



# SIXTH DEANS' COMMITTEE REPORT

---

**AGRICULTURAL EDUCATION DIVISION**  
Indian Council of Agricultural Research  
Krishi Anusandhan Bhawan-II  
Pusa, New Delhi-110012



# SIXTH DEANS' COMMITTEE REPORT



**Agricultural Education Division**  
Indian Council of Agricultural Research  
Krishi Anusandhan Bhawan II  
Pusa, New Delhi 110012

© All Rights Reserved, Indian Council of Agricultural Research

**ISBN: 978-81-7164-284-7**

*Collated by:*

**Dr. R.C.Agrawal**

Deputy Director General (Agricultural Education)

**Dr. A.S. Yadav**

Assistant Director General (EQAR)

**Agricultural Education Division**

**Indian Council of Agricultural Research**

Krishi Anusandhan Bhawan II

New Delhi 110012

*Design & Production*

**Punit Bhasin, DKMA**

---

Published by Dr Anuradha Agrawal, Project Director, ICAR-Directorate of Knowledge Management in Agriculture (DKMA), Krishi Anusandhan Bhavan I, Pusa Campus, New Delhi 110012.

Lasertypeset and printed at M/s Chandu Press, 469, Patparganj Industrial Area, Delhi 110092.



सत्यमेव जयते

**डॉ. हिमांशु पाठक**

सचिव (डेयर) एवं महानिदेशक (भाकृअनुप)

**Dr HIMANSHU PATHAK**

SECRETARY (DARE) & DIRECTOR GENERAL (ICAR)

भारत सरकार

कृषि अनुसंधान और शिक्षा विभाग एवं

भारतीय कृषि अनुसंधान परिषद

कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA

DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION (DARE)

AND

INDIAN COUNCIL OF AGRICULTURAL RESEARCH (ICAR)

MINISTRY OF AGRICULTURE AND FARMERS WELFARE

KRISHI BHAVAN, NEW DELHI 110 001

Tel.: 23382629; 23386711 Fax: 91-11-23384773

E-mail: dg.icar@nic.in

## Foreword

The Indian Council of Agricultural Research (ICAR) has played the vital role in transforming the agricultural higher education to produce highly skilled human resource equipped with advance knowledge and capable of fulfilling the agricultural needs of the country. National Education Policy (NEP-2020) of India represents a comprehensive and ambitious vision for the future of education in the country. There is an urgent need to revise and align the agricultural education system in the country in line with NEP-2020 norms to build a competent human resource for undertaking education, research and extension activities at diversified, ecologically sustainable and economically viable agricultural and allied sectors with integration of technology and innovation.

The Indian Council of Agricultural Research (ICAR) has been at the forefront of promoting excellence in agricultural education, focusing on the development of a skilled workforce to meet the nation's growing agricultural demands. To ensure that agricultural education stays relevant, the ICAR has regularly revised curricula through various Deans' Committees, with five such committees already having updated the academic standards over the years. These revisions align the education system with both national and international standards ensuring students are prepared for the challenges of modern agriculture.

The Sixth Deans' Committee, constituted in the year 2021, has prudently with congruence of excellence and relevance revised the undergraduate course curriculum, course contents, degree nomenclature including entry-exit options recommending the reforms in admission including lateral entry options and examinations. The committee had updated the course curriculum as per the guidelines of NEP-2020 focussing skill enhancement with integration of digital learning to align with the evolving global requirements and the advent of new technologies with focus on better employability, flexibility in movement from one institution to another, multiple entry and exit options, choice-based credit system. Experiential learning and entrepreneurship development programs have been included for training student in real work situations to develop them as future entrepreneurs. Academic Bank of Credits (ABC) introduced to facilitate

movement from one institution to another with credit transfer. Innovative teaching approaches such as online, open distance learning (ODL) and blended learning have been emphasized to merge traditional and non-traditional educational methods. The continuous updating of course curricula based on recent technological advancements ensures that students remain at the cutting edge of agricultural knowledge.

The Council expresses gratitude to Dr. Tej Partap, Chairman of the Sixth Deans' Committee, for his leadership, as well as to the committee members for their efforts in aligning agricultural education with NEP-2020 and global trends. I appreciate the efforts of Dr. R. C. Agrawal, Deputy Director General (Education) and all the committee members to align, update and contextualise the academic pursuits with NEP-2020 guidelines and to prepare this valuable report. Dr Ajit Singh Yadav, ADG (EQAR & Member Secretary, Sixth Deans' Committee) has rendered untiring efforts in arranging meetings and facilitating the course of deliberations, drafting and compilation of report.

The ICAR shall strive to implement all the recommendations of the report. I hope it will help to achieve our mission to make agricultural education more accessible, affordable, relevant, practical and professional pursuing national and international quality education standards.



**(Himanshu Pathak)**

Dated: 10 September, 2024  
New Delhi

# Overview of 6<sup>th</sup> Deans Committee Report

Indian Council of Agricultural Research (ICAR) under the Department of Agricultural Research and Education Government of India, is tasked with the responsibility to aid, impart and coordinate agricultural education to develop high-quality human resources in the country. The National Education Policy-2020 (NEP-2020) presents an opportunity for substantial reforms in the education system, including higher agricultural education. Soon after the announcement of the NEP-2020, ICAR formulated a committee and developed the guidelines “Implementation strategy for National Education Policy-2020 in Agricultural Education system” during September, 2021. Accordingly, all the Agricultural Universities (AUs) started implementing various provision of NEP-2020 in their respective AUs. Following the committee’s recommendations, the Sixth Deans’ Committee was constituted on August 17, 2021 (orders issued on Sep 15, 2021 vide notification *F. No. Edn.5/24/202/EQR/VI Deans*). The 6<sup>th</sup> Deans’ Committee was mandated to revamp the course curriculum, credit framework, and academic standards for agricultural education. This initiative aims to standardize uniform academic structures across the country both in public and private institutions offering undergraduate (UG) programs in agriculture and allied sciences.

To formulate the guidelines, course curriculum & credit framework, and other aspects series of meetings and consultations (both off line and online) of committee were held and all aspects were discussed in detail taking into consideration of NEP-2020 provisions. The member of the committee consulted the subject specific experts by holding off line and online meeting. A meeting was also organized with CEO, Agriculture Skill council of India on modalities of integration of vocational courses in the general agriculture education course framework. Further, a meeting with Chairman, UGC was also held to discuss the UG course curriculum of all agriculture and allied science disciplines as per the NEP-2020 and UGC guidelines. The general guidelines, course curriculum and credit framework was also presented in Vice-Chancellor’ Conference held at NASC, New Delhi and suggestions were incorporated in the report. The report was also presented in a meeting chaired by Secretary DARE & DG ICAR. All Deputy Director General (DDGs) & Assistant Director General (ADGs) of education suggested the changes which were incorporated. The report was also sent to all DDGs for their inputs and suggestions. The draft report was sent all Vice Chancellors of SAUs/CAUs/DUs/CUs with agriculture faculty for taking views/suggestions of faculty and students. In addition, views of foreign experts were also invited on the draft report. The final report on general guidelines, course curriculum, credit framework of all the UG disciplines was prepared in consultation with stakeholders.

Guided by the principles and philosophy of NEP-2020, the committee developed a comprehensive report outlining a restructured course curriculum and credit framework for 13 UG disciplines in agriculture and allied sciences and necessary provisions have been made in the curriculum to enable an individual to study report major and minor courses along with choice of electives. The 13 UG disciplines of which the course curriculum and credit framework was restructured includes Agriculture, Agricultural Engineering, Biotechnology, Dairy

Technology, Fisheries Science, Food Technology, Forestry, Community Science, Horticulture, Food Nutrition and Dietetics, Sericulture with inclusion of two new disciplines namely Natural Farming and Agribusiness Management.

Key features of the report include curriculum revision, modification of academic structure of degrees/diplomas/certificates, the introduction of an academic banking system (ABC), a multiple entry-and-exit system, flexible course selection, introduction of skill enhancement courses, making internship as part of UG-certificate, UG-diploma and degree requirements, and the incorporation of industry-oriented internships as part of UG requirements. A course entitled “*Deeksharambh*” has been introduced in the first semester for a duration of two weeks to acquaint students to learn from each other’s life experiences, traditional values and traditional cultures and values. Common courses have been proposed developing better communication skills and personality development as well as to have a broader view of agriculture and allied sectors. New age courses like artificial intelligence, robotics, machine learning, etc. have been incorporated into the course curricula for preparing student in the era of Digital Technology. Progressive assessment of the student/s is part of course curriculum and the focus is enhancing their critical thinking and creativity rather than rote reading.

During this comprehensive exercise of restructuring the course curriculum and credit framework, the much-needed support, inputs and participation rendered by Hon’ble Vice-Chancellors of SAUs/CAUs/DUs/ CUs with Agriculture Faculty is greatly acknowledged. The support and help extended by all Deputy Director Generals is much appreciated.

I also take this opportunity to express a deep sense of gratitude to Dr Trilochan Mohapatra, Former Secretary, DARE and Director-General, ICAR for his initiatives, guidance and support. I feel extremely happy to take this opportunity to express my deep sense of gratitude to Dr Himanshu Pathak, Secretary DARE and DG, ICAR for reposing faith in the committee and also constantly providing visionary guidance, cordial support and valuable inputs which helped in completing this task through various stages.

I hope, the educational reforms as suggested by the Sixth Deans Committee shall lead to a complete overhaul, and re-energise the higher agricultural education system to overcome the challenges currently being faced in India and thereby, deliver high quality higher agricultural education with equity and inclusion with focus to make the agricultural graduates as global leaders equipped with skills of better employment.



**(R.C.Agrawal)**

Deputy Director General (Agricultural Education)

Dated: 10 September, 2024  
ICAR, New Delhi



# Preface

Enhancing quality of human resource is a pre-requisite for implementing and upgrading research programs, developing technologies, evolving institutional arrangements to face challenges and to harness opportunities in the global perspective. Moreover, in the agriculture and allied sectors, such aspects are still more important due to the rapid changes occurring in challenges as well as in technologies. There is an urgent need of adequate trained manpower, that is professionally competent, socially sensitive and ethically strong to -- provide the technical backstopping in the changing resource constraints scenario in terms of land and water availability, and sustain agricultural growth with challenges of climatic adversities.

The ICAR having the mandate of guiding, managing and coordinating agricultural education in the country has been working in this regard and the National Agricultural Research, Education and Extension (NAREE) system continues to strive for maintaining and upgrading the quality and relevance of higher agricultural education through the partnership with 76 Agricultural Universities (AUs) comprising State Agricultural Universities (SAUs), ICAR Deemed-to-be-Universities (ICAR DUs), Central Agricultural Universities (CAUs) and Central Universities (CUs) with Agriculture faculty. One such measure that Council has taken periodically is the constitution of Deans' Committee for revising the course curriculum and also to undertake reforms in agricultural education in line with national priority.

National Education Policy (NEP-2020) was launched by the Government of India for transforming India's education system, seeking reforms at school, college, and university levels to build a knowledge-driven society. The NEP-2020 clearly indicates the need for reviving agricultural education which must be aligned with NEP-2020 based on its five pillars, namely, Access, Equity, Quality, Affordability, and Accountability. The NEP-2020 calls for improvement in both the capacity and quality of agricultural education with the aim to develop good, thoughtful, well-rounded, and creative individuals. This policy also focuses on the study of one or more specialized areas of interest at a deep level, and also on developing character, ethical and constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and twenty-first century capabilities across a range of disciplines.

This report is the outcome of the Sixth Deans' committee, which was constituted by the Council to restructure course curricula of the UG programs and to align these with the NEP-2020 adopting a bottom-up approach involving all stakeholders. The Committee considered the academic aspects needed to be incorporated for the transformation of agricultural education system so as to prepare the youth to take up the challenges and opportunities in this vital and vibrant field. The main responsibility of the committee was the articulation of the knowledge and skills needed among the graduates and reform the course curricula for technological integration-based innovations for enhancing their skills, entrepreneurship, employment potentials, thus transforming them from job-seekers to job- providers.

The report is in two parts. The PART-I comprises general recommendations on curriculum and credits as well as other guidelines on admissions, evaluations, etc., that is applicable to all disciplines and institutions involved in imparting higher agricultural education. The PART-II comprises discipline-wise recommended course curricula of undergraduate programs for thirteen ICAR approved disciplines. As per the provisions of NEP-2020, there are options for multiple entry and exit. Provision has been made for exit after the 1st year for award of UG-Certificate and after 2nd year for award of UG-Diploma after completion of internships at each level. Similarly, entry options for UG-Certificate and UG-Diploma holders have been made in 3<sup>rd</sup> and 5<sup>th</sup> semesters, respectively. Choice based skill enhancement courses have been integrated in the course programs. The restructured undergraduate curricula are designed to enable the students to take up entrepreneurship as a career path through several modes of skill development programs as in-plant training, internship, projects and rural agricultural work experience, etc.

Common courses of multi-disciplinary, value-added, and ability enhancement categories as per NEP-2020 guidelines have been recommended for all the disciplines to enhance the communication skills and development of personality of students and to prepare them for collaboration with other sectors to face the next generation challenges from a holistic point of view. Due emphasis has been given for imbibing the traditional knowledge, values and ethics among the students through different courses like the Deeksharambh, NCC, NSS and focus has also been given on health and wellness.

The students will also take online courses, which will be choice based, to groom their passion or strengthen their knowledge and competency in any field beyond the prescribed courses. There are provisions for elective courses, which will also be choice based and the institutions will also have the liberty to develop new elective courses as per local needs and available expertise. As per NEP-2020 guideline, introduction of Academic Bank of Credits (ABC) for the students will be in practice, which can facilitate institutional transfer of students. New age courses like artificial intelligence, robotics, machine learning, nanobiotechnology, renewable energy, information technology etc. have been duly internalized in course curricula.

The committee is grateful to Dr Himanshu Pathak, Secretary DARE and Director General, ICAR; Dr Trilochan Mohapatra, former Secretary DARE & DG, ICAR for reposing faith in the Committee and giving opportunity and providing guidance in restructuring the course contents and also for giving their valuable inputs for updating the curricula as per the need of agriculture and allied sectors to face challenges at global level.

The Committee is highly beholden to Dr R.C. Agrawal, DDG (Agril. Edn.), ICAR for his valued inputs, guidance and constant support. The Committee also puts on record its gratitude to all Deputy Director Generals, ICAR; Vice Chancellors; Deans and other stakeholders for their constant guidance and support, which were critical in shaping this document and completing this important task. The committee also gratefully acknowledges the contributions of Dr Bimlesh Maan, ADG (EP&HS); Dr Seema Jaggi, ADG (HRD); Dr Vanita Jain, Dr Smita Sirohi, Dr K.P. Tripathi, Principal Scientists of Education Division, ICAR. The contribution of Subject Matter Specialists as members and special invitees of the Deans' Committee, is gratefully acknowledged.

We also take this opportunity to thank and acknowledge the contributions of Sixth Deans Committee members, namely, Dr Shanti K. Sharma ADG (HRM) (Natural Framing); Dr Sanjaya K Dash (Agril Engineering); Dr Jayant Deka (Agriculture); Dr R R B Singh (Dairy Technology); Dr R F Sutar (Food Technology); Dr Reeta Raghuvanshi (Food Nutrition and Dietetics); Dr Meenu Shrivastava (Community Science); Dr K T Parthiban (Forestry); Dr M I S Gill (Horticulture); Dr S Chandrasekhar (Sericulture); Dr Ramesh Bhat (Biotechnology); Dr V R Kiresur (ABM) and Dr B K Das (Fisheries Science) for their important role in this strenuous task.

The report is expected to stimulate policy innovations and also institutional reforms in academics paving way in building students for more meaningful and satisfying lives and work roles and enabling economic independence of learners capable of global competence. We are confident the guidelines and curriculum in this report would encourage higher agricultural education institutions to shape new generation youth in agriculture and allied fields and motivate all stakeholders, educationists to policy makers in contributing in fulfilling the aspiration of NEW INDIA.



**(Ajit Singh Yadav)**  
Member Secretary  
(6<sup>th</sup> Deans' Committee)



**(Tej Partap)**  
Chairman  
(6<sup>th</sup> Deans' Committee)



# ICAR-SIXTH DEANS' COMMITTEE

## Task Accomplishment Certificate

The 6<sup>th</sup> Deans Committee was set up by ICAR, on the recommendations of the ICAR Expert Committee on Implementation Strategy for executing National Education Policy (NEP-2020) across the 13 disciplines that fall under Agriculture and Allied Disciplines of Agricultural Education system. Under National Education Policy (NEP-2020) regime, ICAR as Professional Standards Setting Body (PSSB) for Agricultural Education in the country, has the primary task of prescribing the course curricula and credit framework that will govern agricultural education in the country. Therefore, as a step towards implementing NEP-2020, ICAR constituted 6<sup>th</sup> Deans' Committee with a specific mandate of restructuring course curricula and regulations for the degree programs in operation under agricultural education in the country.

The committee members, comprising the Chairman and Deans, representing each academic program, as expert members, held several deliberations and prepared a framework of the restructured academic system, defining credit hours, focus of semesters, integration of skill development opportunities and system of specialization within the degree programs and other provisions of NEP-2020, which will be common to all programs. Thereafter, each Member-Dean, worked with experts within their respective disciplines working across universities/institutions to restructure the course curricula as per NEP-NHEQF, that was considered paramount imperative. Draft notes were circulated among the members and academic experts for their suggestions. Committee also received inputs from ICAR, foreign experts, Vice Chancellors, DDGs and other stakeholders through the office of Deputy Director General-Agricultural Education. Report of the 6<sup>th</sup> Deans Committee is an outcome of these efforts.

This NEP-NHEQF guided restructuring of Undergraduate Programs of Agricultural Science, is expected to help build strong foundation of both knowledge and skills. More emphasis has been given to Skill training and flexibility in choice of courses to adopt the choice-based credit system. It is our belief that the restructured academic programs will help produce new generation of human resources in agricultural domain/disciplines, which will be equipped to meet the needs of new knowledge and skills in agricultural sector.

The committee members draw satisfaction in accomplishing this task and are grateful to ICAR for reposing trust on them to undertake this onerous task, as well as to office of DDG (Agricultural Education) for coordinating the support services during the process. We thank all those academicians across the agricultural education landscape of the country, who were consulted, who offered new ideas, and those who offered constructive criticism. Down the years, we look forward to see the fruits of this work by way of transformed agricultural education system of the country.



(TEJ PARTAP)

Chairman, Sixth Deans' Committee, ICAR



# CONTENTS

<b>Topic</b>	<b>Pages</b>
<i>Foreword</i>	<i>iii</i>
<i>Overview of 6<sup>th</sup> Deans Committee Report</i>	<i>v</i>
<i>Preface</i>	<i>vii</i>
<i>ICAR-Sixth Deans Committee</i>	<i>xi</i>
1. Sixth Deans' Committee: Terms of Reference	1
2. Prologue	2
3. Executive Summary	4
4. Restructuring of undergraduate programs	9
5. Common Courses	23
6. UGC approved skill courses	37
<b>Syllabi of different disciplines</b>	<b>39</b>
Agriculture	41
Agricultural Engineering	129
Biotechnology	200
Dairy Technology	331
Fisheries Science	417
Food Technology	510
Forestry	594
Community Science	725
Horticulture	864
Food Nutrition and Dietetics	936
Sericulture	1036
Agribusiness Management	1150
Natural Farming	1237
Annexures	1327





# 1. Sixth Deans' Committee: Terms of Reference

## 1.1 Constitution of Committee for drafting the Implementation Strategy for Higher Agriculture Education

As a follow up to the National Education Policy-2020 (NEP 2020), ICAR, as Professional Standards Setting Body (PSSB) of agricultural education for the NEP-2020, set up a high-level committee comprising the Vice Chancellors of Agriculture Universities. It was asked to devise a strategy for implementing NEP-2020 in agricultural education. Besides several other recommendations, the high-level committee recommended the constitution of Sixth Deans' Committee for restructuring the course curricula, framed by the Fifth Deans' Committee. Universities have adopted the Fifth Deans Committee for implementation since 2016. The NEP-2020 required that this course curriculum is restructured to fit into the new academic regime.

## 1.2 Notification for Setting up the Sixth Deans' Committee

On the Recommendations of ICAR-NEP Implementation Strategy Committee, ICAR constituted the Sixth Deans' Committee on August 17, 2021 (orders issued on Sep 15, 2021) vide notification *F. No. Edn.5/24/2021/EQR/VI Deans*. The 6<sup>th</sup> Deans' Committee was mandated to restructure the existing course curricula so as to enable implementation of NEP- 2020 in agricultural education.

