Fundamentals of Mathematical Statistics. Sultan Chand &Sons.
4. Gupta, S. C. and Kapoor, V. K. 2019. Fundamental Applied Statistics. Sultan Chand & Sons.
5. Nageswara Rao, G. 2007. Statistics for Agricultural Sciences. BS Publications.
6. Rangaswamy, R. 2018. A Text Book of Agricultural Statistics. New Age Int. Publications Ltd.

## Department of Basic Engineering & Applied Sciences- Elective courses

## EBE 4201 Food Business Management and Entrepreneurship Development 3 (3+0)

**Objective**

To enable the students to learn various aspects of business management and entrepreneurship development in food processing

**Theory**

**Module I** **(7 Hours)**

Introduction and definitions related to project management and entrepreneurship. Fundamentals of project management and entrepreneurship development.

**Module II** **(8 Hours)**

Project formulation: Market survey techniques, project identification, project selection, project proposal, and work breakdown structure. Network scheduling: Activity networks, use of CPM and PERT in project scheduling.

**Module III** **(8 Hours)**

Resource planning, resource allocation, and project scheduling with limited resources. Estimation of project costs, earned value analysis, project techno-economic viability, and break-even analysis.

**Module IV** **(7 Hours)**

Identification of business opportunity in the food processing sector. Government policies for the promotion of entrepreneurship in food processing. Launching and organizing an enterprise, enterprise selection, market assessment, feasibility study, and SWOT analysis.

**Module V** **(7 Hours)**

Resource mobilization, financial institutions in promoting entrepreneurship, supply chain management, and a case study of a food business.

**Lecture Schedule**

1. Definitions of Project and Project Management
2. Key Concepts: Project Life Cycle, Project Constraints (Scope, Time, Cost)
3. Importance of Project Management in Business Ventures
4. Definition and Characteristics of Entrepreneurship
5. Motivational, Social, and Environmental Factors of Entrepreneurs
6. Entrepreneurial Attributes and Competencies
7. Introduction to Project Formulation
8. Techniques for Conducting Market Surveys (Surveys, Questionnaires, Focus Groups)
9. Project Identification and Selection Methods
10. Components of a Project Proposal
11. Work Breakdown Structure (WBS) – Definition and Application in Projects
12. Introduction to Network Scheduling
13. Difference between CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique)

14. Application of CPM and PERT in Project Scheduling
15. Resource Planning: Importance in Project Management
16. Techniques for Resource Allocation
17. Project Scheduling with Limited Resources: Strategies and Tools
18. Mid Examination
19. Techniques for Estimating Project Costs
20. Earned Value Analysis (EVA): Concepts and Applications in Project Monitoring
21. Assessing Techno-Economic Viability of a Project
22. Break-Even Analysis: Definition, Importance, and Calculation
23. Overview of the Food Processing Industry in India
24. Key Opportunities and Challenges in the Sector
25. Current Government Schemes and Policies (PMFME, Mega Food Parks)
26. Role of Food Processing Ministry in Entrepreneurship Development
27. Enterprise Selection Process
28. Market Assessment and Feasibility Study: Steps and Tools
29. SWOT Analysis for Identifying Strengths, Weaknesses, Opportunities, and Threats
30. Importance of Business Planning in Entrepreneurship
31. Methods for Mobilizing Financial, Human, and Physical Resources
32. Role of Financial Institutions in Promoting Entrepreneurship
33. Overview of Institutions like NABARD, SIDBI, and Venture Capitalists
34. Government's Financial Support and Loan Schemes for Entrepreneurs
35. Importance of Efficient Supply Chain in Food Processing
36. Strategies for Managing the Supply Chain
37. In-depth Case Study of a Successful Food Processing Business

**Suggested Readings**


1. Awasthi D and Jaggi R. Entrepreneurship and Management Inputs for Entrepreneurs in Food Processing Sector. Ahmedabad EDII
2. Bell, G. F. and Balkwill, J. Management and Engineering. Prentice Hall International
3. Bharatia, C. R. Food Technology and Entrepreneurship Management. Surendra Publications
4. Jordan, Lisa. Food Industry: Food Processing and Management. 2 edn. Callisto


## EBE 4202 MATLAB Programming 3 (2+1)

**Objectives**

- To enable the students to know the different features of MATLAB
- Have hands-on exercise in the MATLAB for different agricultural engineering applications

**Theory**

**Module I** **(4 Hours)**

Introduction: platform and features, prerequisites and system requirements, advantages and disadvantages.Commands, environment, working with variables and arrays, workspace, variables and functions, data types, operator, formatting text.