## 1.3 Terms of References of the 6<sup>th</sup> Deans' Committee

- i) Restructuring of all UG Programs, all UG programs to be restructured as per NEP-2020 and NHEQF.
- ii) Structure of first year UG Certificate Course, areas, end of course test and criteria for entry into second year Diploma course as per provisions of NEP-2020.
- iii) Admission Criteria for UG-Certificate and UG Diploma courses, in view of the multiple entry and exit system provision under NEP-2020.
- iv) Guidelines for Entrepreneurship of students.
- v) Guidelines on provision for increasing gross enrolment ratio (GER), progressively.
- vi) Defining UG and PG degrees for general market needs, as well as for specialist jobs and uniformity in UG and PG degree nomenclature.
- vii) Any other point related to NEP-2020.

# 2. Prologue

## 2.1 Aim of Restructuring Agricultural Education

Education is at the heart of both personal and community development; its mission is to enable each of us, without exception, to develop all our talents to the full and to realize our creative potential, including responsibility for our own lives and achievement of our personal aim. There is, therefore, every reason to place renewed emphasis on the moral and cultural dimensions, apart from what is taught presently, enabling each person to grasp the individuality of other people and to understand the world's progression towards an uncertain future.

The 21<sup>st</sup> century is showing all signs of providing unprecedented means for communication and for the circulation and storage of information. Therefore, it will impose on education two demands which at first sight may appear contradictory. Education must transmit, efficiently and on a massive scale, an increasing amount of constantly evolving knowledge and know-how adapted to a knowledge driven civilization, because this forms the basis of the skills of the future. At the same time, it must find and mark the reference points that will make it possible, on the one hand, for people not to be overwhelmed by the flow of information, invading the public and private domains and, on the other hand, to keep the development of individuals and communities as its end in view. Education must, as it were, simultaneously provide maps of a complex world in constant turmoil and the compass that will enable people to find their way in it.

In this view of the future, traditional responses to the demand for education that are essentially quantitatively, and knowledge based are no longer appropriate. It is not enough to supply each student with a store of knowledge to be drawn on from then on. Instead, everyone must be equipped to seize learning opportunities throughout life, both to broaden her or his knowledge, skills, and attitudes, and to adapt to a changing, complex and interdependent world.

## 2.2 Four Pillars of Education

The International Commission on Education in its report “Learning: The Treasure Within” (UNESCO, 1996) has defined “why and how” agenda for modifying education for 21<sup>st</sup> century, globally. It advocated inclusion of the concept of following four pillars of education if education is to succeed in

its task. NEP also has advocated similar perspective of future education system in India. Sixth Deans' Committee would like to lay stress on institutions to reorganize their existing academic system of agricultural education around these four fundamental types of learning. In a way these pillars must remain the pillars of knowledge, throughout a person's life.

1. *Learning to know* -- acquiring the instruments of understanding.
2. *Learning to do* -- to be able to act creatively on one's environment.
3. *Learning to live together* -- so as to participate and cooperate in all human activities.
4. *Learning to be* an essential progression which proceeds from the previous three.

These four paths of knowledge, all form a whole with many points of contact, intersection, and exchange among them.

### **2.3 Constitution of the report**

The report is in two parts. PART-I comprises General Report on curriculum and credits as well as other general guidelines on admissions, evaluations, etc., that is applicable to all disciplines, colleges, universities, institutions, who are involved in imparting higher agricultural education in any of the following ways in the country.

PART-II of the report comprises discipline-wise recommendations, on restructured course curricula of undergraduate degree programs, for 13 ICAR approved disciplines, as follows.

1. Agriculture
2. Agricultural Engineering
3. Biotechnology
4. Dairy Technology
5. Fisheries Science
6. Food Technology
7. Forestry
8. Community Science
9. Horticulture
10. Food Nutrition and Dietetics
11. Sericulture
12. Agribusiness Management
13. Natural Farming

# 3. Executive Summary

New Education Policy-2020 (NEP-2020) of India proposed many changes in the education system of India, including higher agriculture education system. A national level Committee was constituted by ICAR to develop an implementation strategy to comply with various provisions of National Education Policy (NEP-2020). ICAR constituted the Sixth Deans' Committee to restructure the existing course curricula so as to enable implementation of NEP-2020 in agricultural education. As per the NEP-2020 recommendations, the Sixth Deans' Committee has incorporated following several new initiatives in the proposed restructured UG curricula.

## 3.1 Classification of level of courses with targeted outcomes

The courses have been classified as per the level of teaching and also based on targeted outcome.

- The 1st year of the UG programme (NHEQF Level 4. 5) includes the Foundation courses, introductory courses and skills enhancement courses/training in the chosen area, ability enhancement courses. It is aimed that student/s will acquire the basic knowledge in respective disciplines and adequate skill in some selected areas, to enable them for employment/ entrepreneurship.
- The 2nd year (NHEQF Level 5) includes the basic core courses and additional skill enhancement in chosen areas/ courses. It is aimed that the student/s will acquire the higher level knowledge in respective disciplines and adequate skills in some selected areas, to enable them employment at middle level/ supervisory level or for entrepreneurship.
- The 3rd year includes the advanced core subjects and their practical applications with an objective that the student will have deeper understanding of the subjects and their major application areas.
- The 4th year (NHEQF Level 6) will have the specialization/ elective courses and advanced skill enhancement through project and internship. The student will acquire advanced knowledge and skill in different areas so as to meet the higher order requirements of the society and industry as well as other prospective employers. It will also enable the graduates to become a job provider rather than a job seeker through establishment of enterprises in concerned fields.

## 3.2 Multiple Entry and Exit

There is provision of multiple entry and exit at different levels. The student/s will have the option to exit after the 1<sup>st</sup> year. He/ she/ ze has to complete 10 weeks of internship (10 credits) after 1<sup>st</sup> year (2 semesters) to be eligible for award of UG-Certificate. The student has another option to exit after the 2<sup>nd</sup> year. The student has to complete another 10 weeks of internship (10 credits) after 2<sup>nd</sup> year (4 semesters) to be eligible for award of UG-Diploma.

After four years of study, the student will be awarded UG degree in concerned discipline. No exit after 3 years (6 semesters) is recommended considering the professional nature of the courses.

The lateral entry at 3<sup>rd</sup> semester will be for the candidates having UG-certificate or those who have completed Diploma (3 years course after 10<sup>th</sup>) in recognised HAEIs. The lateral entry in 5<sup>th</sup> semester will be for candidates who have completed UG-Diploma.

## 3.3 New courses for acquiring advanced knowledge and skill and for strengthening their cultural and ethical values and through choice based programs

### 3.3.1 *Deeksharambh (Induction—cum-foundation course)*

A course entitled “*Deeksharambh*” (0+2) (Non-gradual) will be offered at the start of first semester for a duration of two weeks. This will create a platform for students to learn from each other's life experiences, help for cultural Integration of students from different backgrounds, know about the operational framework of academic process in university, instilling life and social skills, social awareness, ethics and values, team work, leadership, creativity, etc. It will also help in identifying the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario. There will be sessions by alumni, business leaders, outstanding achievers in related fields, people with inspiring life experiences as well as the University academic and research managers.

### 3.3.2 Common courses

The following common courses have been proposed to be offered across the disciplines. This will enable the student for better communication skills and personality development as well as to have a broader view of agriculture and allied sectors, which will allow them for future collaboration with other sectors to face the next generation challenges from a holistic point of view.

- Farming based livelihood systems
- Entrepreneurship Development and Business Management
- Agriculture Marketing and Trade
- Communication Skills
- Personality Development
- Environmental Studies and Disaster Management
- Agricultural Informatics and Artificial Intelligence

In addition to these common courses and *Deeksharambh*, the courses such as Physical Education, First Aid, Yoga Practices, Meditation, NCC and NSS have also been made compulsory for students for better social awareness and health of the future generation.

### 3.3.3 New age courses

New age courses like artificial intelligence, robotics, machine learning, etc. have been incorporated into the course curricula. Besides an array of elective courses have been included so that the student can get deeper knowledge and understanding in the subject of his/her/ze interest. Due emphasis has been given to include the latest topics and subjects in both core and elective courses. Practical exercises and teaching methodology are proposed to make the young generation more imaginative, innovative, ingenious, creative and competent.

### 3.3.4 Online courses

The students will have to take a minimum of 10 credits of online courses, comprising one or more courses, as a partial requirement for the UG programme. The online courses can be from any field such as Basic Sciences, Humanities, Psychology, Anthropology, Economics, Engineering, Business Management, Languages including foreign language, Communication skills/ Music, etc. and can be taken from any online portal. The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses.

### 3.3.5 Elective courses

The institutions will offer a bouquet of Elective courses to be offered to the students. The students will have the freedom to choose a subject among these courses. The institutions should develop capabilities to offer maximum of the Elective courses proposed in this report. The institutions will also have the liberty to develop new Elective courses as per local needs and available expertise.

## 3.4 Imparting Traditional Knowledge, Values and Ethics

Due emphasis has been given for imbibing the traditional knowledge, values and ethics among the students through different courses like the *Deeksharambh*, NCC/ NSS. It is proposed that Study tours shall be conducted across the country to make the student aware about the socio-cultural-economic status of the people of the country and develop respect for their values and ethics.

## 3.5 Entrepreneurship development as a career path

The restructured undergraduate curricula are designed to enable the students to take up entrepreneurship as a career path. As per NEP- 2020, the curricula in all the disciplines of Agricultural education have been refined and fine-tuned with intensive focus on choice-based skill enhancement programs.

Skill enhancement courses are included in different modes as follows:

- Skill enhancement courses in the 1st year and 2nd year as part of the course programs;
- Internship for exit programs after 1st year/ 2nd year; and
- Advanced skill enhancement through Student READY programs such as in-plant training/ internship/ projects in 4th year.

The skills acquired must make the students proactive, pioneering, prospect oriented during their internship or industrial attachment to serve as apprentices in the relevant field. It will empower them to grasp viable avenues of self-employment and entrepreneurship along with diversified career options in different facets of related domains.

### **3.5.1 Skill Enhancement Courses**

Skill enhancement courses are essential requirements for any programme (UG-Certificate/ UG-Diploma or Degree). These will be choice based; student can choose the areas of skill enhancement from a bouquet of skill enhancement modules offered by the parent institution. The institutions will develop capabilities for offering such courses.

An institution is at liberty to (and in fact, it should) work in partnership with capable organizations/ companies/ NGOs/ progressive entrepreneurs/ farmers for running various skill enhancement programs.

The University/ HAEIs may also formulate and offer courses in any other areas as identified by it, based on institutional expertise/ capabilities/ resources. In addition, the skill enhancement courses suggested by the UGC, may also be offered.

### **3.5.2 Internship**

Those students who wish to exit with UG-certificate after one year, has to undergo 10 weeks of internship programme (10 credits) after 1<sup>st</sup> Year. Similarly, the students who wish to exit with UG-Diploma after 2<sup>nd</sup> year, has to undergo 10 weeks of internship programme (10 credits) after 2<sup>nd</sup> Year. The goal of Internship at exit for UG-Certificate and UG-Diploma is to further strengthen skills in the chosen area/ subject.

Internship should be preferably arranged outside of the parent institution at any assigned organization/ industry/ research institution/ project or with a progressive farmer/ agri enterprise, etc.

### **3.5.3 Projects**

For some disciplines, Projects have been kept as an integral part of the course programme. This will enable the students to develop required competencies and skill in either research or entrepreneurship or potential employment avenues rather than having only mere qualifications. They will be able to choose appropriate career in research or employment/ entrepreneurship, discover their interests, aptitudes and potentialities and maximise their potentialities and self-confidence. It will also add to creativity and critical thinking of the students.

## **3.6 Introduction of new degree programs**

Two new degree programs have been proposed in this report in two important areas.

1. Considering the natural strength of the country and future opportunities, a new UG course on Natural farming has been included. The syllabus is based on Bhartiya Prakartik Krishi Paddhati (BPKP) in India to enhance production, sustainability, saving of water, improvement in soil health and farmland ecosystem, and reducing the market inputs. These important aspects of natural farming are considered as cost-effective and suitable for livelihood of large number of farmers and sustainable rural development.
2. A new degree programme on Agribusiness Management has been included. These students are expected to acquire competency and confidence to start their own enterprise, as well as will have adequate competency for getting jobs.



### **3.7 Light but tight educational programme**

As per the norms of the NEP-2020, the programme has been made light but tight for the students. The total credit hours have been kept at 166 considering the specific need of the professional courses, however, in some of the disciplines, viz. Agril Engineering, Food Technology and Dairy Technology, the total credit hours ranged from 172 to 174. At the same time, the students have been given the option of the skill development courses, internship, online courses, etc., which will make their learning experience more pleasurable and learning efficient.

### **3.8 Progressive evaluation**

In the course programme, 20% has been kept for progressive assessment of the student within the semester in form of quizzes/ group assignments. The assessment of the students through quizzes should focus on their critical thinking and creativity rather than rote reading.

The quiz and progressive assessment can also be considered in the form of group assignments (which should encourage creativity, critical thinking and problem- solving attitude).

### **3.9 Academic Bank of Credit**

As per NEP-2020 guidelines, the HAEI will create an Academic Bank of Credits (ABC) of each student and recognise the ABC of a student as per the norms of the HAEI/ NEP-2020 recommendations.

### **3.10 Migration of students from one institution to other**

It has been proposed for inter-institutional transfer of students with accumulation of the ABC. The University/ HAEI may admit students either by holding its own admission test or use merit as criteria or by following any of the existing norms of both transferring and accepting Universities/HAEIs. The migration shall be subject to availability of seats at the accepting HAEI. It is recommended to make institutional migration after 4<sup>th</sup> semester. HAEIs are at liberty to put in place rules/ regulations relaxing/ modifying existing provisions of migration, providing more freedom and ease to students.

### **3.11 Minimum requirement for establishing colleges for agriculture and allied disciplines**

The minimum requirements for establishing colleges for 13 agriculture and allied sciences disciplines shall be as per the ICAR Model Act-2023 and various guidelines and orders being issued by ICAR from time to time.

### **3.12 Making implementation of the recommendations of the Deans' Committee mandatory**

Efforts have been made to improve the quality of agricultural education to make it internationally competitive. Implementation of the recommendations of the Sixth Deans' Committee to be made mandatory for accreditation of academic programs and academic institutions by the National Agricultural Education Accreditation Board (NAEAB) of ICAR.



# 4. Restructuring of Undergraduate Programmes

## 4.1 Restructuring of UG Programs

The restructuring has been done based on the following NHEQF levels:

- Year 1, Certificate Course, NEP-NHEQF Level 4.5
- Year-2, Diploma Course, NEP-NHEQF Level 5.0
- Year 4, B.Sc. (Hons.)/ B. F. Sc. (Hons.)/ B. Tech. NEP-NHEQF Level 6.0

The restructured program for the undergraduate agriculture education with multiple entry and exit options is illustrated in Figure 4.1.

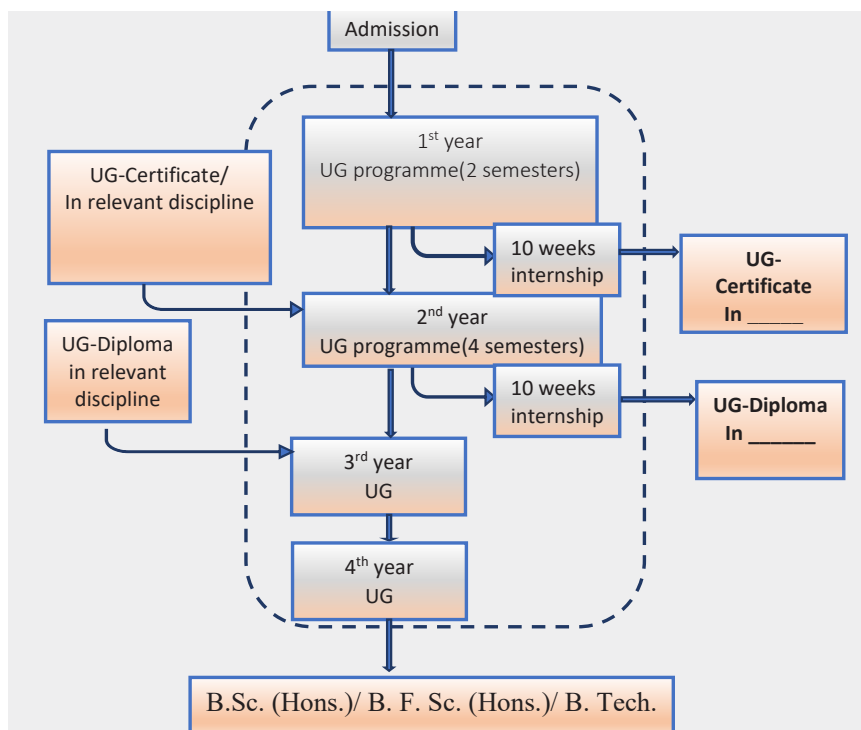


Fig. 4.1 Framework of Undergraduate Programmes

The eligibility for entry into the UG programs will be + 2 Science; the students will be admitted as per norms of ICAR/ SAUs/CAUs. The 1st year of the programme will be having the foundation, introductory and skill enhancement courses. The 2nd year will be having basic core courses with

some more options for skill enhancement. The 3rd year of the programme will have advanced core courses. The 4th year programme will emphasize more on the specialisation and elective courses as well as advanced skill enhancement through internship.

There will be exit options after 1st year and 2nd year for UG-Certificate and UG-Diploma. However, the students opting to exit with UG-Certificate or UG-Diploma will have to take up 10 weeks internship after the 1st year (2 semester) and 2nd year (4 semesters), respectively.

Table 4.1 shows the restructured undergraduate programs for the higher agricultural educational institutions (HAEIs).

**Table 4.1 Types of courses and learning outcomes for the restructured undergraduate programs for the HAEIs**

Year	Types of courses	Learning outcome	Exit option
YEAR 1 NHEQF Level 4.5	Foundation courses, introductory courses and skills enhancement training/ training in the chosen area, ability enhancement courses	Students will acquire the basic knowledge in respective disciplines and adequate skill in some selected areas, to enable them for employment/ entrepreneurship	A student must complete 10 weeks of internship (10 credits) after 1st year if exit with UG-Certificate is opted
YEAR-2 NHEQF Level 5	Basic core courses and additional skill enhancement in chosen areas/ courses	Students will acquire the higher level knowledge in respective disciplines and adequate skill in some selected areas, to enable them for employment at middle level/ supervisory level or for entrepreneurship	A student must complete 10 weeks of internship (10 credits) after 2nd year if exit with UG-Diploma is opted
YEAR-3	Advanced core subjects and their practical applications	Students will have deeper understanding of the subjects and their major application areas	No exit after 3rd year
YEAR-4 NHEQF Level 6	Specialization/ Elective courses and advanced skill enhancement through project and internship	Students will acquire advanced knowledge and skill in different areas so as to meet the higher order requirements of the society and industry as well as other prospective employers. It will also enable the graduates to become a job provider rather than being a job seeker through establishment of enterprises in concerned fields.	UG degree in concerned discipline

## 4.2 Credit Hours Allocation

A total of 166-174 credit hours is recommended for the four years of UG programs. The credit distributions for the different courses have been specified for individual disciplines. The general structure is given in Table 4.2.

**Table 4.2 General Credits Allocation Scheme of UG Programs (Credit hours)**

Semester	Core Courses (Major+ Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non-Gradial	Online Courses/ MOOC
I	12	3(2)		1(3) + 2(4)	4	-	22	2(1)	10
II	10	3(5)	3(6)	1(3) + 2(7)	4	-	23	-	
Post-II semester						10(12)			
III	16	----		2(8)	2	-	20		
IV	12	3(9)	3 (10)	----	2	-	20	-	
Post-IV semester						10(13)			
V	21	-	-	-	-	-	21	2(11)	
VI	21	-	-	-	-	-	21	-	
VII	20	-	-	-	-	-	20	-	
VIII	-	-	-	-	-	20	20	-	
Total	112	9	6	8	12	20	167	4	10

- (1) Deeksharambh (Induction-cum-Foundation Course) of 2 credits (2 weeks duration).
- (2) Farming based Livelihood systems
- (3) NCC/NSS; (4) Communication Skills; (5) Entrepreneurship Development and Business Management
- (6) Environmental Studies and Disaster Management;
- (7) Personality Development; (8) Physical Education, First Aid, Yoga Practices and Meditation.
- (9) Agriculture Marketing and Trade; (10) Agriculture Informatics and Artificial Intelligence
- (11) Study tour (10-14 days).
- (12) Only for those opting for an exit with UG-Certificate. (13) Only for those opting for an exit with UG-Diploma

One multidisciplinary course in Agricultural Engineering discipline is different from the above common courses keeping in view the discipline specific requirement.