**Module II** **(12 Hours)**

Control Statements: if statement, if-else statement, if-elseif statement, nested if-else, switch. MATLAB loops: for loop, while loop, nested loop, break, continue.MATLAB error control: error control statement-try and catch.

**Module III** **(9 Hours)**

Arrays and functions: matrices and arrays, multi-dimensional arrays, compatible array, sparse matrices; Functions: normal functions, predefined functions, user-defined functions, anonymous Function

**Module IV** **(7 Hours)**

2D Plots: fplot(), Semilogx(), Semilogy(), loglog(), fill(), Bar(), errorbar(), barh(), plotyy(), area(), Pie(), hist(), stem(), Stairs(), compass(), comet(), contour(), quiver(), pcolor(); 3D Plots: plot3(), fill3(), contour3(), surf(), surfc(), mesh(), meshz(), waterfall(), stem3(), ribbon(), sphere(), ellipsoid(), cylinder(), slice()

**Practical**

Hands on experience with MATLAB functionalities and its installation on different platforms; MATLAB project based on real time Agricultural Engineering problems.

**Lecture Schedule**

1. Introduction: platform and features, prerequisites and system requirements, advantages and disadvantages.
2. Commands, environment, working with variables and arrays.
3. Workspace, variables and functions, data types.
4. Operator, formatting text.
5. Control Statements: if statement,
6. if-else statement
7. if-elseif statement,
8. Nested if-else
9. Switch Statement
10. Project on Agricultural engineering problems - scripting
11. MATLAB loops: for loop,
12. While loop
13. Nested loop
14. break, continue
15. Project on Agricultural engineering problems - scripting
16. MATLAB error control: error control statement-try and catch.
17. Arrays matrices and arrays
18. Multi-dimensional arrays, compatible array, sparsematrices
19. Cell, structure
20. Project on Agricultural engineering problems - scripting
21. Functions: normal functions
22. Predefined functions
23. User-defined functions
24. Anonymous Functions
25. Project on Agricultural engineering problems – scripting

26. 2D Plots: fplot(), Semilogx(), Semilogy(), loglog(), fill()
27. Bar(), errorbar(), barh(), Plotyy(), area(), Pie(), hist(), stem()
28. Stairs(), compass(), comet(), Contour(), quiver(), pcolor()
29. 3D Plots: plot3(), fill3(), contour3(), Surf(), surfc(), mesh(), meshz(),
30. Waterfall(), stem3(), ribbon(), Sphere(), ellipsoid(), cylinder(), slice()
31. Project on Agricultural engineering problems – scripting
32. Project on Agricultural engineering problems - scripting

**Practical Schedule**

1. Installation of Matlab
2. Workspace, variables and functions, data types.
3. Command line operations with numbers, operator, formatting text.
4. Matrix operations- add, subtract, transpose, inverse, multiply, all matrix functions
5. Simple programs with control Statements: if statement, if-else statement, if-else-if statement
6. Nested if-else,switch.
7. MATLAB loops: for loop, While loop
8. Nested loop, break, continue.
9. MATLAB error control: error control statement-try and catch.
10. Programs with matrices and arrays, Multi-dimensional arrays
11. Functions: normal functions, Predefined functions
12. User-defined functions, Anonymous Function.
13. 2D Plots: fplot(), Semilogx(), Semilogy(), loglog(), fill()
14. Plots -Bar(), errorbar(), barh(), Plotxy(), area(), Pie(), hist(), stem()
15. Stairs(), compass(), comet(), contour(), quiver(), pcolor()
16. 3D Plots: plot3(), fill3(), contour3(), surf(), surfc(), mesh(), meshz()
17. Waterfall(), stem3(), ribbon(), sphere(), ellipsoid(), cylinder(), slice()
18. Projects with agricultural engineering problems

**Suggested Readings**


1. B. B. Chaudhuri, 2007, MATLAB Programming
2. D. Hanselman, B. Littlefield, Mastering MATLAB 7, Pearson Education
3. Peter Issa Kattan, 2008, MATLAB for Beginners: A Gentle Approach
4. S. N. Ala, Understanding MATLAB: A Textbook for Beginners, 2013
5. William, J.P, Introduction to MATLAB for Engineers, Third Ed., 2011


## EBE 4203 Python Programming 3 (2+1)

**Objectives**

- To enable the students to know the different features of Python programming and have hands-on exercise on it
- To use the Python programming for different agricultural engineering applications

**Theory**

**Module I** **(4 Hours)**

Introduction: history, applications, installation. Variables, data types, keywords, literals, operators, comments.

**Module II** **(9 Hours)**

Conditional statements: if else, loops, for loop, while loop, break, continue, pass. strings, lists,tuples, list vs tuple. Functions: functions, built-in functions, lambda functions.

**Module III** **(7 Hours)**

Files I/O, modules, exceptions, date, Regex, read CSV File, write CSV File, read excel file, writeexcel file, assert, list comprehension, collection.

**Module IV** **(12 Hours)**

Module, math module, OS module, random module, statistics module, sys module, IDEs, arrays, command line arguments, stack and queue. Python OOPs: OOPs concepts, object class, constructors, inheritance, abstraction.

**Practical**

Hands-on experience with Python and its installation on different platforms; Accessing python from GUI and from command prompt / terminal, a project based on real time agricultural engineering problems.

**Lecture Schedule**

1. Introduction: history, applications
2. Installation on various platforms
3. Variables, data types, keywords, literals
4. Operators, comments
5. Conditional statements: if-else
6. Loops, for loop
7. While loop
8. Scripting for Agricultural Engineering problems
9. Break, continue, pass.
10. Strings, lists,tuples, list vs tuple.
11. Functions: functions, built-in functions
12. lambda functions.
13. Scripting exercises for Agricultural Engineering problems
14. Files I/O
15. Modules, exceptions
16. Date, Regex
17. Read CSV File, write CSV File
18. Read excel file, write excel file
19. Scripting exercises for Agricultural Engineering problems
20. assert, list comprehension, collection.
21. Module, math module
22. OS module, Random module
23. Statistics module, sys module
24. IDEs, Scripting exercises for Agricultural Engineering problems
25. Arrays
26. Command line arguments
27. Stack and queue

28. Python OOPs: OOPs concepts, Object class
29. Constructors
30. Inheritance
31. Abstraction.
32. Scripting exercises for Agricultural Engineering problems

**Practical Schedule**

1. Python installation - windows
2. Python installation - Linux
3. Hands- on with variables, data types, literals, Operators, comments.
4. Conditional statements: if else
5. Loops, for loop, While loop
6. Break, continue, pass
7. Strings, Lists,tuples
8. Functions: built-in functions, Lambda functions.
9. Files I/O, modules, exceptions, date, Regex
10. Read CSV File, write CSV File, read Excel file, write Excel file
11. assert, list comprehension, collection.
12. Programs using math module, IDEs, OS module, sys module, random module, statistics module
13. Programs using Arrays, Command line arguments, Stack and queue.
14. Python OOPs: OOPs concepts, object class, constructors, Inheritance, abstraction.
15. Case study on agricultural engineering problems
16. Project agricultural engineering problems
17. Project agricultural engineering problems

**Suggested Readings**


1. David M. Beazley, Python essential Reference, Fourth Edition, ISBN-13: 978-0-672-32862-6.
2. Martin C. Brow, Python: The Complete Reference
3. Rupesh Nasre, Python Programming, AICTE
4. Samir Madhavan, Mastering Python for data science, Packt publishing, Open Source


## EBE 4204 Artificial Intelligence 3 (2+1)

**Objective**

To enable the students to know the details of problem solving in artificial intelligence, details of knowledge, reasoning, and planning in artificial intelligence, learning, communicating, perceiving, and acting in artificial intelligence

**Theory**

**Module I** **(2 Hours)**

Foundation and history of artificial intelligence; Intelligent agents, structure of agents; AI programming languages, introduction to LISP and PROLOG.