Note:

- The credit hours mentioned in the Table 4.2 include both theory and practical.
- The total credit allocation and the allocation for different types of courses including online courses for some disciplines such as Agricultural Engineering, Dairy Technology and Food Technology are slightly different than those mentioned in the Table 4.2, so as to accommodate the specific need of these disciplines.
- Also, some minor deviations in the courses and credits allocations are allowed across disciplines considering the specific nature of the courses.
- The three-year course curricula of all disciplines of agricultural and allied sciences do not cover the teaching of elective/ specialized courses, that in fact qualify the students in specializing in

a particular subject in which the student intends to do further studies. These courses have been presently listed under the 7th and 8th semesters (in IV year). Therefore, the Sixth Deans' Committee is of the view that the option of B. Sc. (Hons.) with research may lead to deficiency of the knowledge and learning of the elective / specialized subjects needed for PG studies. For B. Tech. programs, the framework prescribed by AICTE/ UGC may be applicable. Under such circumstances, the Committee recommends that the launching of UG degree with research should be deferred for the time being. ICAR may consider about this aspect along with considering restructuring PG/ Ph.D. programs. Also considering the professional nature of the courses, the exit after at the end of 3rd year (at the end of 6th semester) is not recommended.

- Each class (contact hour) will be of 50 min duration and one practical will be of two contact hours.
- If the student has to take up any deficiency course(s), that has to be satisfactorily completed within the first year.

### 4.3 *Deeksharambh (Introduction- cum-foundation course)*

The goal of higher education is to nurture students by blossoming their hidden potentials to pursue the academic and professional studies in a diligent, honest and responsible manner. It is possible by facilitating them to develop a sense of integrity with diverse faculties and build linkages with peers, society and community as a whole and lastly be proficient in earning livelihood independently along with sustaining society and nature.

A course entitled Deeksharambh (0+2) (Non-gradual) will be offered at the start of first semester for a duration of two weeks. This will be a part of first semester for all purposes including the calculation of Net Instruction Days (NIDs).

The goal of Deeksharambh is to inculcate life skills, develop bonding with mentors, peers and seniors, familiarize with institutional academic framework and functioning, It must educate students to explore their potentials and understand the purpose of their life with reference to serving the community, nation and global society.

Often the incoming undergraduate students are influenced by their parents and relatives to join higher studies, without understanding their own interests and talents. Therefore, the very purpose of initiating Deeksharambh: the induction cum foundation course is to acclimatize the student with the new surroundings, develop bond with fellow students and teachers. It is the time when a student should become clear as to what he/she/ze is going to study in a particular discipline, or even it is time to quit and join another discipline of his/ her choice. They must develop sensitivity towards various issues of social relevance and imbibe human values to become responsible citizens.

Thus, ensuring a well-designed Induction-cum-foundation program by the institutions shall be designed to become helpful to both teachers and students for setting the pace of productive teaching and learning experiences.

#### Four Pillars of Deeksharambh

Socializing: Meeting new students, senior students, attend lectures by Eminent People.

Associating: Visits to university / college, visits to Dept./Branch/ Program of study and important places on campus, local area, city and so on.

Acclimatizing with rules and regulations, student support system, etc.

Experiencing: Subject lectures, study skills, small-group activities, physical activity, creative and performing arts, literary activities, universal human values, etc.

Deeksharambh will create a platform for students to:

- learn from each other's life experiences,
- help for cultural integration of students from different backgrounds,
- know about the operational framework of academic process in university,
- instilling life and social skills,
- social awareness, ethics and values, team work, leadership, creativity, etc., and
- identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

There will be sessions by alumni, business leaders, outstanding achievers in related fields, people with inspiring life experiences as well as the University academic and research managers.

Steps will be taken by the institutions to identify the strength and weakness of students (with remedial measures) and diverse potentialities and to enhance cultural Integration of students from different backgrounds.

#### 4.4 Common courses

The following common courses have been proposed to be offered across the disciplines, which in addition to giving the students a broader view of agriculture and allied sectors, will enable them for better communication skills and personality development. Besides, this will also help them to -- look beyond the boundaries of their own subject/ discipline, and collaborate in future with other sectors to face the next generation challenges from a holistic point of view.

- Farming based livelihood systems
- Entrepreneurship Development and Business Management
- Agriculture Marketing and Trade
- Communication Skills
- Personality Development
- Environmental Studies and Disaster Management
- Agricultural Informatics and artificial Intelligence

In addition to these common courses and Deeksharambh, the courses as Physical Education, First Aid, Yoga Practices and Meditation, NCC and NSS have also been made compulsory for students for improving social awareness, ethics, moral values and health of the future generation.

#### 4.5 New age courses

Courses like artificial intelligence, robotics, machine learning, etc. have been incorporated into the course curricula. Besides an array of elective courses have been included so that the student can get deeper knowledge and understanding in the subject of his interest. Emphasis has also been given to include the latest topics and subjects in both core and elective courses. Practical exercises

and pedagogy are proposed to make the next generation more imaginative, innovative, ingenious, creative and competent.

#### **4.6 Deficiency courses**

If the student has to take up any deficiency course(s), it has to be completed within the first year.

#### **4.7 Entrepreneurship development**

Entrepreneurship is a key driver of the economy of a nation, which has been encouraged through NEP-2020. Expectation is that an early orientation of the young minds towards skill enhancement and entrepreneurship will inculcate entrepreneurial mind set, allowing them to have first-hand experience of working with institutions, organizations, companies, industrial setup and investors so as to understand their dynamics in the real-world setting.

The restructured undergraduate curricula are designed to enable the students to take up entrepreneurship as a career path. As per NEP-2020, the curricula in all the disciplines of Agricultural education have been refined and fine-tuned with intensive focus on choice-based skill enhancement programs.

- Skill enhancement courses are included in following different modes:
- skill enhancement courses in the 1st year and 2nd year as part of the course programs;
- internship for exit programs after 1st year/ 2nd year; and
- advanced skill enhancement through Student READY: Experiential Learning/Hands on Training/Skill development/ RAWE/ Industrial attachment/IPT/ student project and Internship etc. in 4th year.

Internship can be seen as a mini capsule of intense learning for a student, a way to apply the theory into practice, expand their knowledge base and a platform to integrate all learnings of formal classroom setup.

Addition of new age courses related to Agriculture, Forestry, Fisheries, Agricultural Engineering, Community Science, Food Nutrition and Dietetics, etc., and incorporation of choice based online courses, which can be taken up from NPTEL, moo KIT, edX, Coursera, SWAYAM or any other portal in open digital learning environment. Practical exercises and teaching methodology are so designed to make the young generation more imaginative, innovative, ingenious, creative and competent.

The skill set acquired must make them proactive, pioneering, prospect oriented during their internship or industrial attachment to serve as apprentices in the relevant field. This will empower them to grasp viable avenues of self-employment and entrepreneurship along with diversified career options in different facets of related domains.

##### **4.7.1 Skill Enhancement Courses**

The skill enhancement programs will be choice based; student can choose the areas of skill enhancement from a bouquet of skill enhancement modules offered by the parent institution. The institutions will develop capabilities for offering such courses.

An institution is at liberty to (and in fact, it should) work in partnership with capable organizations/ companies/ NGOs/ progressive entrepreneurs/ farmers for running various skill enhancement programs.

In the report, for each discipline the list of Skill Enhancement Courses (SEC) has been suggested. The University/ HAEIs may also formulate and offer courses in any other areas as identified by it, based on institutional expertise/ capabilities/ resources. In addition, the skill enhancement courses suggested by the UGC, as listed, may also be offered.

The evaluation of the skill enhancement programs will be as per the evaluation criteria of courses with only practical. However, for the internship programs, the evaluation will be done jointly by the host and parent organisations/ institutions.

#### **4.7.2 Internship**

The internship proposed under NEP-2020 have been an integral part of agricultural education (as proposed by Fifth Deans' Committee) under the broad category of Student READY programs. It includes various activities such as Experiential Learning/ Hands-on Training, Skill Development Training, Rural Agriculture Work Experience (RAWEX), In-Plant Training/ Industrial Attachment and Students' Projects. Therefore, in the recommended structure, the student READY is further strengthened as per NEP-2020 guidelines.

Those students who wish to exit with UG-certificate after one year, has to undergo 10 weeks of internship programme (10 credits) after 1st Year. Similarly, the students who wish to exit with UG-Diploma after second year, has to undergo 10 weeks of internship programme (10 credits) after 2nd Year. The goal of Internship at exit for UG-Certificate and UG-Diploma is to further strengthen skills in the chosen area/ subject.

Internship should be preferably arranged outside of the parent institution at any assigned organization/ industry/ research institution/ project or with a progressive farmer/ agri enterprise, etc.

HAEIs will ensure that the Internship program is aligned with the course that the student has chosen. It is recommended that each HAEI appoints one or more Coordinators for the internship programs. The coordinator must plan/execute/ monitor internship programme implementation at the institution level.

#### **4.7.3 Projects**

For some disciplines, projects have been kept as an integral part of the course programme. This will enable the students to develop required competencies and skill in either research or entrepreneurship or potential employment avenues rather than having only mere qualifications, choose appropriate career in research or employment/ entrepreneurship, discover their interests, aptitudes and potentialities and maximise his/ her/ze potentialities and self-confidence. It will also add to creativity and critical thinking of the students. This will also help the students gain research skills and be more innovative in planning, executing, reporting and presenting the things.

### **4.8 Study tour**

There will be a study tour of 10-14 days' duration during the 5th semester of the UG programme. The students will preferably visit the leading industries/ enterprises/ institutions/ organisations and



other places of academic interest outside the state (of location of the institution). This, in addition to exposing the students to the indigenous as well as the latest technologies in their related fields, will also help the students to know about the socio-economic-cultural variations within the country. The course will be of 0+2 credits, non-gradual.

#### **4.9 Online courses**

The students will have to take a minimum of 10 credits of online courses, which will comprise of one or more courses, as a partial requirement for the UG programme.

(As per UGC guideline, a 1- to 3- credit SWAYAM course is expected to be covered in 4-12 weeks' duration including the assessment component, in which it should be 40 hours for 3- credit courses to 80 hours for a 6-credit course for the learning from e-content, reading references material, discussion forum posting and assignment.)

*The online courses can be from any field such as Basic Sciences, Humanities, Psychology, Anthropology, Economics, Engineering, Business Management, Languages including foreign language, Communication skills/ Music, etc., and can be taken from NPTEL, mooKIT, edX, Coursera, SWAYAM or any other portal.*

The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses.

The courses will be non-gradual as separate certificates would be issued by institutes offering the courses. These can be taken any time during the duration of UG program, but preferably during the 3rd and 4th years.

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.

The requirement of credits for online courses for B. Tech. programs is different due to the specific need of the disciplines.

#### **4.10 Elective courses**

The institutions will offer a bouquet of Elective courses to be offered to the students. The students will have the freedom to choose a subject among these courses. The institutions should develop capabilities to offer maximum of the Elective courses proposed in this report. The institutions will also have the liberty to develop and offer more Elective courses relevant to the subject as per local/ regional needs and available expertise. The elective courses can be offered from other disciplines in a Universality/HAEL.

#### **4.11 Imparting Traditional Knowledge, Values and Ethics**

Due emphasis has been given for imbibing the traditional knowledge, values and ethics among the students through different courses like the Deeksharambh, NCC and NSS. It is proposed the Study tour shall be conducted across the country to be aware about the socio-cultural-economic status of the people of the country and develop respect for their values and ethics.



#### 4.12 Introduction of new degree programs

Two new degree programs have been proposed in this report in two important areas.

Considering the natural strength of the country and future opportunities, a new UG course on Natural farming has been included. The syllabus is based on Bhartiya Prakartik Krishi Paddhati (BPKP) in India to enhance production, sustainability, saving of water, improvement in soil health and farmland ecosystem and reducing the market inputs. These important aspects of natural farming are considered as cost- effective and suitable for livelihood of large number of farmers and sustainable rural development.

A new degree programme on Agribusiness Management has been included. These students are expected to acquire competency and confidence to start their own enterprise, as well as will have adequate competency for getting jobs.

#### 4.13 Light but tight educational programme

As per the norms of the NEP-2020, the programme has been made light but tight for the students. The total credit hours vary from 166-174 considering the specific need of the professional courses. At the same time, the students have been given the option of the skill development courses, internship, online courses, etc., which will make their learning experience pleasurable and learning more efficient.

#### 4.14 Moderation of courses at institution level

The following flexibility is allowed to the institutions for offering the courses:

- A. Maximum 30% modification in the syllabus for any individual subject. It is recommended the HAEI should consider updating the course curricula around 5% every year. That would enable addition of new contents replacing obsolete/ old contents in the courses.
- B. Formulation /addition/ change of Skill Enhancement modules as per needs/ facilities available.
- C. Interchange of courses in between semesters within a year (but no change of course shall be normally allowed in between years).
- D. Change of maximum two core courses (If any course is removed from the list of core course, it should be kept as elective), However, the total credit hours should not be lower than the prescribed.
- E. Inclusion of any number of courses as Electives and freedom to offer the Elective courses.
- F. Modification/ change of credit hours for any four courses (however, total credit hours should not differ by more than four).
- G. In case the skill enhancement/ internship programs are conducted in collaboration with industry/ other organizations/ agencies, students may be expected to remain out of the campus for a certain period within the semester. In that situation, the timetable should be so adjusted for the remaining part of the net instruction days (NIDs) of the corresponding semester, that each credit has at least 15 contact hours.

#### 4.15 Central Assistance for strengthening higher agricultural education

The central Assistance for strengthening higher agricultural education, as proposed by the Fifth Deans' Committee, may be continued.

#### 4.16 Admission Criteria

The eligibility and mode of admission for entry into the UG programs will be as per the prevailing ICAR/ SAU norms.

Agricultural universities/ colleges and other general universities offering agricultural disciplines, will fall under the umbrella of ICAR, as PSSB for agricultural education, as mandated by NEP-2020.

Institutions are at liberty to assess their student intake capacity, and announce the number of seats available in the first semester, and for lateral entries at 3rd semester and 5th semester.

The lateral entry at 3rd semester will be for the candidates having UG-certificate or those who have completed Diploma (3 years course after 10th) in recognised institutions. The lateral entry in 5th semester will be for candidates who have completed UG-Diploma.

There cannot be guarantee for migration to another HAEI. Institutions are at liberty to make their own decisions/ norms/guidelines on the matter of seats and admissions in 3rd and 5th semesters.

#### 4.17 Provision of lateral entry for Diploma holders from recognised institutions

Candidates having a Diploma from polytechnics (after completion of 3 years course after 10th in related disciplines) will be entitled to take admission in the 2nd year (3rd semester) program. The HAEI may admit students either by holding its own admission test or use merit as criteria for by following any of the existing norms of the University/HAEI.

#### 4.18 Migration from one University to other

The UG-Certificate/ UG-Diploma passed candidate from a HAEI will be eligible for admission into any agricultural university/institution in the country at appropriate level, provided the admitting university has provision of seats to admit them.

It is recommended to make institutional migration after 4th semester more convenient. HAEIs are at liberty to put in place rules/ regulations relaxing/ modifying existing provisions of migration, providing more freedom and ease to students. The migration shall be subject to availability of seats at the accepting HAEI.

Provided further, any such rule/ regulation that is notified by UGC regarding changes in admission criteria, migration, etc., these notifications will be considered/ examined by ICAR and re-notified to make them applicable to agricultural education falling under its domain.

#### 4.19 Exit Option

There will be three exits during the restructured UG programme.

Exit after 1st year: A student may opt to exit after the 1st year of UG programme. However, he/ she/ze has to complete 10 weeks of internship (10 credits) to be eligible for being awarded UG-Certificate degree. (The students going to the higher level need not take 10 weeks internship at this stage.)

Exit after 2nd year: A student may opt to exit after the 2nd year of UG programme. However, he/ she/ze has to complete 10 weeks of internship (10 credits) to be eligible for being awarded UG-

Certificate degree. (The students going to the higher level need not take 10 weeks internship at this stage.)

Exit after 4-years programme leading to B.Sc. (Hons.)/ B.F.Sc. (Hons.)/ B. Tech. degree.

#### 4.20 Maximum residential period

Students who exit with a UG- Certificate or UG- Diploma are permitted to re-enter within three academic years and complete the degree programme.

Students may be permitted to take a break from the study during the period of study but the total duration for completing the programme shall not exceed 7 years.

#### 4.21 Examination and Evaluation system

There will be a uniform system of the evaluation and grading to be followed with Grade point average (GPA) system. The following pattern of examination is recommended.

**Table 4.3 Evaluation system**

	External theory	Internal theory (Mid-term)	Quiz/ progressive assessment	Final Practical
For courses having both theory and practical components	40%	20%	20%	20%
For courses with theory only	50%	30%	20%	-
Courses with practical only	-	30%	20%	50% (Internal)

For the external theory examinations, the question paper will be obtained from external experts. The HoDs of the respective departments will ensure due coverage of the syllabus with the provision of moderation, if necessary. Paper evaluation to be done by a faculty other than the course instructor(s).

The external theory examinations should be of 2 to 2.5 hours' duration and the mid-term examinations should be normally of 1-hour duration. The format of assessment and duration of quizzes/ progressive assessment duration will depend upon the course teacher.

Internal practical examination to be conducted by the course instructor and one faculty nominated by the HoD of the concerned department.

The evaluation of the skill enhancement courses will be done as courses with practical only.

Usually for any subject, there will be two quizzes within the semester, one before the mid-term and one after. There will be provision of corrections in between, i.e. the students scoring lower than 50% marks in any one quiz can opt for appearing for a third quiz to improve their grades. The assessment of the students through quizzes should focus on their critical thinking and creativity rather than rote reading.

The quiz and progressive assessment can also be considered in form of group assignments (which should encourage creativity, critical thinking and problem-solving attitude).

The evaluation of internship will be done both by the parent institute and the host industry/ organisation. It should be 50% weightage for each. The student shall submit a report to the parent

institute and present the learnings before the other students and faculty after the internship programme. The format of evaluation may be developed by the parent institute.

The online/MOOC courses, successfully completed by the student, will be indicated in the transcript with 'Satisfactory' remark.

When students take deficiency course(s), they will be assessed as 'Satisfactory' or 'Unsatisfactory' without any grade points.

The evaluation will be done on a 10-point scale.

10 point = 100 marks

The per cent of marks in a subject will be divided by 10 to obtain the grade point.

The grade point average for a semester will be calculated as follows.

$$GPA = \frac{\sum (\text{Grade point} \times \text{credit hours})_{\text{in one semester}}}{\text{Total credit hours in the semester}}$$

The Cumulative grade point earned at any stage of the course will be calculated as cumulative grade point average (CGPA) as follows.

$$CGPA = \frac{\sum (\text{Grade point} \times \text{credit hours})_{\text{until last semester}}}{\text{Total credit hours until last semester}}$$

If a student passes in a subject in a second attempt, for calculation of CGPA, the grade point for the subject in the second attempt will only be considered. The final CGPA will be named as overall grade point average (OGPA), which will be mentioned in the final transcript of the students.

#### 4.22 Award of Divisions

The award of the divisions will be as follows

**Table 4.4 Award of the divisions**

OGPA	Division
5 to <6	Pass
6 to <7	II division
7 to <8	I Division
>=8	1st division and distinction

#### 4.23 Uniformity in Nomenclature of Degrees

To ensure hassle free movement of students throughout the country, it is important that nomenclature of degrees awarded is same, across all HAEIs. The nomenclature will be as follows.

##### a. UG-Certificate with mention of discipline

e.g. UG-Certificate in Agriculture, UG-Certificate in Horticulture, UG-Certificate in Agricultural Engineering

Note: If any institution is at present offering any certificate course of the duration of one year lower, it may continue to do so, but this certificate course will not be considered at par with

the UG-Certificate, if the student has not taken admission through the appropriate entrance examination for entry into the 4-year UG program.

b. UG-Diploma with mention of discipline

e.g. UG-Diploma in Agriculture, UG-Diploma in Horticulture, UG-Diploma in Agricultural Engineering

Note: If any institution is at present offering any Diploma course of two years or less than two years' duration after +2 Science, it may continue to do so, but this diploma course will not be considered at par with the UG-Diploma, if the student has not taken admission through the appropriate entrance examination for entry into the 4-year UG program.

The nomenclature of undergraduate degrees will be as per the recommendations of the 5th Deans' Committee as follows:

B. Sc. (Hons.)/ B. F. Sc. (Hons.)/ B. Tech. followed by discipline

e.g. B. Sc. (Hons.) Agriculture/ B. F. Sc (Hons.)/ B. Tech. (Agricultural Engineering)

The nomenclature of degrees may change in case any such revision is suggested by the UGC.

#### **4.24 Increasing Gross Enrolment Ratio (GER)**

Keeping in view the NEP-2020 call for increasing GER, it is recommended that provision is made by institutions to launch stand-alone UG-Certificate and/ or UG-Diploma courses in specific subjects/ disciplines. The entrance examinations for such programs will be separate. The students completing the UG-Certificate will have to appear separate entrance test for continuing to higher level as per University/HAEI norms. Similarly, the students completing the UG-Diploma will have to appear separate entrance test for continuing to higher level as per University/HAEI norms.

#### **4.25 Academic Bank of Credits (ABC)**

As per NEP-2020 guidelines, the HAEI will create an Academic Bank of Credits (ABC) of each student and recognise the ABC of a student as per the norms of the HAEI/ NEP-2020 recommendations.

#### **4.26 Blended learning**

Blended learning has gained tremendous popularity as it combines the benefits of traditional classroom teaching with emerging technology and online educational resources to make learning more real-time, contextual, and engaging. This provision will enable blended learning to expand the open /distance learning options and to promote extensive use of technology in learning and skilling. This would help in overcoming the constraints of physical infrastructure and scalability while enhancing access, equity, and affordability and ensuring quality and accountability. The blended learning option shall also enhance accessibility of learning for Divyangs.

#### **4.27 Minimum requirement for establishing colleges for agriculture and allied disciplines**

The minimum requirements for establishing colleges for 13 agricultures and allied disciplines shall be as per the ICAR Model Act-2023 and various guidelines and orders being issued by ICAR from time to time.

The new NEP-2020 has been introduced in the country to formalize changes in the system, from school to college/ university level. Keeping in mind the concurrent developing scenario and stakeholders' demands, especially in agriculture education, research and extension systems across the regions, delivery of education content henceforth, will focus on key-concepts, ideas, applications and problem-solving angles so as to empower students to become employment ready.

The Indian Council of Agricultural Research has been declared Professional Standards Setting Body (PSSB) for agriculture and allied subjects under NEP-2020. The Council has been coordinating with all agricultural universities since 1960s or so for addressing the issues of quality agricultural education. Primary focus of national coordination in agricultural education was given to update course curricula periodically and concerned universities to adopt them. As a result of long term persuasions by ICAR and realization of stakeholders' demand, agricultural universities have been implementing ICAR recommended Course Curricula for 13 undergraduate programs, 80 Post Graduate programs and 79 Ph. D. programs.

Later on, it was perceived that merely changing the course curricula would not be sufficient to address the quality education, but a sound framework suggesting minimum requirements for degree programs especially requirements of teaching and non-teaching staff, instructional laboratory and instructional farms and supporting units of the following disciplines are also equally essential:

1. Agriculture
2. Agricultural Engineering
3. Biotechnology
4. Dairy Technology
5. Fisheries Science
6. Food Technology
7. Forestry
8. Community Science
9. Horticulture
10. Food Nutrition and Dietetics
11. Sericulture
12. Agribusiness Management
13. Natural Farming

#### **4.28 Making implementation of the recommendations of the Deans' Committee mandatory**

Efforts have been made to improve the quality of agricultural education to make it internationally competitive. Implementation of the recommendations of the Sixth Deans' Committee to be made mandatory for accreditation of academic programs and academic institutions by the National Agricultural Education Accreditation Board (NAEAB).

# 5. COMMON COURSES

## *Deeksharambh (Induction-cum-Foundation Programme)*

0+2 (NG)

### **Objective**

- To give a broad view and application areas of the subject of study
- 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.

### **Activities**

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

- i. Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University
- ii. Creating awareness on the subject of study, and the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario
- iii. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences
- iv. 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
- v. Field visits to related fields/ establishments
- vi. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills



## Farming based Livelihood Systems

3 (2+1)

### Objective

- i) To make the students aware about farming-based livelihood systems in agriculture
- ii) To disseminate the knowledge and skill how farming-based systems can be a source of livelihood

### Theory

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. 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. 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. 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<sup>st</sup> 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.

### Suggested Readings

1. 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
2. Ashley, C.; Carney, D. (1999). Sustainable Livelihoods: Lessons from Early Experience; Department for International Development: London, UK, Volume 7. [Google Scholar]



3. Reddy, S.R. 2016. Farming System and Sustainable Agriculture, Kalyani Publishers, New Delhi.
4. Panwar et al. 2020. Integrated Farming System models for Agricultural Diversification, Enhanced Income and employment, Indian Council of Agricultural Research, New Delhi.
5. Singh, J.P., et al. 2015. Region Specific Integrated Farming System Models, ICAR-Indian Institute of Farming Systems Research, Modipuram.
6. Walia, S. S. and U. S. Walia, 2020. Farming System and Sustainable Agriculture, Scientific Publishers, Jodhpur, Rajasthan.
7. 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 Patna, P.O. Bihar Veterinary College, Patna 800 014, Bihar.
8. Carloni, A. 2001. Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa, Consultation Document, FAO, Rome, Italy
9. Evenson, R.E. 2000. Agricultural Productivity and Production in Developing Countries. In FAO, The State of Food and Agriculture, FAO, Rome, Italy
10. 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

## Entrepreneurship Development and Business Management

**3(2+1)**

### Objective

1. To provide student an insight into the concept and scope of entrepreneurship.
2. To expose the student to various aspects of establishment and management of a small business unit.
3. To enable the student to develop financially viable agribusiness proposal.

### Theory

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. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in 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 project; project report preparation, Enterprise Management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal

management–manpower planning, labour turn over, wages / salaries. 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, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural 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.

## Suggested Readings

- Charantimath P.M. 2009. Entrepreneurship Development and Small Business Enterprises. Pearson Publications, New Delhi.
- Desai, V. 2015. Entrepreneurship: Development and Management, Himalaya Publishing House.
- Desai, Vasant. 1997. Small Scale Industries and Entrepreneurship. Himalaya Publ. House
- Grover, Indu. 2008. Handbook on Empowerment and Entrepreneurship. Agrotech Public Academy.
- Gupta, C.B. 2001. Management Theory and Practice. Sultan Chand & Sons.
- Khanka, S.S. 1999. Entrepreneurial Development. S. Chand & Co.
- Mehra, P. 2016. Business Communication for Managers. Pearson India, New Delhi.
- Pandey, M. and Tewari, D. 2010. The Agribusiness Book. IBDC Publishers, Lucknow.
- Singh, D. 1995. Effective Managerial Leadership. Deep & Deep Publ.
- Singhal, R.K. 2013, Entrepreneurship Development & Management, Katson Books.
- Tripathi, P.C. and Reddy, P.N. 1991. Principles of Management. Tata McGraw Hill.

## Agriculture Marketing and Trade

**3 (2+1)**

### Objective

1. To understand the fundamentals of agricultural marketing and trade
2. To analyze the factors influencing supply and demand in agricultural markets
3. To explore different marketing channels and strategies in agriculture
4. To examine the role of government policies and regulations in agricultural markets

### Theory

Agricultural Marketing: 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 agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales

promotion and publicity – meaning, merits and demerits; marketing process and functions: 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 channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. 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 in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for innovations in agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA), and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. 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.

### 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 Singh, Joginder. 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.

**Agricultural Informatics and Artificial Intelligence****3 (2+1)****Objective**

- i) To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.
- ii) To provide basic knowledge of computer with applications in agriculture
- iii) To make the students familiar with agricultural-informatics, its components and applications in agriculture and Artificial intelligence

**Theory**

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, Introduction to Visual Basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations.

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.

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, 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 etc.

**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).

### Suggested Readings

1. Fundamentals of Computer by V. Rajaroman.
2. Introduction to Information Technology by Pearson.
3. Introduction to Database Management System by C. J. Date.
4. Concepts and Techniques of Programming in C by Dhabal Prasad Sethi and Manoranjan, Wiley India.
5. Introductory Agri Informatics by Mahapatra, Subrat K et al, Jain Brothers Publication.
6. Russell, Stuart, Artificial Intelligence: A Modern Approach, Pearson Edition 2013.
7. Nilson N.J. 2001. Principles of Artificial Intelligence. Narosa.

### 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

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. 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. Ecosystems - Concept of an ecosystem - Structure and function of an ecosystem - Energy flow in the ecosystem. Types of ecosystem. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India. Importance and Value of biodiversity. Biodiversity hot spots. Threats and Conservation of biodiversity Environmental Pollution: Definition, cause, effects and control measures of: a. Air pollution. b. Water pollution. c. Soil pollution. d. Marine pollution. e. Noise pollution. f. Thermal pollution. h. 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. Social issues and the Environment: Urban problems related to energy. Water conservation, rain water 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. 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 un polluted 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.

### 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 and Kanna, S. 2023. Forest, Environment, Biodiversity and Sustainable development. Narendra Publishing House, New Delhi
5. Prasanthrajan, M. and Mahendran, P.P. 2008. A text book on Ecology and Environmental Science. ISBN 81-8321-104-6. Agrotech Publishing Academy, Udaipur
6. Sharma, P.D. 2009. Ecology and Environment, Rastogi Publications, Meerat, India
7. Tyler Miller and Scot Spoolman. 2009. Living in the Environment (Concepts, Connections, and Solutions). Brooks/cole, Cengage learning publication, Belmont, USA



## 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

**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.

**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.

**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.

### Suggested readings

1. Allport, G. W. 1937. Personality: A Psychological Interpretation. Holt, New York.
2. Brown Michele and Gyles Brandreth. 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

**Personality Development****2 (1+1)****Objective**

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability.

**Theory**

Personality Definition, Nature of personality, theories of personality and its types. The humanistic 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.

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. 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.

**Suggested reading**

- 1) Andrews, Sudhir. 1988. How to Succeed at Interviews. 21st (rep.) New Delhi. 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) Kumar, Pravesh. 2005. All about Self- Motivation. New Delhi. Goodwill Publishing House
- 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) Smith, B. 2004. Body Language. Delhi: Rohan Book Company.
- 7) Shaffer, D. R. 2009. Social and Personality Development (6th Edition). Belmont, CA: Wadsworth

**Physical Education, First Aid, Yoga Practice and Meditation****2 (0+2)****Objectives**

1. To make the students aware about Physical Education, First Aid and Yoga Practices
2. 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 ageing and role of regular exercise on ageing 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:

- Asanas: Definition and Importance, Padmasana, Gaumukhasana, Bhadrasana, Vajrasana, Shashankasana, Pashchimotana, Ushtrasana, Tadasana, Padhasana, Ardhanandrasana, Bhujangasana, Utanpadana, Sarvangasana, Parvatasana, Patangasana, Shishupalanasana– left leg-right leg, Pavanmuktana, Halasana, Sarpasana, Ardhanandrasana, Sawasana
- Suryanamskara Pranayama (Definition and Importance) Omkara, Suryabhedana, Chandrabhedana, AnulomViloma, Shitali, Shitkari, Bhastrika, Bhramari
- Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandha
- Mudras (Definition and Importance) Gyanmudra, Dhyana mudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
- Role of yoga in sports
- Teaching of Asanas – demonstration, practice, correction and practice.

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.

## 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 citizen.

- 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 time 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.

### **NCC-II**

**1 (0+1)**

### **Objective**

- 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.
- 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.

**NSS- I**

**1 (0+1)**

### **Objective**

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful 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**

- 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

**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 skilled in executing democratic leadership, developing skill in program, 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.

# 6. UGC Skill Courses

## UGC recommended list of skill development training areas

In addition to skill development training courses identified by respective universities from respective disciplines of study, such as agriculture, agribusiness, horticulture, forestry, etc. Skill development courses may also be selected by universities from the following list of skill trainings advised in the UGC notification. “Guidelines for the Introduction of Short -Term Skill Development Courses in Higher Educational Institutions”. The university/ college may select any number of short-term skill development courses from the broad areas as mentioned below, in which they will have built institutional capacity for training or joined partnership with specialized institution capable of imparting such training program. The courses may be planned as integrated part of the UG-Certificate and UG-Diploma Programmes (after suitable planning of the contents) or they may be offered in stand-alone mode leading to award of certificates on the skill areas.

- i. Artificial Intelligence, and machine learning
- ii. Artificial Intelligence, and Robotics
- iii. IoT (Internet of Things)/ Industrial IoT/Smart Cities
- iv. Data Science and Analytics
- v. Cloud Computing
- vi. Virtual Reality, Augmented Reality and Extended Reality
- vii. Cyber Security and Digital Forensics
- viii. 5G Connectivity
- ix. Digital Fluency/ Digital transformation
- x. Industrial Automation and Robotics Process Automation (RPA)
- xi. Electronic System Designs/ VLSI Designs
- xii. Electronic Manufacturing
- xiii. Basic Coding in Computing Languages
- xiv. Computer-Aided Design (CAD)/Computer-Aided Manufacturing (CAM)
- xv. Mechanical Tooling and Processes/ Mechatronics
- xvi. Architectural Drafting, Basic 3D Design
- xvii. Building Information Modelling (BIM)
- xviii. 3D Printing
- xix. Electrician/Electrical and Electronics
- xx. Mobile Communication, Mobile Repairing and Basics of DTH Installation

- xxi. Digital Marketing - courses in Search Engine Optimization (SEO), social media marketing, content marketing, and e-commerce management
- xxii. Health and Wellness - courses focusing on mental health counselling, nutrition and dietetics, and fitness training in response to the growing awareness of personal well-being and holistic health and wellness
- xxiii. Financial Technology (FinTech) - courses in digital payments, blockchain technology, digital currencies, and financial regulations
- xxiv. Fashion Technology, Fashion design, stitching, etc. (home science colleges)
- xxv. Yogic Sciences
- xxvi. Soft skills and courses in effective communication, critical thinking and problem-solving, creative thinking and innovation, novel and adaptive thinking, design thinking and mindset, computational thinking, virtual collaboration, cross-cultural competency, new media literacy, team building, etc.
- xxvii. Basics of start-ups and Entrepreneurship – leadership, project planning, management, Event Management, marketing, financing, and agri-business entrepreneurship, etc.

The university / college may also offer short-term courses in any other areas identified by it, based on the skill gap studies as well as institutional expertise, e.g. agriculture, horticulture, home science etc. The skill courses run by various Sector Skill Councils can also be adopted.

# AGRICULTURAL ENGINEERING

**Course Curricula for Undergraduate Programme in Agricultural Engineering UG- Certificate in Agricultural Engineering UG- Diploma in Agricultural Engineering B. Tech. (Agricultural Engineering)**

## **INTRODUCTION**

In the 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; internet of things (IoT), sensors, automation and robotics, etc. are finding more and more applications. Intelligent machines and autonomous vehicles are being introduced to increase efficiency and reduce 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. Hence, the education and research in agricultural engineering in appropriate areas have become of paramount importance in the present context.

However, the actual benefits of these can be properly harvested only if the students have sound exposure to the latent developments in the field in addition to having due acquaintance with the traditional and indigenous knowledge in the related fields. 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 restructuring of under-graduate programs in Agricultural Engineering has been carried out as per NEP guidelines. It is aimed to build among students a strong foundation of knowledge with increased practical exposure and skilling to build competence and confidence for the application of the gained knowledge. The restructured 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. Besides, as per NEP-2020, provision for multiple exit and entry options have also been included.

The details of the course structure for the Undergraduate courses in Agricultural Engineering (UG-Certificate, UG-Diploma and B. Tech.) have been prepared after having multistage in-depth deliberations and discussions with the Deans and faculty members of the Agricultural Engineering discipline of different SAUs and CAUs, stakeholders from related industries, Govt. Institutions and alumni. It is expected that the course curriculum will strengthen the knowledge and skill base of the students and meet the expectations of the NEP-2020 towards making India a knowledge superpower and realizing the dream of *Atmanirbhar Bharat*.

## HIGHLIGHTS

- The B. Tech. (Agricultural Engineering) programme will be of 180 credits, which includes 174 credits offered by the parent institute and 6 credits of online courses (to be taken by the student as per his/her/ze choice). In addition, there will be four credits of two non-gradual courses (*Deeksharambh* (Introduction-cum-Foundation course): 2 credits and 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 1<sup>st</sup> 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. Steps will be taken to identify the strength and weakness of students (with remedial measures) and diverse potentialities and to enhance cultural Integration of students from different backgrounds. 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 1<sup>st</sup> 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 1<sup>st</sup> 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, enabling the student to get acquainted with the basic principles and applications of agricultural engineering. After satisfactory completion of the courses of 2<sup>nd</sup> 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 2<sup>nd</sup> 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 7<sup>th</sup> semester) and Project-II (4 credits in 8<sup>th</sup> 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.
- An institution is at liberty to (and in fact it should) work in partnership with capable organizations/ companies/ NGOs/ progressive entrepreneurs for running the Skill Enhancement courses. In such cases, a detailed content should be prepared in consultation with the industry/ organization and the institution should have a regular monitoring for the learning process. The evaluation can be done jointly by the institute and collaborating partners.
- The third year and fourth year courses have been designed to impart specialized knowledge to the students in the major disciplines. 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.
- There will be adequate choice of electives/ specialized courses for the students. The Universities will have flexibility to include more courses as Electives depending on specific needs and situational variations. The student may also opt any relevant course offered in the same semester by other constituent colleges of the HAEI as Elective.

- 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<sup>th</sup> semester, the students will have a study tour of 10-14 days duration, which will be counted as 2 credits (Non-gradual).
- 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-gradual 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.
- At each stage of exit (UG-Certificate/ UG-Diploma and B. Tech.), the students are expected to acquire competency and confidence to get jobs, to face the real challenges in varied jobs and research, as well as to start their own enterprise. The social skills acquired by the students will also make the students more empathetic towards the society and social issues.
- 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 1<sup>st</sup> and 2<sup>nd</sup> 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 3<sup>rd</sup> year. This will increase their acquaintance with the social/ technical problems, improve their analytical ability of the issues/ challenges and enhance their social responsibility. However, these are suggestive only and the Universities can plan their timetables as per the local facilities/ university norms and needs.
- In case the skill enhancement/ internship programs are conducted in collaboration with industry/ other organizations/ agencies, the students may be expected to remain out of the campus for a certain period within the semester. In that situation, the timetable should be so adjusted for the remaining part of the net instruction days (NIDs) of the corresponding semester, that each credit has at least 15 contact hours.