**Module II** **(8 Hours)**

Solving problems by searching, problem solving agents, infrastructure for search algorithms, measuring problem solving performance, blind search strategies, breadth first search, depth first search, heuristic search techniques, best first- A* algorithm, AO* algorithm; Hill climbing search, Genetic algorithms; Games, game tree, game playing, min-max algorithms, alpha beta pruning; Logical agents, knowledge representation issues, predicate logic, logic programming; Constraint satisfaction problems, backtracking search.

**Module III** **(11 Hours)**

Knowledge representation- representing knowledge using rules, rules based deduction systems, semantic nets, frames, inheritance, temporal reasoning; Quantifying uncertainty, reasoning under uncertainty; Probabilistic reasoning- review of probability, Baye's probabilistic interferences, Dempstershafer theory, fuzzy reasoning; Classical planning- planning, representation for planning, partial order planning algorithm; Planning and acting in the real world- planning in situational calculus, high- level actions.

**Module IV** **(5 Hours)**

Supervised learning, artificial neural networks, neural network structures, single-layer feed-forward neural networks (perceptron), multilayer feed-forward neural networks, learning in multilayer networks; Knowledge in learning- a logical formulation of learning, explanation-based learning.

**Module V** **(5 Hours)**

Natural language processing- principles of natural language processing; Expert systems, knowledge acquisition concepts; Robotics, AI application to robotics; Current trends in intelligent systems.

**Practical**

Hands on exercise on problem solving in artificial intelligence, details of knowledge, reasoning, and planning in artificial intelligence, learning in artificial intelligence, communicating, perceiving, and acting in artificial intelligence and verifying engineering concepts in artificial intelligence.

**Lecture Schedule**

1. Foundation and history of artificial intelligence; Intelligent agents, structure of agents.
2. AI programming languages, introduction to LISP and PROLOG.
3. Solving problems by searching, problem solving agents, infrastructure for search algorithms
4. measuring problem solving performance, blind search strategies
5. breadth first search, depth first search
6. heuristic search techniques, best first- A* algorithm, AO* algorithm;
7. Hill climbing search,
8. Genetic algorithms;
9. Games, game tree, game playing, min-max algorithms, alpha beta pruning;
10. Logical agents, knowledge representation issues,
11. predicate logic, logic programming;
12. Constraint satisfaction problems, backtracking search.

13. Knowledge representation- representing knowledge using rules, rules based deduction systems,
14. Semantic nets, frames, inheritance, temporal reasoning;
15. Quantifying uncertainty, reasoning under uncertainty;
16. Probabilistic reasoning- review of probability,
17. Baye's probabilistic interferences,
18. Dempster-shafer theory,
19. Fuzzy reasoning;
20. Classical planning- planning, representation for planning,
21. partial order planning algorithm;
22. Planning and acting in the real world- planning in situational calculus,
23. High- level actions.
24. Supervised learning, artificial neural networks,
25. Neural network structures, single-layer feed-forward neural networks (perceptron),
26. Multilayer feed-forward neural networks, learning in multilayer networks;
27. Knowledge in learning- a logical formulation of learning, explanation-based learning.
28. Natural language processing- principles of natural language processing;
29. Expert systems, knowledge acquisition concepts;
30. Robotics, AI application to robotics;
31. Current trends in intelligent systems.

**Practical Schedule**

1. AI programming languages, introduction to LISP
2. Introduction to PROLOG.
3. Solving problems by searching
4. Breadth first search
5. Depth first search
6. A* algorithm
7. AO* algorithm
8. Genetic algorithms
9. Games, game tree, game playing, min-max algorithms
10. Constraint satisfaction problems, backtracking search.
11. Knowledge representation- representing knowledge using rules, rules based deduction systems,
12. fuzzy reasoning problems
13. Partial order planning algorithm implementation
14. Problems with artificial neural networks
15. Multilayer feed-forward neural networks
16. Natural language processing models – demonstration programs
17. Demonstration of Expert systems
18. Simple programs on robotics

**Suggested Readings**


1. Nilson, N. J. 2002. Principles of Artificial Intelligence. Narosa Publishing House.
2. Rich, E. and Knight, K. 1991. Artificial Intelligence. Times McGraw-Hill.
3. Russell, S. and Norvig, P. 1998. Artificial Intelligence: A Modern Approach. Prentice Hall.
4. Winston, P. H. 1992. Artificial intelligence. Addition Wesley 3rd edn.