### **Entry and Exit Options**

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

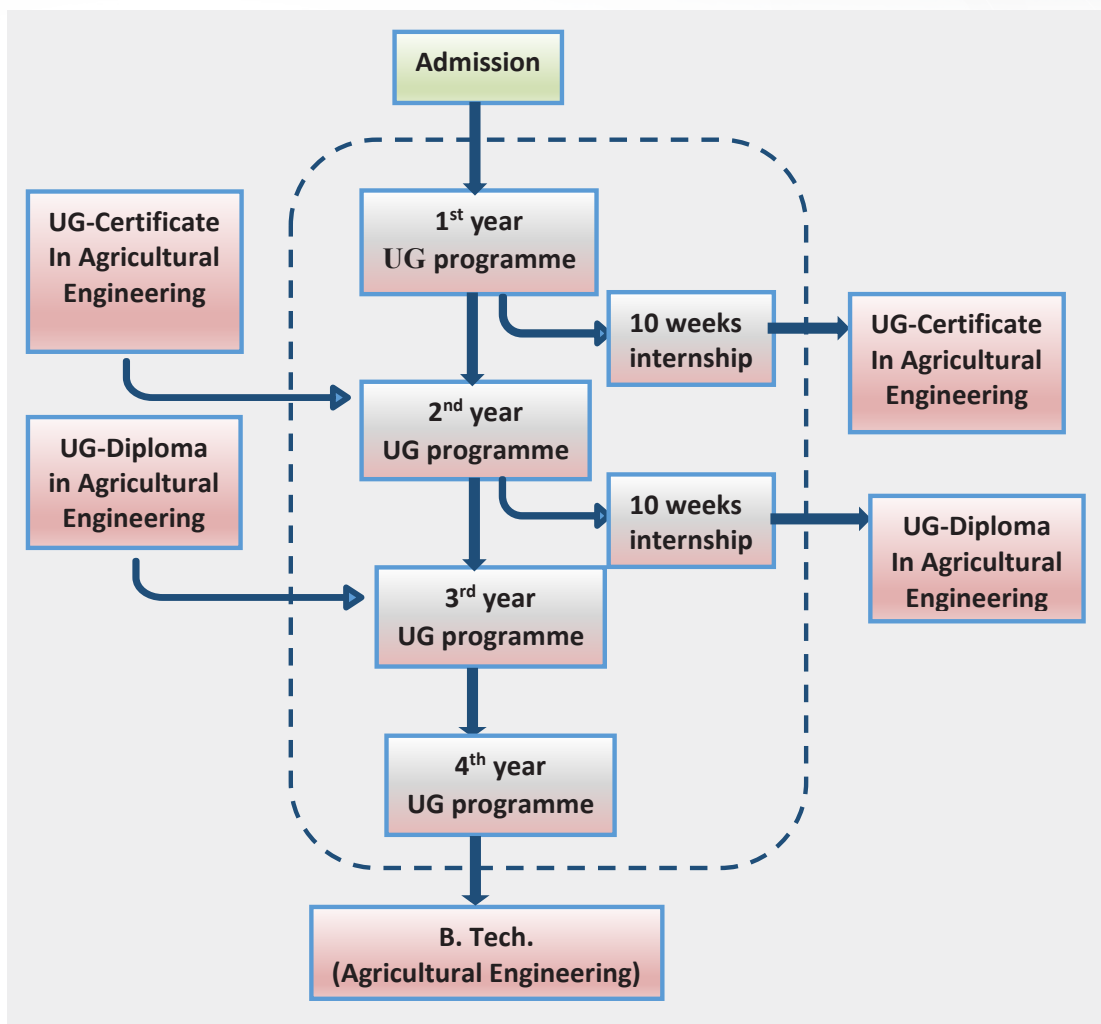


Fig. 1 Entry and Exit options for the UG programs in Agricultural Engineering

### Eligibility for Entry into 1<sup>st</sup> year UG programme

+2 Science with Mathematics as one subject or as per the criteria decided by the ICAR/ SAU.

### Exit options

1. **UG-Certificate in Agricultural Engineering** (exit after first year and completion of 10 weeks' internship).
2. **UG-Diploma in Agricultural Engineering** (exit after second year and completion of 10 weeks' internship).
3. **B. Tech. (Agricultural Engineering)** (on successful completion of four-year degree requirements).

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

## ACADEMIC PROGRAMME

### Semester wise course distribution

Sl. No.	Course Title	Credit Hours	Total Credit hours
<b>First Year</b>			
<b>I semester</b>			
1	<i>Deeksharambh</i>	0+2 (NG) Non-gradual	<b>20 (11+9)</b>
2	Crop Production and Protection Technologies	4 (3+1)	
3	Introduction to Agricultural Engineering	4 (3+1)	
4	Surveying and Levelling	3 (1+2)	
5	Workshop Technology and Practice	2 (0+2)	
6	Basic Electrical Gadgets and Instruments	3 (2+1)	
7	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
8	NSS- I/ NCC- I	1 (0+1)	
<b>II semester</b>			
1	Skill Enhancement	8 (0+8)	<b>21 (5+16)</b>
2	Engineering Drawing	2 (0+2)	
3	Computer Programing and Data Structures	2 (0+2)	
4	Farming Based Livelihood Systems	3 (2+1)	
5	Environmental Studies and Disaster Management	3 (2+1)	
6	Communication Skills	2 (1+1)	
7	NSS-II/ NCC- II	1 (0+1)	
<b>Post-II semester</b>			
1	Internship (for 10 weeks, only for exit option for award of UG-Certificate)	10 (0+10)	
<b>Second Year</b>			
<b>III semester</b>			
1	Engineering Mathematics- I	3 (3+0)	<b>25 (16+9)</b>
2	Engineering Physics	3 (2+1)	
3	Engineering Chemistry	3 (2+1)	
4	Engineering Mechanics	3 (2+1)	
5	Soil Mechanics	2 (1+1)	

Sl. No.	Course Title	Credit Hours	Total Credit hours
6	Fluid Mechanics and Open Channel Hydraulics	3 (2+1)	
7	Engineering Properties of Agricultural Produce and Food Science	3 (2+1)	
8	Farm Machinery & Equipment- I	3 (2+1)	
9	Physical Education, First Aid, Yoga Practice and meditation	2 (0+2)	
<b>IV semester</b>			
1	Engineering Mathematics-II	3 (3+0)	<b>25 (18+7)</b>
2	Theory of Structures	2 (1+1)	
3	Building Construction & Cost Estimation	2 (2+0)	
4	Watershed Hydrology	3 (2+1)	
5	Soil and Water Conservation Engineering	3 (2+1)	
6	Farm Machinery & Equipment II	3 (2+1)	
7	Renewable Energy Sources	3 (2+1)	
8	Post-harvest Engineering of Cereals, Pulses and Oilseeds	3 (2+1)	
9	Entrepreneurship Development and Business Management	3 (2+1)	
<b>Post-IV semester</b>			
1	Internship (for 10 weeks, only for exit option for award of UG-Diploma)	10 (0+10)	
<b>Third Year</b>			
<b>V semester</b>			
1	Strength of Materials	2 (1+1)	<b>21 (15+6) +2 (Non-gradial)</b>
2	Theory of Machines	2 (2+0)	
3	Thermodynamics and Heat Transfer	3 (3+0)	
4	Tractor & Automotive Engines	3 (2+1)	
5	Irrigation and Drainage Engineering	4 (3+1)	
6	Food and Dairy Engineering	4 (3+1)	
7	Personality Development	2 (1+1)	
8	Seminar	1 (0+1)	
9	Study tour	2 (0+2) NG	
<b>VI Semester</b>			
1	Tractor Systems & Controls	3 (2+1)	<b>21 (13+8)</b>
2	Groundwater, Wells and Pumps	3 (2+1)	
3	Sensors, AI and Robotics in Agriculture	3 (2+1)	
4	Agricultural Structures & Environment Control	3 (2+1)	
5	Bioenergy Systems: Design and Applications	3 (2+1)	
6	Refrigeration and Air-conditioning	3 (2+1)	
8	Post-harvest Engineering of Horticultural Crops	2 (1+1)	
9	Case Study	1 (0+1)	

Sl. No.	Course Title	Credit Hours	Total Credit hours
<b>Fourth Year</b>			
<b>VII semester</b>			
1	Project- I	3 (0+3)	<b>20 (10+10)</b>
2	Engineering Graphics and Design	2 (0+2)	
3	Food Quality and Safety	3 (2+1)	
4	Watershed Planning and Management	3 (2+1)	
5	Sprinkler & Micro Irrigation Systems	2 (1+1)	
6	Machine Design	2 (2+0)	
7	Electrical Machines	3 (2+1)	
8	Agricultural Statistics and Data Analysis	2 (1+1)	
<b>VIII semester</b>			
1	Project -II	4 (0+4)	<b>21 (6+15)</b>
2	In-plant Training/ Research Internship	8 (0+8)	
4	Elective- I	3 (2+1)	
3	Elective- II	3 (2+1)	
4	Elective- III	3 (2+1)	
		<b>TOTAL</b>	<b>174 (94+80)</b>
	*On-line courses	6	<b>6</b>
		<b>Grand Total</b>	<b>174+6*</b>

### Department/ section wise course breakup

Sl. No.	Course Title	Credit hours	Total
<b>Foundation courses/ Ability Enhancement Courses, etc.</b>			
1	Deeksharambh	0+2 (Non-gradual)*	4 (0+4)
2	NSS-I/ NCC - I	1 (0+1)	
3	NSS-I/ NCC - II	1 (0+1)	
4	Physical Education, First Aid and Yoga Practice	2 (0+2)	
<b>Basic Agriculture</b>			
1	Crop Production and Protection Technologies	4 (3+1)	12 (8+4)
2	Farming Based Livelihood Systems*	3 (2+1)	
3	Environmental Studies and Disaster Management*	3 (2+1)	
4	Agricultural Statistics and Data Analysis	2 (1+1)	
<b>Social Sciences</b>			
1	Communication Skills*	2 (1+1)	7 (4+3)
2	Personality Development*	2 (1+1)	
2	Entrepreneurship Development and Business Management*	3 (2+1)	

Sl. No.	Course Title	Credit hours	Total
<b>Common Agricultural Engineering</b>			
1	Introduction To Agricultural Engineering	4 (3+1)	6 (3+3)
2	Seminar	1 (0+1)	
3	Case Study	1 (0+1)	
4	Study Tour	2 (0+2) NG*	
<b>Skill Enhancement Courses/ Project</b>			
1	Skill Enhancement	8 (0+8)	15 (0+15)
2	Project- I	3 (0+3)	
3	Project- II	4 (0+4)	
<b>In-plant training/ Internship</b>			
1	Internship only for exit option with UG-Certificate	10 (0+10)#	8 (0+8) #Credits not included in the total credits calculated for B. Tech. programme
2	Internship only for exit option with UG-Diploma	10 (0+10)#	
3	In-plant Training/ Research Internship	8 (0+8)	
<b>Basic Sciences</b>			
1	Engineering Mathematics- I	3 (3+0)	12 (10+2)
2	Engineering Mathematics- II	3 (3+0)	
3	Engineering Physics	3 (2+1)	
4	Engineering Chemistry	3 (2+1)	
<b>Agricultural Structures and Civil and Environmental Engineering</b>			
1	Surveying and Levelling	3 (1+2)	17 (10+7)
2	Engineering Mechanics	3 (2+1)	
3	Soil Mechanics	2 (1+1)	
4	Theory of Structure	2 (1+1)	
5	Building Construction and Cost Estimation	2 (2+0)	
6	Strength of Materials	2 (1+1)	
7	Agricultural Structures and Environmental Control	3 (2+1)	
<b>Mechanical Engineering</b>			
1	Workshop Technology and Practices	2 (0+2)	16 (9+7)
2	Engineering Drawing	2 (0+2)	
3	Theory of Machines	2 (2+0)	
4	Thermodynamics and Heat Transfer	3 (3+0)	
5	Refrigeration and Air Conditioning	3 (2+1)	
6	Machine Design	2 (2+0)	
7	Engineering Graphics and Design	2 (0+2)	
<b>Electrical and Electronics Engineering</b>			
1	Basic Electrical Gadgets and Instruments	3 (2+1)	6 (4+2)
2	Electrical Machines	3 (2+1)	

Sl. No.	Course Title	Credit hours	Total
<b>Computer Science and Engineering</b>			
1	Agricultural Informatics and Artificial Intelligence*	3 (2+1)	8 (4+4)
2	Computer programming and data structures	2 (0+2)	
3	Sensors, Artificial Intelligence and Robotics in Agriculture	3 (2+1)	
<b>Farm Machinery and Power Engineering</b>			
1	Farm Machinery and Equipment- I	3 (2+1)	12 (8+4)
2	Farm Machinery and Equipment- II	3 (2+1)	
3	Tractor and Automotive Engines	3 (2+1)	
4	Tractor Systems and Controls	3 (2+1)	
<b>Renewable Energy Engineering</b>			
1	Renewable Energy Sources	3 (2+1)	6 (4+2)
2	Bio-energy Systems: Design and Applications	3 (2+1)	
<b>Soil and Water Conservation Engineering</b>			
1	Fluid Mechanics and Open Channel Hydraulics	3 (2+1)	12 (8+4)
2	Watershed Hydrology	3 (2+1)	
3	Soil and Water Conservation Engineering	3 (2+1)	
4	Watershed Planning and Management	3 (2+1)	
<b>Irrigation and Drainage Engineering</b>			
1	Irrigation and Drainage Engineering	4 (3+1)	9 (6+3)
2	Groundwater, Wells and Pumps	3 (2+1)	
3	Sprinkler and Micro Irrigation Systems	2 (1+1)	
<b>Processing and Food Engineering</b>			
1	Engineering Properties of Agricultural Produce and Food Science	3 (2+1)	15 (10+5)
2	Post-harvest Engineering of Cereals, Pulses and Oilseeds	3 (2+1)	
3	Food and Dairy Engineering	4 (3+1)	
4	Post-harvest Engineering of Horticultural Crops	2 (1+1)	
5	Food Quality and Safety	3 (2+1)	

\* Common courses across the disciplines

### ELECTIVE COURSES

1	Mechanics of Tillage and Traction	3 (2+1)	9 (any three courses to be chosen)
2	Farm Machinery Design and Production	3 (2+1)	
3	Tractor Design and Testing	3 (2+1)	
4	Hydraulic Drives and Controls	3 (2+1)	



5	Human Engineering and Safety	3 (2+1)	
6	Precision Agriculture and System Management	3 (2+1)	
7	Photovoltaic Technology and Systems	3 (2+1)	
8	Wind Power Technology and Systems	3 (2+1)	
9	Waste and By-products Utilization	3 (2+1)	
10	Floods and Control Measures	3 (2+1)	
11	Remote Sensing and GIS Applications	3 (2+1)	
12	Information Technology for Land and Water Management	3 (2+1)	
13	Wasteland Development	3 (2+1)	
14	Minor Irrigation and Command Area Development	3 (2+1)	
15	Management of Canal Irrigation System	3 (2+1)	
16	Water Quality and Management Measures	3 (2+1)	
17	Landscape Irrigation Design and Management	3 (2+1)	
18	Application of Plastics in Agriculture	3 (2+1)	
19	Precision Farming Techniques for Protected Cultivation	3 (2+1)	
20	Environmental Engineering	3 (2+1)	
21	Development of Processed Food Products	3 (2+1)	
22	Food Packaging Technology	3 (2+1)	
23	Food Plant and Equipment Design	3 (2+1)	
24	Emerging Technologies in Food Processing	3 (3+0)	
25	Processing of Livestock, Fish and Marine Products	3 (2+1)	
26	Food Business Management and Entrepreneurship Development	3 (3+0)	
27	MATLAB Programming	3 (1+2)	
28	Python Programming	3 (1+2)	
29	Artificial Intelligence	3 (2+1)	
30	Advances in Automation and Robotics in Agriculture	3 (2+1)	
31	Machine Learning	3 (2+1)	
32	Operations Research	3 (3+0)	
33	Mechatronics	3 (2+1)	
34	Natural Fibres: Extraction & Properties	3 (2+1)	
35	Natural Fibre Applications in Agriculture	3 (2+1)	
36	Processing of Natural Fibres	3 (2+1)	
37	Agricultural Marketing and Trade	3 (2+1)	

## SUMMARY OF CREDIT DISTRIBUTIONS

Type of courses		Credits
Core courses (major & minor/s)	:	125
Common courses (MDC+VAC+AEC)	:	26
Skill Enhancement Courses (SEC)	:	8
Internship/ in-plant training	:	8
Project		7
* Online courses	:	6
<b>Total</b>	<b>:</b>	<b>174+6*</b>

The credits of *Deeksharambh* (0+2) and Study tour (0+2) have not been included in the total 180 credit hours.

Credits allocation scheme of UG Agricultural Engineering programs is given in Table-1

**Table 1 Credits Allocation Scheme of UG Agricultural Engineering programs (Credit hours)**

Sem-ester	Core Courses* (majors/ Minors)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non-Gradial courses	Online Courses/ MOOC
I	12	4 <sup>(2)</sup>	3 <sup>(3)</sup>	1 <sup>(4)</sup>	-	-	20	2 <sup>(1)</sup>	6
II	2	3 <sup>(5)</sup>	3 <sup>(6)</sup>	2 <sup>(7)</sup> +1 <sup>(8)</sup> +2 <sup>(9)</sup>	8	-	21	-	
Post-II semester	-	-	-	-	-	10 <sup>(10)</sup>			
III	23	-	-	2 <sup>(11)</sup>	-	-	25		
IV	22	3 <sup>(12)</sup>	-	-	-	-	25	-	
Post-IV semester	-	-	-	-	-	10 <sup>(13)</sup>			
V	19	-	-	2 <sup>(14)</sup>	-	-	21	2 <sup>(15)</sup>	
VI	21	-	-	-	-	-	21	-	
VII	17	-	-	-	-	3	20	-	
VIII	9	-	-	-	-	12	21	-	
<b>Total</b>	<b>125</b>	<b>10</b>	<b>6</b>	<b>10</b>	<b>8</b>	<b>15</b>	<b>174</b>	<b>4</b>	<b>6</b>

<sup>(1)</sup> *Deeksharambh* (Induction-cum-Foundation Course); <sup>(2)</sup> Crop Production and Protection Technologies

<sup>(3)</sup> Agricultural Informatics; <sup>(4)</sup> NCC-I/ NSS-I; <sup>(5)</sup> Farming Based Livelihood Systems;

<sup>(6)</sup> Environmental Studies and Disaster Management; <sup>(7)</sup> Communication Skills;

<sup>(8)</sup> NCC-II/ NSS-II; <sup>(9)</sup> Computer Programming and Data Structures

<sup>(10)</sup> Internship (only for those opting for an exit with UG-Certificate)

<sup>(11)</sup> Physical Education, First Aid and Yoga Practices

<sup>(12)</sup> Entrepreneurship Development and Business Management

<sup>(13)</sup> Internship (only for those opting for an exit with UG-Diploma); <sup>(14)</sup> Personality Development; <sup>(15)</sup> Study tour

\*Includes the Elective courses.

## Detailed Syllabi

### Semester I

#### **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:

- I. discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University
- II. creating awareness on the subject of study, and the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario
- III. interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences;
- IV. 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;
- V. field visits to related fields/ establishments; and
- VI. sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills.

#### **Crop Production and Protection Technologies**

**4 (3+1)**

##### **Objective**

To enable the students to have basic idea on crop production and protection practices to 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**

Introduction and scope of agronomy; Classification of crops; Effect of different weather parameters on crop growth and development; Principles of tillage, tith 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.

Soil-water-plant relationship, crop coefficients, water requirement of crops and critical stages for irrigation; Weeds and their management in crops; Crop rotation, cropping systems, cropping scheme, relay cropping, mixed cropping and intercropping.

Soil forming processes; Classification and composition of soil, soil taxonomy orders; Important soil 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.

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.

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 of gypsum 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.

## 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 Publishers Ludhiana.
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.

## 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

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; Scope of research and higher studies in Agricultural Engineering in India and abroad.

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.

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.

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.

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.

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); Study of farm implements (pesticide application, harvesting and threshing); Study of various components of 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.

### 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.

## 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

Surveying: introduction, classification and basic principles; Linear measurements, chain surveying, cross staff survey, compass survey, planimeter; Errors in measurements, their elimination and correction; Plane table surveying, methods, advantages and disadvantages.

Levelling, levelling difficulties and error in levelling, contouring, computation of area and volume.

Theodolite traversing, introduction to setting of curves; Total station, electronic theodolite; Introduction to GPS survey.

### Practical

Linear measurements using different instruments; Reconnaissance survey in the field; Use of 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

### Suggested Readings

1. Agor R. *A Text Book of Surveying & Levelling*. Khanna Publishers, New Delhi
2. Arora K R. 1990. *Surveying (Vol. I)*, Standard Book House, Delhi.
3. Kanetkar T P. 1993. *Surveying and Levelling*. Pune Vidyarthi Griha, Prakashan, Pune.
4. Punmia B C. 1987. *Surveying (Vol. I)*. Laxmi Publications, New Delhi.



**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

**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.

**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**

Introduction to different electrical appliances used in agricultural buildings, structures and farm .0operations; Difference between AC and DC supply system; Introduction to AC fundamentals; AC



through series RL, RC, and RLC circuits, parallel AC 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 in three-phase circuit, various methods of three phase power measurement like (one wattmeter and two –wattmeter method).

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, comparator).

Introduction to digital electronics and logic gates: Basic theorem of boolean algebra, combinational logic circuits (basic gates, SOP rule and K-map), binary adder.

Principles of general instruments, measurement of displacement, temperature, velocity, force and 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, wind velocity, solar radiation, anemometer, multimeter, etc.

## Practical

### *Basic Electrical and Electronics Gadgets*

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, pyranometer, multimeter, etc.; To acquaint with different other types of instruments used in agriculture and food processing applications.

## 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.

## **Agricultural Informatics and Artificial Intelligence**

**3 (2+1)**

### **Objective**

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**

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, Introduction to Visual Basic, Java, Fortran, C/C++, etc. concepts and standard input/output operations.

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.

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, 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 etc.

### 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)

### 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.

### 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 time 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- 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.

## Semester II

### Skill Enhancement

**8 (0+8)**

### Objective

To enable the students to acquire basic skills in agricultural engineering so that in case they exit with UG-certificate, they can work as operators and technicians in the fields of farm machinery, micro-irrigation, solar and wind energy or food processing, etc. or can go for self-employment or start their own agro-service centre, agro-processing centre or similar activities. Thus the broad objective of this course is Skill for Employment and Entrepreneurship Development.

### Indicative Modules

- Operation and maintenance of farm machinery
- Repair and maintenance of tractors and power tillers
- Management of agricultural machinery custom hiring and maintenance facilities
- Fabrication, operation and maintenance of renewable energy devices
- Operation and maintenance of drones used for agricultural applications
- Machine vision, sensors and sensors architecture
- Design of solar PV system using softwares
- Installation and maintenance of on-grid and off-grid solar systems
- Design and maintenance of agri-voltaic systems
- Valorization of agri-biomass and organic waste
- Energy audit, energy conservation and energy efficiency
- Repair and maintenance of pumps and irrigation systems
- Installation and maintenance of micro-irrigation systems
- Application of remote sensing and GIS for agricultural water management
- Operation and maintenance of hydro-meteorological instruments
- Geophysical survey and investigations for groundwater exploration and installation of tube well/ bore well
- Installation and maintenance of roof top rain water harvesting systems
- Operation and maintenance of soil conservation structures
- Construction, management and maintenance of protected cultivation structures
- Agro processing methods, equipment operation and maintenance
- Operation and management of multi-commodity agro-processing centre
- Primary processing and value addition and cold chain logistics

xxiii. Food grain godown and warehouse management

xxiv. Post-harvest value chain management including logistics

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 skill areas. The selection of the module(s) will be entirely on the student's choice.

Indicative details of the skill enhancement modules are given at the end of this section. The credit hours for each module have been kept as 0+4. However, the institution is at liberty to modify the credit hours/ contents for the skill enhancement modules depending on the level of skill to be imparted to the students. For example, if a student wishes to take up three or four skill modules, the contents and credits can be modified for those skill modules, making the total 8 credits. However, in no case, more than four modules are recommended for offering to a student.

It is emphasized that the purpose is to impart practical knowledge/ skill for operating the system and none of the course should be taken in theoretical mode. In specific cases, the skill enhancement in the specific area can be further continued during the 10 weeks' internship in case of exits for UG-certificate and UG-Diploma for further strengthening of the skill.

The above modules and details are indicative only and the institutions have the liberty to formulate new modules and modify the content of the modules relevant to the respective regions or even modify the titles of the above modules. It is advised that the institutions should define the detailed breakup of the skill areas depending on the facilities/ expertise available.

The course can also be offered in partnership with capable organizations/ companies/ NGOs/ progressive entrepreneurs. In such cases, a detailed content should be prepared in consultation with the industry/ organization and the institution should have a regular monitoring for the learning process. The evaluation can be done jointly by the institute and collaborating partners. The timetable for the remaining part of the semester will be adjusted accordingly as mentioned earlier.

## **Engineering Drawing**

**2 (0+2)**

### **Objective**

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

### **Practical**

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, reference planes, points and lines in space; 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; 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; 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

### 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.

### 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; Structure programming, C programming, a simple C programming, execution of a C program, program and instruction; Familiarizing with Turbo 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.

### 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.

### **Farming based Livelihood Systems**

**3 (2+1)**

#### **Objectives**

1. To make the students aware about farming-based livelihood systems in agriculture
2. To disseminate the knowledge and skill how farming based systems can be a source of livelihood

#### **Theory**

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. 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. 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. 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<sup>st</sup> Century in view of circular economy, green economy, climate change, digitalization and changing life style.

#### **Practical**

Survey of farming systems and agriculture- 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.

## 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. and Carney, D. 1999. Sustainable Livelihoods: Lessons from Early Experience; Department for International Development: London, UK; Volume 7. [Google Scholar].
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 Gulliver, A. with Gibbon, D. 2001. Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. FAO & World Bank, Rome
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 Patna, 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.

## Environmental Studies and Disaster Management

**3 (2+1)**

### Objective

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

### Theory

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. 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 hot spots. Threats and Conservation of biodiversity

Environmental Pollution: Definition, cause, effects and control measures of: a. Air pollution. b. Water pollution. c. Soil pollution. d. Marine pollution. e. Noise pollution. f. Thermal pollution. h. 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. Social Issues and the Environment: Urban problems related to energy. Water conservation, rain water 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. 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 un polluted 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

### 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), Bengaluru. 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.
5. Prasanthrajan, M. and Mahendran, P.P. 2008. A text book on Ecology and Environmental Science. ISBN 81-8321-104-6. Agrotech Publishing Academy, Udaipur
6. Sharma, P.D. 2009, Ecology and Environment, Rastogi Publications, Meerut, India.
7. Tyler, Miller and Spoolman, Scot. 2009. Living in the Environment (Concepts, Connections, and Solutions). Brooks/cole, Cengage learning publication, Belmont, USA

## Communication Skills

2 (1+1)

### Objective

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication skill and demonstrate positive group communication

### Theory

**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.

**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.

**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.

### Suggested readings

1. Allport, G. W. 1937. Personality: A Psychological Interpretation. Holt, New York.
2. Brown Michele and Gyles Brandreth. 1994. How to Interview and be Interviewed. Sheldon Press, London.
3. Dale, Carnegie. 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

**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.

**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 skilful 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.

## Post-II semester

### Internship (only for exit option for award of UG-Certificate)

**10 (0+10)**

#### Objective

To provide students with an opportunity to put into practice the skills they have learned while studying in the institute, so that in case they exit with UG-certificate, they will be able to get proper engagement/ employment and will be competent to start an enterprise.

#### Activity

The students will have internship/ training for 10 weeks' duration either in the parent institute (attaching the students to facilities such as farm machinery testing centre, incubation centres, prototype production facilities, etc.) or in industry, farm machinery service centre or related organisations involved in agri-engineering activities. The College/ University will facilitate attaching the students to the organisations.

After completion of internship, the students will have to submit a report on their learnings and also present in form of a seminar. The assessment will be based on the report / assessment received from the industry/ organisation and the report and the presentation made at the College. Ideally the weightage will be 50% each for both internal and external. The SAUs may modify the weightage and breakups.

## Semester III

### Engineering Mathematics-I

**3 (3+0)**

#### Objective

To make the students acquainted with the basic mathematics applied in engineering and their applications in solving engineering problems

#### Theory

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.



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.

Differential calculus: Functions of two or more variables, Taylor's and Maclaurin's expansions, Maxima and minima.

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.

Integral calculus: Double integrals, change of order of integration, triple integrals, application of double and triple integrals to find area and volume.

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.

### 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.

### 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

Magnetism: Dia, para and ferro-magnetism- classification; Langrevin theory of dia, and para magnetism, adiabatic demagnetization, Weiss molecular field theory; Introduction to quantum mechanics: wave particles duality, deBroglie concept uncertainty principle, time dependent and time independent Schrodinger equation.

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.

Semiconductors: Intrinsic and extrinsic semi-conductors, law of mass action, determination of energy gap in semi-conductors, donors and acceptor levels; Superconductivity: super conductivity, critical magnetic field, Meissner effect, isotope effect, Type I and II superconductors, Josephson's effect, DC and AC squids, introduction to high  $T_c$  superconductors.

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 wave length of light by using prism and spectrometer; 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.

### 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

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.

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.

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.

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 its 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  $\lambda_{\max}$  and verification of Beer-Lambert law.

## 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.

## 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

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.

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.

Simple stresses and strain, Hooke's law, Poisson's ratio, modulus of elasticity, Strain related problems.

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-flexure.

Torsion of circular shaft, torsional effect, hoop stress, power transmitted by a shaft.

Principal stresses and strain, analysis of plane and complex stress, principal planes and principal stresses, Mohr's circle, finding out principal stresses, different analysis.

### 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.

### 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.

### 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

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.

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.

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.

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 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 soil; Shear strength of soil by direct shear test; Shear strength of soil by tri-axial shear test.

## Suggested Readings

1. Punmia, B. C., Jain, A. K. and Jain, A. K. 2005. *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.

## 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

Properties of fluids: Ideal and real fluid, units; Pressure and its 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.

Kinematics of fluid flow: Lagrangian and Eulerian description of fluid motion, continuity equation, path lines, streak lines and stream lines, 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, venturimeter, orifice meter and pitot tube, siphon.

Flow through orifices (measurement of discharge, measurement of time), flow through mouthpieces; Flow over notches, flow over weirs, end contraction of rectangular weirs, ventilation of weirs, various types of nappe.

Laminar and turbulent flow in pipes, general equation for head loss Darcy equation, Moody's diagram, minor and major hydraulic losses through pipes and fittings, flow through network of pipes, hydraulic gradient and energy gradient, Chezy's formula for loss of head in pipes, flow through simple and compound pipes, transmission of power through pipes.

Open channel design and hydraulics: Chezy's formula, Bazin's formula, Kutter's, Manning's formula, best hydraulic section, velocity and pressure profiles in open channels, hydraulic jump; Discharge measurement in open channels: current meter.

Dimensional analysis and similitude: Rayleigh's method and Buckingham's 'pi' theorem, types of similarities, dimensionless numbers; Introduction to fluid machinery.

### 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 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.

### Suggested Reading

1. Bansal, R. K. 2019. *A Text book of Fluid Mechanics*. Laxmi Publications, New Delhi.
2. Ramanathan, S. 2011. *Hydraulics, Fluid Mechanics & Hydraulic Machines*. Dhanpat Rai & Sons, Delhi.
3. Khurmi, R. S. and Khurmi, N. 1987. *Hydraulics, Fluid Mechanics and Hydraulic Machines*. S. Chand & Co. Ltd., New Delhi.
4. Modi, P. N. and Seth, S. M. 2017. *Hydraulics & Fluid Mechanics including Hydraulic Machines*. Standard Book House, Delhi.

## Engineering Properties of Agricultural Produce and Food Science

3 (2+1)

### Objective

To make the students acquainted with the different engineering properties of agricultural produce and to help them understand the importance of these properties in handling, processing and storage

### Theory

Different engineering properties of food and their importance; Application of engineering properties in handling, processing and storage; Physical properties, viz. shape, size, roundness, sphericity, volume, density, porosity, specific gravity, surface area; Colour properties, CIE colour model.

Thermal properties, viz. heat capacity, specific heat, thermal conductivity, thermal diffusivity, heat of respiration, co-efficient of thermal expansion; Electrical and dielectric properties as resistance, capacitance, dielectric loss factor, loss tangent, and dielectric constant; Frictional properties, viz. static friction, kinetic friction, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials; Aero-dynamic characteristics such as drag coefficient, terminal velocity.



Rheological characteristics of food, elastic, plastic and viscous behaviour, visco-elasticity; rheological models to explain food characteristics; Fluid behaviour as Newtonian, non-Newtonian, pseudo-plastic, dilatant, thixotropic, rheopectic and Bingham plastic; Textural characteristics of foods.

Non-destructive methods of quality determination of foods; Principles of machine vision systems, spectroscopy, hyperspectral imaging and acoustic techniques.

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, Different 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 behavior 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.

### Suggested Readings

1. Mohesin, N. N. 1980. *Physical Properties of Plants & Animals*. Gordon & Breach Science Publishers, New York.
2. Rao, M. A. and Rizvi, S. H. 1995. *Engineering Properties of Foods*. Marcel Dekker Inc. New York.
3. Serpil, S. and Servet, G. S. 2005. *Physical Properties of Foods*. Springer Science+Business Media, LLC, 233 Spring Street, New York.
4. Singhal, O. P. and Samuel, D. V. K. 2003. *Engineering Properties of Biological Materials*. Saroj Prakasan, New Delhi.

### 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

Introduction to farm mechanization; Classification of farm machines; Unit operations in crop production; Identification and selection of machines for various operations on the farm.

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.

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.

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.

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.

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.

## 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.

## Physical Education, First Aid, Yoga Practice and Meditation

2 (0+2)

### Objectives

1. To make the students aware about Physical Education, First Aid and Yoga Practices
2. To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general wellbeing 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 ageing and role of regular exercise on ageing 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

- Asanas: Definition and Importance, Padmasan, Gaumukhasan, hadrasan, Vajrajan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan– left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhhanurasan, Sawasan
- Suryanamskar Pranayama (Definition and Importance) Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari
- Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
- Mudras (Definition and Importance) Gyanmudra, Dhyamudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
- Role of yoga in sports
- Teaching of Asanas – demonstration, practice, correction and practice.

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.

## Semester IV

### Engineering Mathematics-II

3 (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

Vector calculus: Scalar and vector point functions, vector differential operator Del, gradient of scalar point function, divergent and curl of vector point function and their physical interpretations, line, surface and volume integrals, Green's, Stock's and Divergence theorem (without proofs), functions of a complex variable, limit, continuity and analytic function, Cauchy-Reimann equations, harmonic functions.

Fourier series: Periodic functions, Euler's formulae, functions having arbitrary period, even and odd functions, half range series expansion, series expansion of functions with finite discontinuity; Laplace Transform: rules for Laplace transform and inverse Laplace transform, applications to find solutions of ordinary and simultaneous differential equations.

Numerical methods: Finite difference operators and their relationship, factorial notation. Newton's forward and backward interpolation formula, Newton's divide difference interpolation and 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 of order four.

#### 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.
- Ramana, B. V. 2008. *Engineering Mathematics*. Tata McGraw-Hill, New Delhi.

### Theory of Structures

2 (1+1)

#### Objectives

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

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.

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

## Suggested Readings

1. Bhavikatti, S. S. 2014. *Design of Steel Structures: By Limit State Method as Per IS: 800-2007*. I K International 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.

## 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

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.

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

Building construction: Building components, foundations, brick work, lintels, columns, roofs and stair cases, different types of floors, plastering and pointing, damp proofing and waterproofing,

white washing, distempering and painting, steps for building construction, needs of different agricultural buildings, types and uses, types of roofs, slope and flat roof buildings.

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, estate development.

Cost economics: Measurement and pricing, economic methods for evaluation of buildings, 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.

### 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

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.

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.

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.

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.

### 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.

### 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

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.

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.

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.

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.

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 device; 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.

## Suggested Readings

1. Chow, V. T. 1985. *Open-Channel Hydraulics*. McGraw- Hill Book Company, Inc.
2. 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.
3. Mahnot, S. C. 2014. *Soil and Water Conservation and Watershed Management*. International Books and Periodicals Supply Service, 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*. 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, Ithaca, 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. Das, G. 2000. *Hydrology and Soil Conservation Engineering*. Prentice Hall of India Pvt. Ltd, New Delhi.
13. USDA. 1964. *Engineering Hand Book on Drop Spillways (Section-11)*. USDA, Soil Conservation Service.

## **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 weeding, harvesting, etc., including operations done by combines, etc.

### **Theory**

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.

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; Hay conditioning, importance, methods of hay conditioning, and calculation of moisture content of hay.

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.

Root crop diggers: Principles of operation, functional components, blade adjustment and approach angle, calculation of material handled; Potato and groundnut diggers; Cotton harvesting-cotton harvesting mechanisms, cotton pickers and strippers; Maize harvesting combines; Vegetables and fruit harvesting equipment and tools.

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.

## 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
9. Suresh, R. and Kumar, S. 2018. *Farm Power and Machinery Engineering*. Standard Publishers.

## Renewable Energy Sources

3 (2+1)

### Objective

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

### Theory

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.

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.

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.

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.

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.

### 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.

### 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

General unit operations in agricultural process engineering and importance of these unit operations in grain processing; Structure and composition of cereals, pulses and oil seeds.

Cleaning and grading: Principles of cleaning, scalping, sorting and grading; screens, different types of screen separators, fixed and variable aperture screens, capacity and effectiveness of screens, sieve analysis; various types of separators as specific gravity, magnetic, disc, spiral, pneumatic, inclined belt draper, velvet roll separator, colour sorter, cyclone separator.

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.

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.

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.

### 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.

### Entrepreneurship Development and Business Management

3 (2+1)

#### Objective

1. To provide the student an insight into the concept and scope of entrepreneurship
2. To expose to various aspects of establishment and management of a small business unit
3. To enable the student to develop financially viable agribusiness proposal.

## Theory

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. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in 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 project; project report preparation, Enterprise Management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages / salaries. 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, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural 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.

## Suggested Readings

- Charantimath, P.M. 2009. *Entrepreneurship Development and Small Business Enterprises*. Pearson Publications, New Delhi.
- Desai, V. 2015. *Entrepreneurship: Development and Management*. Himalaya Publishing House.
- Desai, V.1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House
- Grover, Indu. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
- Gupta, C.B. 2001. *Management Theory and Practice*. Sultan Chand & Sons.
- Khanka, S. S. 1999. *Entrepreneurial Development*. S. Chand & Co.
- Mehra, P. 2016. *Business Communication for Managers*. Pearson India, New Delhi.
- Pandey, M. and Tewari, D. 2010. *The Agribusiness Book*. IBDC Publishers, Lucknow.
- Singh, D. 1995. *Effective Managerial Leadership*. Deep & Deep Publ.
- Singhal, R.K. 2013. *Entrepreneurship Development and Management*. Katson Books.
- Tripathi, P. C. and Reddy, P. N. 1991. *Principles of Management*. Tata McGraw Hill.



**Post-IV semester****Internship (only for exit option for award of UG-Diploma) 10 weeks****10 (0+10)****Objective**

To provide students with an opportunity to put into practice the skills they have learned while studying in the institute, so that in case they exit with UG-Diploma, they will be able to get proper engagement/ employment and will be competent to start an enterprise

**Activity**

The students will have internship/ training for 10 weeks' duration either in the parent institute (attaching the students to facilities such as farm machinery testing centre, incubation centres, prototype production facilities, etc.) or in industry, farm machinery service centre or related organisations involved in agri-engineering activities. The College/ University will facilitate attaching the students to the organisations.

After completion of internship, the students will have to submit a report on their learnings and also present in form of a seminar.

The assessment will be based on the report / assessment received from the industry/ organisation and the report and the presentation made at the College. Ideally the weightage will be 50% each for both internal and external. The HAEIs may modify the weightage and breakups.

**Semester V****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**

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.

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.

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 determine the quality of check of two different aggregates through impact test; 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<sup>nd</sup> and 4<sup>th</sup> week; To prepare concrete specimen to perform the compression, bending test and to measure elasticity - concrete cylinders, cubes and beams to test after 2<sup>nd</sup> and 4<sup>th</sup> 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.

## 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. Lehari, 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.

## Theory of Machines

2 (2+0)

### Objective

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

### Theory

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.

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.

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.

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.

### 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.

### Thermodynamics and Heat Transfer

**3 (3+0)**

#### Objective

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

#### Theory

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.

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.

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.

Thermal radiation, black body radiation, Stefan-Boltzman 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.

### Suggested Readings

1. Gupta, C. P. and Prakash, R. 2008. *Engineering Heat Transfer*. Nem Chand and Bros., Roorkee.
2. Holman, J. P. 2018. *Heat Transfer*. McGraw Hill Book Co., New Delhi.
3. Incropera, F. P. and De Witt, D. P. 2016. *Fundamentals of Heat and Mass Transfer*. John Wiley and Sons, New York.
4. Kumar, D. S. 2016. *Engineering Thermodynamics*. S.K. Kataria & Sons, Delhi.
5. Rajput, R. K. 2019. *A Text Book of Heat and Mass Transfer*. S. Chand & Company Ltd., New Delhi.

### 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

Sources of farm power: conventional and non-conventional energy sources; Classification of tractors and IC engines.

Review of thermodynamic principles of IC (CI and SI) 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.

Study of engine components their construction, operating principles and functions; Engine strokes and comparison of 2-stroke and 4-stroke engine cycles and CI and SI 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.

Different tests on fuel for SI and CI engines; Detonation and knocking in IC engines; Carburetion system, carburetors 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; 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.

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.

### Suggested Readings

1. Ganesan, V. 1999. *Internal Combustion Engines*. Mc Graw 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 Reinhold, 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.

### 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

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.

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.

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.

Surface methods of water application: Border, check basin and furrow irrigation- adaptability, specification and design considerations; Water logging-causes and impacts; Drainage, objectives of drainage, familiarization with the drainage problems of the state, drainage coefficient.

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, 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.