# EBE 4205 Machine Learning 3 (2+1)

**Objectives**

To enable the students to

- Know the basics of machine learning
- Know the applications of machine learning in different fields

**Theory**

**Module I** **(9 Hours)**

Introduction to Machine Learning, Preliminaries, what is machine learning; varieties of machine learning, learning input/output functions, bia, sample application. Boolean functions and their classes, CNF, DNF, decision lists. Version spaces for learning, version graphs, learning search of a version space, candidate elimination methods;

**Module II** **(11 Hours)**

Neural Networks, threshold logic units, linear machines, networks of threshold learning units, Training of feed forward networks by back propagations, neural networks vs. knowledge-based systems; Statistical Learning, background and general method, learning belief networks, nearest neighbor. Decision-trees, supervised learning of uni-variance decision trees, network equivalent of decision trees, over fitting and evaluation.

**Module III** **(6 Hours)**

Inductive Logic Programming, notation and definitions, introducing recursive programs, inductive logic programming vs decision tree induction; Computational learning theory, fundamental theorem, Vapnik Chernonenkis dimension, linear dichotomies and capacity.

**Module IV** **(5 Hours)**

Unsupervised learning, clustering methods based on Euclidian distance and probabilities, hierarchical clustering methods. Introduction to reinforcement and explanation-based learning.

**Practical**

Hands on experience with Machine Learning functionalities and its use in agricultural engineering and allied fields.

**Lecture Schedule**

1. Introduction to Machine Learning, Preliminaries, what is machine learning
2. Varieties of machine learning
3. Learning input/output functions, bia, sample application.
4. Sample application.
5. Boolean functions and their classes, CNF, DNF
6. Decision lists.
7. Version spaces for learning, version graphs
8. Learning search of a version space
9. Candidate elimination methods
10. Neural Networks
11. Threshold logic units, linear machines
12. Networks of threshold learning units

13. Training of feed forward networks by back propagations
14. Neural networks vs. Knowledge-based systems
15. Statistical Learning, background and general method
16. Learning belief networks
17. Nearest neighbor
18. Decision-trees
19. Supervised learning of uni-variance decision trees, network equivalent of decision trees
20. Over fitting and evaluation.
21. Inductive Logic Programming, notation and definitions
22. Introducing recursive programs
23. Inductive logic programming vs decision tree induction
24. Computational learning theory, fundamental theorem
25. Vapnik Chernonenkis dimension
26. Linear dichotomies and capacity
27. Unsupervised learning, clustering methods based on Euclidian distance
28. Clustering methods based on probabilities
29. Hierarchical clustering methods
30. Introduction to reinforcement
31. Explanation-based learning

**Practical Schedule**

1. Hands on experience with Machine Learning functionalities and its use in agricultural engineering fields.
2. Application using Neural networks
3. Neural network with backpropagation
4. Engineering problems using different functions -sigmoid, ReLU, tanh in Neural networks
5. Engineering problems solving – K-nearesr neighbour method
6. Bayesian belief networks
7. Decision Trees
8. Random forest
9. Support Vector Machines
10. K-Means clustering
11. Hierarchical clustering
12. Density clustering
13. Reinforced Neural networks

**Suggested Readings**


1. Ethem, Alpaydin. 2009. Introduction to Machine Learning. 3rd edn. MIT Press.
2. Muller, Andreas C. 2009. Introduction to Machine Learning with Python- A Guide for Data Scientists. Sarah Guido, O'Reilly
3. Muller, J P. and Massaron, L. 2021. Machine Learning for Dummies. 2nd edn. Weily.


## EBE 4206 Operations Research 3 (2+1)

**Objectives**

To enable the students to

- Understand the importance of operations research for solving field problems
- Understand and apply linear programming, transportation problem, etc. for agricultural engineering applications
- Understand the project planning and network analysis

**Theory**

**Module I** **(3 Hours)**

Introduction to operations research: elementary concepts and objectives, applications of operations research in decision making.

**Module II** **(6 Hours)**

Linear programming problem: mathematical formulation of the linear programming problem and its graphical solution, simplex method, simplex method for maximizing and minimizing, mixed constraints, duality theory, the Primal vs. Dual solutions.