## 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. *Drainage Engineering*. ICAR Publications, New Delhi.
3. Bhattacharya, A. K. and Michael, A. M. 2013. *Land Drainage, Principles, Methods and Applications*. Vikas Publication House, Noida (UP).
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.

## Food and Dairy Engineering

4 (3+1)

### Objective

1. To make the students acquainted with the different unit operations in processing and value addition of different dairy and food products
2. To make them understand the different types of equipment and their working principles used for these.

### Theory

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; Thermal processing: thermo-bacteriology, 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.

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, nano-filtration, ultra-filtration and macro-filtration; membrane modules; Extrusion cooking: principle, factors affecting extrusion cooking, single and twin screw extruders.

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.

### Suggested Readings

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

### Personality Development

2 (1+1)

#### Objective

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability

#### Theory

Personality definition, Nature of personality, theories of personality and its types. The humanistic 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.

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.



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.

### Suggested reading

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: Wadsworth.

### Seminar

**1 (0+1)**

### Objective

1. To enable students to improve their knowledge and understanding of a topic
2. 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.

### Study tour

**2 (0+2) NG**

The study tour will be of 10-14 days duration within the 5<sup>th</sup> semester.

The students will visit industries/ institutions, preferably outside the state, so that, in addition to visiting the organisations/ 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.

## Semester VI

### Tractor Systems and Controls

3 (2+1)

#### Objective

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

#### Theory

Transmission system- need of the system in a tractor, types, major functional systems; 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.

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, 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; 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.

#### 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*. 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.

## 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

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.

Darcy's law, determination of hydraulic conductivity by laboratory and field method; Groundwater hydraulics- Dupit's assumptions and Dupit'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.

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.

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, upcoming of saline water, Ghyben-Herzberg relationship between fresh and saline water.

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.

### 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.

### 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.

### Sensors, Artificial Intelligence and Robotics in Agriculture

3 (2+1)

#### Objective

To enable the student to know the

1. Basics and selection of sensors for different agricultural applications
2. Application of artificial intelligence and AI programming techniques
3. Problem-solving through search and knowledge representation and reasoning with AI
4. Use of open source hardware (arduino and raspberry pi); robot programming, controlling algorithm and basics on neural network

Sensors Fundamentals: Introduction to sensors and transducers; Need for sensors in the 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 – Peizo resistive effect – Piezoelectric effect – Pyroelectric effect- Magneto mechanical effect (magnetostriction) – Magneto resistive effect.

Basics of detector materials/ sensor type (Silicon diod, 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.

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, colour sensor, spectral sensor, temperature sensor, humidity sensor, wind speed, motion sensors, position sensor etc.

Biosensors, general components of biosensor, biomolecules in biosensors such as enzyme, DNA, antibody, Nanomaterials in biosensors- Quantum dots.

### **Selection of sensors:**

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.

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.

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.

Application in Agriculture: Introduction to precision farming tools for implementation of precision agriculture; Application of 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.

### 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*. 3<sup>rd</sup> 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 – Verlag GmbH Berlin Heidelberg, Germany, ISBN 978-3-642-15795-0, doi 10.1007/978-3-642-15796-7: 288p.
7. Nikku, S. B. 2020. *Introduction to Robotics – Analysis, Control, Applications*. 3rd edition. John Wiley & Sons Ltd., 2020.
8. Nilsson Nils, J. 1980. *Principles of Artificial Intelligence*. Elsevier.
9. Rich, Knight and Nair. *Artificial Intelligence*. Tata McGraw Hill.
10. Saha, S. K. 2014. *Introduction to Robotics*. Tata McGraw Hills Education, 2014.
11. Schilling Robert, J. 1990. *Fundamentals of robotics – Analysis and control*. Prentice Hall of India.

### Agricultural Structures and Environment Control

3 (2+1)

#### Objective

1. To make the students acquainted with the different types of agricultural structures
2. To enable them to prepare plan and estimate for different farm structures and environment control measures.

#### Theory

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, piggyery and other farm structures.

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.



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.

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 green house; 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.

### 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. Nathanson, 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.

### 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

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.

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).

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.

Environmental aspect of bio-energy; Assessment of greenhouse gas mitigation potential; Cost economics of bio-energy systems.

## 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.

## 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.

## Refrigeration and Air Conditioning

3 (2+1)

### Objective

1. 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

Definition of pure substance, phases of a pure substance, phase change process of a 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.

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.

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, psychrometric chart and its use, elementary psychrometric processes.

Air conditioning: principles, type and functions of air conditioning, physiological principles in air conditioning, air distribution, 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.

### Suggested Readings

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

## 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

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).

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.

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, evaporatively 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.

## 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*.

Kalyani Publishers, New Delhi

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.

## Case study

1 (0+1)

### Objectiv

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.

## Semester VII

### 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 7<sup>th</sup> and 8<sup>th</sup> semesters, viz. Project I (0+3 credit hours in 7<sup>th</sup> semester) and Project II (0+4 credit hours in the 8<sup>th</sup> 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 organisation/ industry).

### Engineering Graphics and Design

**2 (0+2)**

#### Objective

1. To acquaint the students with CAD softwares for drawing of machine components
2. 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 2 D- 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 3-D commands- Extrusion and lift, sweep and press pull, revolving, joining; Demonstration on CNC machine and practice problems.

#### 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.

## Food Quality and Safety

3 (2+1)

### Objectives

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

Basics of food quality, safety and food analysis; Concept, objectives and need of food quality; definition, objective measurement of quality and 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; 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.

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, 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 food 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.

### Suggested Readings

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.

### Websites and weblinks:

12. <https://www.fssai.gov.in/cms/food-safety-and-standards-regulations.php>
13. <https://www.fssai.gov.in/cms/food-recall.php>
14. <https://www.fao.org/fao-who-codexalimentarius/en/>

## 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

Watershed- introduction and characteristics; 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.

Community mobilization and participatory institution building: participatory watershed management, role of watershed associations, user groups and self-help groups; Participatory Rural Appraisal, understanding gender in relation to agriculture.

Water budgeting in a watershed; Management measures - rainwater conservation technologies *in-situ* and *ex-situ* storage, water harvesting and recycling; Dry farming techniques - inter-terrace and inter-bund land management; Integrated watershed management- concept, components, arable



lands - agriculture and horticulture, non-arable lands- forestry, fishery and animal husbandry; Effect of cropping systems, land management and cultural practices on watershed hydrology.

Application of remote sensing and GIS in watershed planning and management; Introduction to Remote Sensing and GIS, Map projections and co-ordinate system. Spatial data structure: Raster, vector. Spatial relationship. Topology. Delineation of watersheds and generation of stream network; Preparation of various thematic maps in watershed; Hydrological Response Unit (HRU); Prioritization of watersheds; Watershed characterization; Watershed action plan; Analytical Hierarchy Process; Watershed evaluation and impact assessment; Quantification of surface and groundwater resources in watersheds; Computer models used for hydrologic and watershed modelling; Soil water assessment tool (SWAT); Case studies.

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.

### 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.

## Sprinkler and Micro Irrigation Systems

2 (1+1)

### Objective

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

### Theory

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.

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; 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 fertilisers, 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.

### 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., Shrimohan and Swaminathan, K. R. 1972. *Design and evaluation of irrigation methods (IARI Monograph No.1)*. Water Technology Center, IARI New Delhi.
5. Michael, A. M. 2012. *Irrigation: Theory and Practice*. Vikas Publishing, 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.

## 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

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; Design of shafts under torsion and combined bending and torsion; Design of keys; Design of muff, sleeve, and rigid flange couplings; Cotter joints, design of socket and spigot cotter joint; knuckle joint; Design of welded subjected to static loads; Design of helical and leaf springs; Design of threaded fasteners subjected to direct static loads, bolted joints loaded in shear and bolted joints subjected to eccentric loading; Design of flat belt and V-belt drives and pulleys; Design of gears; 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, Nai Sarak, 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.

## Electrical Machines

3 (2+1)

### Objective

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

### Theory

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, laws of magnetic circuits, determination of ampere-turns for series and parallel magnetic circuits, hysteresis and eddy current losses.

Transformer: principle of working, construction of single phase transformer, EMF equation, phasor diagram on load/ load, leakage reactance, voltage regulation, power and energy efficiency, open circuit and short circuit tests; D.C. machines: principles operation and performance of DC

machine (generator and motor), EMF and torque equations, excitation of DC generator and their characteristics, DC motor characteristics, starting of shunt and series motor, starters, speed control methods-field and armature control.

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, 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.

### 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.

### 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*. 11<sup>th</sup> 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.

### 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

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 curves, graphs and charts.

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.

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.

Testing of hypothesis – hypothesis, null hypothesis, types of hypothesis, level of significance, degrees of freedom – statistical errors; Large Sample test (Z-test), small sample 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 ( $2 \times 2$  contingency table).

## Practical

Construction of frequency distribution tables and frequency curves; Computation of arithmetic mean, median and mode for un-grouped and grouped data; Computation of harmonic and geometric mean; Computation of standard deviation (SD); Variance and coefficient of variation for un-grouped and grouped data; Computation of skewness, kurtosis; Standard normal distribution test for single sample mean (population SD known and unknown); SND test for two samples means (population SD known and unknown); Computation of binomial distribution; Computation of Poisson distribution; Calculation of correlation coefficient and its testing; Calculation of regression coefficient, regression line; Student's t-test for single sample mean; t-test for two samples means; Paired t test; F- test for equality for two sample variance test; Computation of Chi-square test: goodness of fit and testing of independence of attributes ( $2 \times 2$  contingency table) and  $m \times n$ .

## 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.

## Semester VIII

S. No.	Course Title	Credit hours
1.	Project -II	4 (0+4)
2.	In-plant Training/ Research Internship	8 (0+8)
3.	Elective- I	3 (2+1)
4.	Elective- II	3 (2+1)
5.	Elective- III	3 (2+1)
	<b>Total</b>	<b>21 (6+15)</b>

### **Project-II** **4 (0+4)**

This will be the continuation of work/ study taken under the course Project- I

### **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.

### **Electives- I** **3 (2+1)**

The options for Elective courses and the details are given after this section.

### **Elective- II** **3 (2+1)**

The options for Elective courses and the details are given after this section.

### **Elective- III** **3 (2+1)**

The options for Elective courses and the details are given after this section.



## ELECTIVE COURSES

The detailed syllabi of elective courses is given below.

### **Mechanics of Tillage and Traction**

**3 (2+1)**

#### **Objective**

To enable the students to

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

#### **Theory**

Introduction to mechanics of tillage tools, engineering properties of soil, principles and concepts, stress strain relationship; Design of tillage tools, principles of soil cutting, design equation, force analysis; Application of dimensional analysis in soil dynamics and traction prediction equation.

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.

#### **Suggested Readings**

1. Gill and Vandenberg. 1968. *Soil Dynamics in Tillage and Traction*. Agricultural Research Service, USDA, Govt. Printing Press, Washington, D.C.
2. Liljedahl, J. B., Turnquist, P. K., Smith, D. W. and Hoki, M. 2004. *Tractors and their Power Units*. CBS Publishers
3. Macmillan R H. 2002. *The Mechanics of Tractor-Implement Performance*. International Development Technologies Centre, University of Melbourne.
4. Terzaghi K and Peck R B and Mesri G. 1996. *Soil Mechanics in Engineering Practices*. John Willey & Sons.

### **Farm Machinery Design and Production**

**3 (2+1)**

#### **Objective**

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



## Theory

Introduction to design parameters of agricultural machines and design procedure, characteristics of farm machinery design, research and development aspects of farm machinery; 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; Critical appraisal in production of agricultural machinery, advances in material used for agricultural machinery; Cutting tools including CNC tools and finishing tools; Heat treatment of steels including pack carburizing, shot pining process, etc., limits, fits and tolerances, jigs and fixtures; 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.

## 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.

## Tractor Design and Testing

**3 (2+1)**

### Objective

To enable the students to understand

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

### Theory

Procedure for design and development of agricultural tractor; Study of parameters for balanced design of tractor for stability and weight distribution; Traction theory; hydraulic lift and hitch system design; Design of mechanical power transmission in agricultural tractors: single disc, multi disc and cone clutches; Rolling friction and anti-friction bearings; Design of Ackerman Steering and

tractor hydraulic steering; Study of special design features of tractor engines and their selection, viz. cylinder, piston, piston pin, crankshaft, etc.; Design of seat and controls of an agricultural tractor; Tractor Testing.

### 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.

### 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. Richey, C. B. 1961. *Agricultural Engineering Handbook*. McGraw-Hill Inc., US.
5. Singh, K. 2018. *Automobile Engineering – Vol I and Vol II*. Standard Publishers and Distributors. New Delhi.

## Hydraulic Drives 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

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

## 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.

## 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

### Theory

Human factors in system development- concept of systems, basic processes in system development, performance reliability, human performance; 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; Human motor activities, controls, tools and related devices; Anthropometry: arrangement and utilization of work space, atmospheric conditions, thermo-regulation in human, thermal comfort, environmental factors, air pollution; Dangerous machine (Regulation) act, rehabilitation and compensation to accident victims; Safety gadgets for spraying, threshing, chaff cutting and tractor and trailer operation, etc.

### Practical

Calibration of the subject in the laboratory using bi-cycle ergo-meter; 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.

### 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.

## **Precision Agriculture and System Management**

**3 (2+1)**

### **Objective**

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

### **Theory**

Precision agriculture- need and functional requirements; Familiarization with issues relating to natural resources; Equipment for precision agriculture including sowing and planting machines, power sprayers, land clearing machines, laser guided land levelers, straw-chopper, straw-balers, grain combines, etc.; Introduction to GIS based precision agriculture and its applications; Introduction to sensors and application of sensors for data generation; 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.

### **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

## **Photovoltaic Technology and Systems**

**3(2+1)**

### **Objective**

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

## Theory

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; 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.

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.

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.

## Suggested Readings

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

## 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

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.

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 siting; 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.

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

### Waste and By-Products Utilization

**3 (2+1)**

#### Objective

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

#### Theory

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.

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.



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.

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.

### 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.



## 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

Floods- causes of occurrence, flood classification- probable maximum flood, standard project flood, design flood, flood estimation- methods of estimation; Estimation of flood peak- rational method, empirical methods, unit hydrograph method; Statistics in hydrology, flood frequency methods- log normal, Gumbel's extreme value, log-Pearson type-III distribution; depth-area-duration analysis, flood forecasting; Flood routing- channel routing, Muskingum method, reservoir routing, modified Pul's method; Flood control- history of flood control, structural and non-structural measures of flood control, storage and detention reservoirs, levees, channel improvement.

Gully erosion and its control structures- design and implementation; Earthen embankments- functions, 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 dam, stability of earthen embankments against failure by tension, overturning, sliding, etc., 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.

### 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.

## 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

Basic component of remote sensing (RS), advantages and limitations of RS, 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, 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; 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, 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.

### Suggested Readings

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

### 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

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; Development of database concept for effective natural resources management; Application of remote sensing, geographic information system (GIS) and GPS; Rational data base management system, object oriented approaches; Information system, decision support systems and expert systems; 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.

#### 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.

### 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. 2013. *Climate-Smart Agriculture- Source Book*. FAO, Rome.
4. FAO. 1998. *Land and Water Resources Information Systems*. FAO Land and Water Bulletin 7, 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.

### Wasteland Development

**3 (2+1)**

#### Objective

1. 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
2. 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

Land degradation- concept, classification, arid, semiarid, humid and sub-humid regions, Troll's climatic classification, denuded range land and marginal lands; Wastelands- factors causing waste lands, classification and mapping of wastelands, planning of wasteland development- constraints, agro-climatic conditions, development options, contingency plans; 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; Shifting cultivation, optimal land use options; Wasteland development- hills, semi-arid, coastal areas, water scarce areas, reclamation of waterlogged and salt-affected lands; Mine spoils- impact, land degradation and reclamation and rehabilitation, slope stabilization and mine environment management; Micro-irrigation in wastelands development; Sustainable wasteland development- drought situations, socio-economic perspectives; Participatory approach in wasteland management; Preparation of proposal for wasteland development and benefit-cost analysis.

### 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.

### 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.

### Minor Irrigation and Command Area Development

**3 (2+1)**

#### Objective

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

## Theory

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

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

## 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.

## 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 to control of losses of water in canal commands and for design and layout of different canal outlet structures



## Theory

Typical network of canal irrigation system and its physical components; Canal classifications based on source of water, financial output, purpose, discharge and alignment; Canal alignment: general considerations; Different parts of canal sections, performance indicators for canal irrigation system evaluation; Estimation of water requirements for canal command areas and determination of canal capacity; Base period, water duty and delta, relationship between base period, duty and delta; factors affecting duty and method to improve 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; Maintenance of unlined irrigation canals, measurement of discharge in canals; Rostering (canal running schedule) and warabandi, rotational irrigation, pre-requisite of warabandi; Necessity of canal lining: advantages and disadvantages, types of canal lining and desirable characteristics for the suitability of lining materials, design of lined canals; Functions of distributary head and cross regulators; Canal falls, their necessity and factors affecting canal fall, types of canal falls; 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.

## 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. Sahasrabudhe, S. R. 2011. *Irrigation Engineering and Hydraulic Structures*. S K Kataria & Sons. Reprint 2015.

## 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

Natural factors affecting quality of surface water and groundwater, sources and pollution of groundwater; 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; 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; Water decontamination technologies; 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.

### 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.

## 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

Conventional method of landscape irrigation- hose irrigation system, and 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; 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; 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.

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.

### Suggested Readings

1. Michael, A. M. 2012. *Irrigation: Theory and Practice*. Vikas Publishing House, New Delhi.
2. Singh, N. P. 2010. *Landscape Irrigation and Floriculture Terminology*. Bangalore.
3. Smith, S. W. 1996. *Landscape Irrigation: Design and Management*. John Wiley and Sons, Inc., New York, United States.

## 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

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; 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; 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; 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.

### 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. Charles A. Harper. 2006. *Handbook of Plastics Technologies*. The Complete Guide to Properties and Performance. McGraw-Hill, New Delhi.
4. Chanda, M. and Roy, S. K. 2008. *Plastics Fundamentals, Properties, and Testing*. CRC Press.
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.

### Precision Farming Techniques for Protected Cultivation

3 (2+1)

#### Objective

1. To enable the students to design and construction of green houses in different agro-climatic zones, greenhouse cooling and 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

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; 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.; Greenhouse heating- components, methods, design of heating system; Root media- types, soil and soilless media, composition, estimation, preparation and disinfection, bed preparation.

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.

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.

## Suggested Readings

- Sharma, P. 2007. *Precision Farming*. Daya Publishing House New Delhi.
- Singh, B. and Singh, B. 2014. *Advances in Protected Cultivation*. New India Publishing Company.

## Environmental Engineering

3 (2+1)

### Objective

To enable the students to understand-

1. 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
2. The air pollution, types of pollutants, and their abetments

### Theory

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

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 water collection and disposal, Solid waste quantity, characteristics and disposal for urban and rural areas.

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.

### Suggested Readings

1. Chatterjee, A. K. 2006. *Water Supply, Waste Disposal & Environmental Engineering*. Khanna Publishers, Delhi

- Garg, S. K. 1977. *Environmental Engineering*. Vol, I and II. Khanna Publishers, Delhi
- Rao, P. V. 2002. *Text book of Environmental Engineering*. Prentice Hall of India Pvt. Ltd.

## Development of Processed Food Products

**3 (2+1)**

### Objective

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

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; 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; 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; 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.

### Suggested Readings

- Acharya, K. T. 2017. *Everyday Indian Processed Foods*. National Book Trust.
- Dash, S. K., Chandra, P. and Kar, A. 2024. *Food Engineering Principles and Practice*. CRC Press, Boca Raton, USA
- Mudambi, S. R., Rao, S. M. and Rajgopal, M. V. 2006. *Food Science*. New Age International Publishers.
- Negi, H. P. S., Sharma, S. and Sekhon, K. S. 2007. *Handbook of Cereal Technology*. Kalyani Pub.
- Potter, N. N. and Hotchkiss, J. H. 1995. *Food Science*. Chapman and Hall Pub.
- Rao, D. G. 2009. *Fundamentals of Food Engineering*. PHI Learning Pvt. Ltd, New Delhi.
- Srivastava, R. P. and Kumar, S. 2019. *Fruit and Vegetable Preservation: Principles and Practices*. International Book Distributing Company.

## Food Packaging Technology

**3 (2+1)**

### Objective

To enable the students to



1. Understand the interaction of food, packaging and environment
2. Understand the different methods of package development and packaging
3. Select the best type and form of packaging of specific food for specific end users

## Theory

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; 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.