**Module III** **(5 Hours)**

Transportation problem: definition and mathematical formulation, initial basic feasible solution, optimal solution. Assignment problem: introduction and mathematical formulation, solution of the assignment problem.

**Module IV** **(5 Hours)**

Inventory control: introduction and general notations, economic lot size models with known demand. Replacement theory: introduction and elementary concepts, replacement of items deteriorating with time.

**Module V** **(13 Hours)**

Sequencing problem: introduction and general notations, solution of a sequencing problem. Queuing theory: introduction and classification of queues, solution of queuing models. Project planning and network analysis: introduction and basic definitions in network analysis, rules for drawing network analysis, Critical Path Method (CPM), Project Evaluation and Review Technique (PERT)

**Lecture Schedule**

1. Introduction to Operations Research: Overview and Significance
2. Elementary Concepts of Operations Research
3. Objectives of Operations Research, Applications of Operations Research in Decision Making
4. Introduction to Linear Programming, Mathematical Formulation of Linear Programming Problems
5. Graphical Solution of Linear Programming Problems
6. Simplex Method for Maximizing Objectives
7. Simplex Method for Minimizing Objectives
8. Handling Mixed Constraints in Linear Programming
9. Duality Theory in Linear Programming, Primal vs. Dual Solutions
10. Introduction to Transportation Problems, Mathematical Formulation of Transportation Problems
11. Finding Initial Basic Feasible Solutions
12. Determining Optimal Solutions for Transportation Problems

13. Introduction to Assignment Problems, Mathematical Formulation of Assignment Problems
14. Solution Techniques for Assignment Problems
15. Introduction to Inventory Control, General Notations in Inventory Control
16. Economic Lot Size Models with Known Demand
17. Introduction to Replacement Theory, Elementary Concepts of Replacement Theory
18. Replacement of Items Deteriorating with Time
19. Practical Applications in Inventory and Replacement
20. Introduction to Sequencing Problems, General Notations in Sequencing Problems
21. Solution Techniques for Sequencing Problems
22. Introduction to Queuing Theory, Classification of Queues
23. Solution of Queuing Models
24. Introduction to Project Planning
25. Basic Definitions in Network Analysis
26. Rules for Drawing Network Diagrams
27. Introduction to the Critical Path Method (CPM)
28. Applying the Critical Path Method (CPM)
29. Project Evaluation and Review Technique (PERT)
30. Application of PERT in Project Management
31. Comparison of CPM and PERT
32. Case Studies in Sequencing and Queuing

**Practical Schedule**

1. Objectives of Operations Research, Applications of Operations Research in Decision Making – Case studies
2. Graphical Solution of Linear Programming Problems
3. Simplex Method for Maximizing Objectives
4. Simplex Method for Minimizing Objectives
5. Handling Mixed Constraints in Linear Programming
6. Duality Theory in Linear Programming, Primal vs. Dual Solutions
7. Transportation problem: Finding Initial Basic Feasible Solutions
8. Determining Optimal Solutions for Transportation Problems
9. Solution Techniques for Assignment Problems - Excercises
10. Economic Lot Size Models with Known Demand -case study
11. Replacement theory problems
33. Practical Applications in Inventory and Replacement, Replacement of Items Deteriorating with Time
12. Solution Techniques for Sequencing Problems
13. Solution of Queuing Models- Exercises
14. Project planning- drawing network diagrams exercises
15. Applying the Critical Path Method (CPM) for Agricultural engineering project planning
16. Application of PERT in Project Management – Problems/excercises
17. Case Studies in Sequencing and Queuing

**Suggested Readings**

1. Taha, H. 2003. Operations Research. Macmillan Publishing Company.
2. Winston, W. L. 2004. Operations Research: Applications and Algorithms. Indian University.

# EBE 4207 Agricultural Marketing and Trade 3 (2+1)

**Objectives**

- To understand the fundamentals of agricultural marketing and trade
- To analyze the factors influencing supply and demand in agricultural markets
- To explore different marketing channels and strategies in agriculture
- To examine the role of government policies and regulations in agricultural markets

**Theory**

**Module I** **(7 Hours)**

Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix, and market segmentation. Classification and characteristics of agricultural markets. Demand, supply, and producer's surplus of agricultural commodities. Nature and determinants of demand and supply of farm products. Producer's surplus – meaning and its types, marketable and marketed surplus. Factors affecting the marketable surplus of agricultural commodities.

**Module II** **(4 Hours)**

Pricing considerations and approaches – cost-based and competition-based pricing. Market promotion – advertising, personal selling, sales promotion, and publicity. Meaning, merits, and demerits of these promotional methods.

**Module III** **(8 Hours)**

Marketing process concentration, dispersion, and equalization. Exchange functions – buying and selling. Physical functions – storage, transport, and processing. Facilitating functions – packaging, branding, grading, quality control, and labelling (Agmark). Market functionaries and marketing channels. Types and importance of agencies involved in agricultural marketing. Meaning and definition of marketing channels, number of channel levels, and marketing channels for different farm products.

**Module IV** **(9 Hours)**

Meaning, definition, and types of market integration. Marketing efficiency. Marketing costs, margins, and price spread. Factors affecting the cost of marketing. Reasons for higher marketing costs of farm commodities. Ways of reducing marketing costs. Role of the government in agricultural marketing. Public sector institutions – CWC, SWC, FCI, CACP, and DMI – their objectives and functions. Cooperative marketing in India. Risk in marketing, types of risk, speculation and hedging, and an overview of futures trading. Agricultural prices and policy. Meaning and functions of price, administered prices, and the need for innovations in agricultural price policy.

**Module V** **(7 Hours)**

Concept of international trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agricultural commodities. WTO, Agreement on Agriculture (AoA) and its implications on Indian agriculture, and intellectual property rights (IPR). Role of APMC and its relevance in the present-day context.

**Practical**

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions –NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

**Lecture Schedule**

1. Introduction to Agricultural Marketing
2. Market Structure and Marketing Mix
3. Market Segmentation in Agricultural Marketing
4. Classification and Characteristics of Agricultural Markets
5. Demand and Supply of Agricultural Commodities
6. Producer's Surplus: Concepts and Types
7. Factors Affecting Marketable Surplus
8. Pricing Strategies in Agricultural Marketing -cost-based and price-based
9. Promotion Strategies in Agricultural Marketing- advertising, personal selling, sales promotion, and publicity.
10. Sales Promotion in Agricultural Marketing
11. Meaning, merits, and demerits of these promotional methods.
12. Marketing Process: Concentration, Dispersion, and Equalization
13. Exchange Functions in Agricultural Marketing
14. Physical Functions in Agricultural Marketing
15. Facilitating Functions in Agricultural Marketing -packaging, branding, grading, quality control, and labeling (Agmark)
16. Types and importance of agencies involved in agricultural marketing.
17. Market Functionaries and Marketing Channels
18. Meaning and definition of marketing channels, number of channel levels
19. Marketing Channels for Different Farm Products
20. Market Integration: Meaning and Types
21. Marketing Efficiency and Its Measurement
22. Marketing Costs and Margins
23. Price spread in Agricultural Marketing
24. Reasons for higher marketing costs of farm commodities and ways of reducing marketing costs.
25. Role of Government in Agricultural Marketing - Public sector institutions -objectives and functions
26. Cooperative Marketing in India
27. Risk in Agricultural Marketing -types of risk, speculation and hedging, and an overview of futures trading
28. Agricultural Prices and Policy – need of innovations in Agricultural Price Policy
29. International Trade in Agricultural Commodities -WTO and Agriculture

30. Intellectual Property Rights (IPR) in Agriculture
31. Role of Agricultural Produce Market Committees (APMCs)
32. Challenges and Opportunities in Agricultural Marketing
33. Emerging Trends in Agricultural Marketing
34. Government Initiatives to Promote Agricultural Marketing
35. Case Study: Agricultural Marketing in India

**Practical Schedule**

1. Plot the demand and supply curves for selected agricultural commodities and interpret the shifts.
2. Calculate price elasticity of demand and supply for selected agricultural products and analyze the results.
3. Collect data on market arrivals and prices for selected commodities and analyze their relationship.
4. Compute marketable and marketed surplus for key agricultural commodities and identify the factors affecting them.
5. Collect and analyze price trends of selected commodities over a period of time.
6. Construct index numbers to analyze price changes for selected agricultural products.
7. Visit a local agricultural market to observe the marketing functions and agencies involved.
8. Identify and map marketing channels for selected agricultural products in the local market.
9. Collection of data regarding marketing costs, margins, and price spread and presentation of report in the class.
10. Visit NAFED/State Warehousing Corporation (SWC) to study their organization, functioning, and contribution to agricultural marketing.
11. Assess the level of market integration for a specific commodity by collecting data on market prices from different regions.
12. Analyze the marketing efficiency of a selected agricultural product using real market data.
13. Study how speculation and hedging are used in agricultural markets and explore futures trading for price risk management.
14. Visit a cooperative marketing society to observe its operations and understand its role in the agricultural marketing system.
15. Identify the different risks involved in agricultural marketing and develop risk mitigation strategies for a selected commodity.
16. Study the price spread for a selected agricultural product from producer to consumer, and identify the factors contributing to the price spread.
17. Study the principle of comparative advantage in agricultural commodity trade and analyze its practical applications.
18. Study the various market functionaries involved in agricultural marketing and their roles in the market chain.

**Suggested Readings**


1. Acharya, S.S. and Agarwal, N.L., 2006, Agricultural Marketing in India, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
2. Chinna, S.S., 2005, Agricultural Economics and Indian Agriculture. Kalyani Pub, N Delhi.
3. Dominic Salvatore, Micro Economic Theory
4. Kohls Richard, L. and Uhl Josheph, N., 2002, Marketing of Agricultural Products, Prentice-Hall of India Private Ltd., New Delhi.

5. Kotler and Armstrong, 2005, Principles of Marketing, Pearson Prentice-Hall.
6. Lekhi, R. K. and Jogindr Singh, 2006, Agricultural Economics. Kalyani Publishers, Delhi.
7. Memoria, C.B., Joshi, R.L. and Mulla, N.I., 2003, Principles and Practice of Marketing in India, Kitab Mahal, New Delhi.
8. Pandey Mukesh and Tewari, Deepali, 2004, Rural and Agricultural Marketing, International Book Distributing Co. Ltd, New Delhi.
9. Sharma, R., 2005, Export Management, Laxmi Narain Agarwal, Agra.

## Project/ In-plant Training

## PRO 4101 Project-I 3 (0+3)

**Objective**

To strengthen the skill of the students and for developing their confidence to take up either research or employment/ entrepreneurship as a future career.

**Activity**

The activities should aim at development of advanced skill for research/ employment and entrepreneurship. The activities can be planned considering the total 7 credit Hours allocated in the 7th and 8th semesters, viz. Project I (0+3 credit Hours in 7th semester) and Project II (0+4 credit Hours in the 8th semester).

The course can be taken either for developing research skills in form of project (R and D based, field study based) or for entrepreneurship development (incubation/ experiential learning based). The student will have the option to choose the mode of this course in consultation with a faculty mentor (each student will be attached to a mentor either from the College/ University or from any organization/ industry).

## PRO 4202 Project-II 2 (0+2)

This will be the continuation of work/ study taken under the course Project- I

## IPT 4201 In-plant Training/ Research Internship (8 weeks) 8 (0+8)

**Objective**

To provide students with an opportunity to put into practice the skills they have learned while studying in the institute. In addition, students will have an opportunity to enhance those skills, obtain the perspective of a work environment and benefit from a mentor or supervisor's experience and advice.

**Activity**

The students will have internship/ training for 8 weeks' duration in industries/ research organisations/ institutions. The College/ University will facilitate attaching the students to the organisations. In-plant training may be conducted in split manner in more than one industry/ organization/ institute.

After completion of training/ internship, the students will have to submit a report of their learnings and also present in form of a seminar before nominated faculty members and other students. The assessment will be based on the report / assessment received from the industry/ organisation and the report and the presentation made at the University. Ideally the weightage will be 50% each for both internal and external. The HAEIs may modify the weightage and breakups.

Note: Considering that the students will be out of the campus for 8 weeks within the semester, the timetable for the remaining part of the semester should be so adjusted that each credit hour will have minimum of 15 classes.