Nutritional labelling on packages; CAS and MAP, shrink and cling packaging, vacuum and gas packaging; Active packaging, Smart packaging; Packaging requirement for raw and processed foods and selection of packaging materials; Disposal and recycle of packaging waste.

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 tests 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.

## 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.

## Food Plant and Equipment Design

3 (2+1)

### Objective

To enable the students to

1. Understand the managerial aspects of food processing plant
2. Understand Govt. policy on small and medium scale food processing enterprise
3. Understand the procedure of obtaining license and registration for operating food processing business

### Theory

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; 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.

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; 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 preprocessing 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.

### Suggested Readings

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.

## Emerging Technologies in Food Processing

3 (3+0)

### 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

Introduction, different emerging technologies and their scope and applications.

Principle, equipment and applications of ohmic heating, infrared heating, dielectric heating, microwave heating systems, radio frequency heating equipment, combined microwave vacuum drying new hybrid drying technologies.

Principles and equipment for Vacuum processing, High pressure processing, Pulsed electric field processing, Ultrasonication, Gamma irradiation/ ionising radiation, Ultraviolet radiation processing.

Pulsed X-ray processing, Pulsed light processing, Cold plasma Processing, Ozone treatment, Electron beam processing, Static and oscillating magnetic fields, Dense phase carbon dioxide, High voltage arc discharge.

Nanomaterial utilisation in food processing, manufacture of nanomaterials, applications.

### Suggested Readings

1. Dash, S. K., Chandra, P. and Kar, A. *Food Engineering Principles and Practices*. CRC Press
2. Passos and Ribeiro. *Innovation in Food Engineering – New Techniques and Products*. CRC Press
3. Sun Da-Wen. *Thermal Food Processing – New technologies and Quality Issues*. CRC Press
4. SunDa-Wen. *Emerging technologies in food processing*. Elsevier
5. Tewari and Juneja. *Advances in Thermal and Non-Thermal Food Preservation*. Blackwell

## Processing of Livestock, Fish and Marine Products

3 (2+1)

### Objective

To enable the students to

1. Learn various processes and methods for processing of livestock, fish and marine products
2. Understand the livestock and marine product processing and its applications in industries

## Theory

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; 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; 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; 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.

## Suggested reading

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.

## 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

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

## **MATLAB Programming**

**3 (1+2)**

### **Objective**

To enable the students to know the different features of MATLAB and have hands-on exercise on it and use the MATLAB for different agricultural engineering applications

### **Theory**

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.

MATLAB 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.

Arrays and functions: matrices and arrays, multi-dimensional arrays, compatible array, sparse matrices; Functions: normal functions, predefined functions, user-defined functions, anonymous Function

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.

## **Python Programming**

**3 (1+2)**

### **Objective**

1. To enable the students to know the different features of Python programming and have hands-on exercise on it
2. To use the Python programming for different agricultural engineering applications

### **Theory**

Introduction: history, applications, installation.

Variables, data types, keywords, literals, operators, comments.

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.

Files I/O, modules, exceptions, date, Regex, read CSV File, write CSV File, read excel file, write excel file, assert, list comprehension, collection.

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.

## Artificial Intelligence applications

**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

Foundation and history of artificial intelligence; Intelligent agents, structure of agents; AI programming languages, introduction to LISP and PROLOG; 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; 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; 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; 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.

## 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 3<sup>rd</sup> edn.

## Advances in Automation and Robotics in Agriculture

3 (2+1)

### Objective

To enable the students to gain advanced knowledge and skill for application of automation and robotics in agriculture, know about the modelling of robot mechanisms, robot control architectures and robot design and considerations for agricultural operations

### Theory

Sensors and sensor-driven robot Control, Robot Sensors, Proximity sensors- Infrared sensors, Ultrasonic sensor, Laser range finder, Robot Vision sensors- RGB camera, Thermal Camera, Multispectral sensor, Hyperspectral sensor, Stereo vision system, Optical flow sensor, GPS sensor-RTK, PPK. Sensor noise and uncertainty- Sensor uncertainty, Non-observability, Action uncertainty.

Introduction to Robotics and its importance in Agriculture, classification of robots (Anatomy), Automation and Robotics in Intelligent Environments, History of Robotics, Robot manipulators, Mobile robots, Walking Robot, Humanoid Robots, Autonomous Robots, Traditional Industrial Robots, Requirements for Robots in Intelligent Environments, Status and scope in Agriculture; Modeling of robot mechanisms, Kinematics, Dynamics, Robot sensor selection, Active and passive proximity sensors, Low-level control of actuators, Closed-loop control, Control architectures, Traditional planning architectures, Behavior-based control architectures, and Hybrid architectures. Modeling the Robot Mechanism, Forward kinematics, Inverse kinematics, Jacobian calculation, and Mobile Robot Odometry.

Robot Actuator Control system, Mass, inertia, friction and force, frequent actuators, control approach Proportional, PI, and PID control, Actuators- DC motor, BLDC motor, Linear actuator, Servomotor, Stepper motor, Drivers and control algorithms. Ground Control station system, Transmitters, and receivers, PWM, PPM signal, telemetry system, band, and frequency. Transmitter, receiver, PWM, PPM, Telemetry system, band and frequency; Robot Navigation, Path planning addresses and computing a trajectory, Algorithms, and control navigation, mission planning and control, Geofencing, Triggering, Software for robot control and navigation, Probabilistic Robot Localization- Localization, Mapping, and Model Building; Robot Control Architectures, Deliberative Control Architecture-Perception, modeling, planning, task execution and motor control, Advantages, and disadvantages; Behavior-Based Robot Control Architectures, Reactive, Behavior-Based Control Architectures, Hybrid Control Architectures, Intuitive Robot Interfaces- Graphical programming interfaces, Deictic (pointing) interfaces, Voice recognition and reaction.

AI adaptation and Learning for Robots-Supervised learning, Learning Sensory Patterns -Neural networks, Decision trees, Reinforcement Learning, AI programming techniques. Classical AI, the concept of expert system, conflict resolution, multiple rules, forward chaining, and backward chaining. Advantages and disadvantages of expert system.



Robot design and considerations for agricultural operations, Robots for Seedbed preparation, sowing and transplanting, weeding operation-mechanical and chemical, fruit harvesting, robots for greenhouse application, moisture management, post-harvest losses management, dairy and food packaging, humanoid robots, cattle and poultry farm management, VRT robots, Driverless Autonomous tractor.

## Practical

Demonstration of different types of robots and their use in agricultural operations; Robot mechanisms, forward kinematics, inverse kinematics calculations and modelling; PID control of actuators and their calibration for precise control; Practical on robot actuator control systems for determination of mass, inertia, friction, and forces; Calibration of PID controllers for close-loop controls of the system; Mission planning and computation of trajectory for a robot through Python coding and other software; Sensor-driven robot control for obstacle avoidance using different sensors; Calibration of GPS sensors and 3-D fixing for precise control; Robot control architecture design, control, and behavior study; Robot-supervised learning for sensory patterns to detect leaves, flowers, fruit, animal, human body, etc; Robot design consideration for sowing and transplanting operation; Robot design for weeding operation; Robotic arm design for fruit detection and harvesting; Robotic prime mover design for greenhouse operations for selected crops; Automation of machines for food packaging; Robots for food control and cleaning in cattle and poultry farms; Robots for variable rate application of agricultural inputs; Driverless and autonomous tractor for straight control calibration of movement; Control of humanoid robots for selected agricultural operations and active voice command control.

## Suggested Readings

1. Ben-Ari, Mordechai and Mondada, Francesco. *Elements of Robotics*. Springer Nature, 2017.
2. Bräunl, T. *Embedded Robotics Mobile Robot Design and Applications with Embedded Systems*. Springer Berlin Heidelberg, 2013.
3. Craig, John J. *Introduction to Robotics Mechanics and Control*. 5 Pearson Education, Inc. Pearson Prentice Hall Pearson Education, Inc. Upper Saddle River, NJ, 2005.
4. Miller, Mark R. and Miller, Rex. *Robots and Robotics, Principles, Systems, and Industrial Applications*. McGraw-Hill Education, 2017.
5. Schilling, Robert. J. *Fundamentals of Robotics – Analysis and Control*. Prentice Hall of India, 1990.
6. Siegwart, Roland, Nourbakhsh, Illah Reza and Scaramuzza, Davide. *Introduction to autonomous Mobile Robots*. MIT press, 2011.
7. Zhang, Dan, and Bin Wei, eds. *Robotics and mechatronics for agriculture*. CRC Press, 2017.

## Machine Learning

**3 (2+1)**

### Objective

To enable the students to

1. Know the basics of machine learning
2. Know the applications of machine learning in different fields



## Theory

Introduction to Machine Learning, Preliminaries, what is machine learning; varieties of machine learning, learning input/output functions, bias, 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; 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.

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. 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.

## Suggested Readings

1. Ethem, Alpaydin. 2009. *Introduction to Machine Learning*. 3<sup>rd</sup> 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*. 2<sup>nd</sup> edn. Wiley.

## Operations Research

**3 (3+0)**

### Objective

To enable the students to

1. Understand the importance of operations research for solving field problems
2. Understand and apply linear programming, transportation problem, etc. for agricultural engineering applications
3. Understand the project planning and network analysis

### Theory

Introduction to operations research: elementary concepts and objectives, applications of operations research in decision making; 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; Transportation problem, definition and mathematical formulation, initial basic feasible solution, optimal solution; Assignment problem, introduction and mathematical formulation, solution of Assignment problem; 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; 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).

### Suggested Readings

1. Taha, H. 2003. *Operations Research*. Macmillan Publishing Company.
2. Winston, W. L. 2004. *Operations Research: Applications and Algorithms*. Indian University.

### Mechatronics

**3 (2+1)**

#### Objective

To enable the students to

1. Know the measurement system, control systems, microprocessor-based controllers of A.C. & D.C. motor
2. Understand the principles behind the working of different data acquisition, digital signal processing
3. Know the different application of microcontrollers, PLC. robotics, robot components, robot classification and specification

#### Theory

Definition of mechatronics, measurement system, control systems, microprocessor based controllers, mechatronics approach; Sensors and transducers- performance terminology, displacement, position and proximity sensors, photo-electric transducers, flow transducers, optical sensors and transducers;

Actuators and mechanical actuation systems- hydraulic and pneumatic actuation systems, measurement system, electrical actuation systems, A.C. motor, D.C. motor, stepper motor, signal conditioning process, filtering digital signal, data acquisition system, multiplexers, digital signal processing, pulse modulation, data presentation systems.

System modelling and control- mathematical models, engineering systems, electro-mechanical and hydraulic-mechanical systems, modelling dynamic systems, transfer functions, control modes and PID controller.

Micro-processor and computer- computer and interfacing, micro-computer structure, micro-controllers, application of microcontrollers, PLC, robotics, robot classification and specification, robot components, work envelopes, other basic parameters of robots, robot applications, robot applications in manufacturing, material transfer and machine loading/ unloading, processing operations like welding and painting, assembly operations, inspection, automation, future applications.

#### Practical

Study of different types transducers; Selection of sensor for a particular application from catalogue and internet; Design of a mechatronics product/ system; Application of mechatronics for

enhancing product values; Study of electrical actuation systems with A.C. Motor and with D.C. Motor; Study of electrical actuation systems with Stepper Motor; Study of the PID Controller; Study of the hardware and software of mechatronics kit; Study of the pulse modulation, data presentation systems; Moving a table in X-direction within the range of proximity sensors using Control-X software; Running a motor with PLC; Running a conveyor with computer; Study of the movement of actuating cylinders and sensors.

### Suggested Readings

1. Bolton, W. 2015. *Mechatronics*. Pearson Education Asia.
2. Craig, J. J. 1986. *Introduction to Robotics*. Pearson Education International.
3. Doebelin, E. O. 1966. *Measurement Systems*. McGraw-Hill Inc.
4. Malvino, A. P. 1983. *Digital Computer Electronics*. McGraw-Hill Inc.
5. Niku, S. Y. 2001. *Introduction to Robotics: Analysis, systems and Applications*. Pearson Education International.
6. Stadler, W. 1995. *Analytical Robotics and Mechatronics*. McGraw-Hill Inc.

### Natural Fibres: Extraction and Properties

3 (2+1)

#### Objective

To enable the students to

1. Importance of natural fibres and the quality management of natural textile fibres
2. Understand the properties of different types of natural fibres and their extraction methods
3. Understand the different equipment involved in natural fibres extraction

#### Theory

Introduction to Natural Fibres: Natural fibres definition, Detailed Classification; Natural fibres–physical and chemical properties, Advantages and disadvantages of Natural Fibres; Plant Fibres; Animal Fibres; Applications of Natural Fibres. Identification, characterization and quality management of natural textile fibres.

Cotton: Types, Morphology, Physical and Chemical properties, grading and marketing, Organic and Bt cotton, processing and utilization; Wool: types, Morphology, Physical and Chemical Properties, grading and marketing processing and application; Jute: Cultivation- Extraction and Retting methods, physical and mechanical properties, grading and marketing, significance of Jute in Packaging. diversified application of jute; Other (Natural) Textile Fibres: Long Vegetables fibres, Cultivation and extraction of Flax, Sisal, Pineapple leaf, Maize, banana, hemp; Physical and Chemical Properties, grading and marketing, processing and end use application.

Silk: Types of Silk, Cultivation of mulberry, production of silk cocoon, storage, Sorting, cooking, brushing, reeling (Methods and Machines), morphology, Physical and Chemical Properties, grading and marketing, processing-degumming and weighting.

Physical Properties of Natural fibres: Fibre Morphology; Fibre length, diameter, l/b ratio and its significance; concept of denier and tex; colour and lustre, Fibre defects and root content; cross sectional study of fibres; yarn count, moisture regain, thermal behavior; Mechanical Properties:

Stress-stain curve, tenacity, elongation, tensile modulus, bundle strength, compressional and resilience properties.

### Practical

Identification of natural fibres; Extractions of jute, cotton, flax, banana, sisal and ramie; Retting of Jute and Flax; Quality evaluation of jute and other fibres; Determination of mechanical and insulation properties.

### Suggested Readings

1. Cook, J. G. 2005. *Hand Book of Textile Fibers*. Wood Head Publishers, London, Vol 1 & 2
2. Corbmann, P. B. 2001. *Textile Fiber to Fabric*. Mc Graw-Hill International Education, 6th edn.
3. Gohl and Vilensky. 2003. *Textile Science*. 2nd edn. Mahajan Book Publishers,
4. Mishra, S.P. 1998. *Fibre Science and Technology*. New Age India International Ltd. New Delhi.
5. Shenai, V. A. 2004. *Technology of Textile Processing- Textile Fibers*. Sevak Publications.
6. Sreenivasa Murthy, H.V. 1994. *Introduction Textile Fibres*. Textile Association of India, Bombay.
7. Tammanna and Sonwalkar, N. 2002. *Handbook of Silk Technology*. Wiley Eastern Limited, New Delhi.

## Natural Fibre Applications in Agriculture

3 (2+1)

### Objective

To enable the students to

1. Know the different applications of natural fibres such as in soil and water conservation, packaging, energy production and soil less farming, etc.
2. Understand the economics of using natural fibres for these applications

### Theory

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, 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, 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.

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 Soiless Farming: Overview of organic and natural farming, soiless 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 soiless 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.

## 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.

## Processing of Natural Fibres

3 (2 + 1)

### Objective

To enable the students to

1. Understand the chemical composition of natural fibres and their conversion methods
2. Understand the different mechanical and chemical processing methods of natural fibres
3. Know about the different value addition methods for natural fibres

### Theory

Concept of spinning: Hand spinning system; Charkha spinning system; Concepts and working principles of ginning, opening, cleaning and blending.

Concept of Yarn Manufacture: cotton system, woolen system, worsted system, jute system, flax (wet) system: Blow room, Carding (Flat type and roller-clearer), Drawing machine, roving machine, Ring spinning, Rotor spinning; Modern developments in spinning; Principle of ring doubler and two-for-one twister; Fibre packing density of yarn; Yarn twist and its relation to yarn properties. Stress-strain relation, Mass irregularity.

Preparatory weaving: Winding, Warping, Sizing, beaming, drawing and denting; Weaving: Concept of weaving, Handloom, Primary and secondary motions of loom; shedding, picking, Beat-up, Loom timing, Take-up and Let-off motions; Type of sheds; Tappet, dobby and jacquard Warp and weft stop motions; Warp protector motion. Shuttle loom, Shuttle-less looms, Basic designs; Basic woven fabric structure and design; Knitting: Concept of knitting, Warp knitting, weft knitting, advances in knitting; Nonwoven: Concept of nonwoven and classification of nonwoven, advances in non-woven preparation.

Basic Yarn testing: Count, Twist, tensile strength, CSP, Hairiness, Fabric testing: GSM, EPI, PPI, Tensile strength, tearing strength, Bursting strength, Crease recovery angle, Stiffness, Air permeability, Thermal conductivity; Fabric hand and comfort; Wetting and wicking; Water-vapour transmission.

Chemical composition of plant and animal fibres - Natural and added impurities; Pre-treatment of natural fibre for surface cleaning/ removing impurities – Desizing; Scouring; Degumming; Bleaching- reductive, oxidative; combined scouring and bleaching; Woollenization; Mercerization; fluorescent brightening agents; de-pigmentation; cottonisation; Carbonization, Felting of wool.

Value-addition of natural fibre by colouration- Introduction to dyes and pigments; Classification of dyes based on the source and application; Colouration of natural fibres- Direct, Acid, basic, Reactive, Vat, Sulphur, Solubilized and Natural dyes; Measurement of colour parameters; Evaluation of colour fastness against washing, light, bleaching, solvent; Dyeing machine; Dyeing of different textile forms-Hank yarn, Cone, Loose fibre, woven fabric, knitted fabrics and nonwoven fabric; Finishing: Physical, mechanical, physico-mechanical and chemical finishing; temporary and permanent finishing.

### Practical

Basic concepts of spinning; Manufacture of yarn from natural fibres; Practical on weaving and knitting; Yarn and fabric testing; Pre-treatments of natural fibres; Bleaching and dyeing of natural fibres; Finishing of natural fibres.



## Suggested reading

1. Booth J. E. 1996. *Principles of Textile Testing: An Introduction to Physical Methods of Testing Textile Fibres, Yarns and Fabrics*. 6th edn. London: Newnes Butterworths
2. Brown, R. 1978. *Weaving, Spinning and Dyeing Book*. London: Routledge and Kegan Paul.
3. Cegarra, J. P. and Valladperas, J. 1992. *The Dyeing of Textile Manual, the Scientific Bases and the Techniques of Application*. Italy: NecovaOfrito.
4. Corbman, B. P. 1983. *Fibre to Fabric step by Step Weaving*. 6th edn. New York: McGraw Hill.
5. David G, Sinclair, Roy, S. 1989. *Giles Laboratory Course in Dyeing*. 4th edn. London: Society of Dyers and Colourist.
6. Eichhorn SJ, Hearle JWS, Jaffe M, and Kikutani T. 2009. *Handbook of Textile Fibre Structure: Fundamentals and Manufactured Polymer Fibres*, Volume 1 in Woodhead Publishing Series in Textiles.
7. Fannin and Allen, A. 1979. *Handloom Weaving Technology*. New York: Van Nostrand Reinhold.
8. Jarman, C. 1998. *Plant Fibre Processing: A Handbook*. eBook 9781780442990, pp.64
9. Ponting, K. G. 1981. *A Dictionary of Dyes and Dyeing*. London: Bell and Hymen Ltd.
10. Rouette, H. K. 2001. *Encyclopaedia of Textile Finishes*. Berlin: Springer Verlag.
11. Saville, B. P. 1999. *Physical Testing of Textiles*. Woodhead publication. CRC Press.
12. Shenai, V. A. 1985. *Technology of Dyeing: Technology of Textile Processing*. Vol. VI. Sevak Publication.
13. Shenai, V. A. 1985. *Technology of Printing: Technology of Textile Processing*. Vol. IV. Sevak Publication.

## Agricultural Marketing and Trade

**3 (2+1)**

### Objective

To enable the students to

1. understand the fundamentals of agricultural marketing and trade
2. analyze the factors influencing supply and demand in agricultural markets
3. explore different marketing channels and strategies in agriculture
4. examine the role of government policies and regulations in agricultural markets

### Theory

Agricultural Marketing: 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 agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity – meaning, merits and demerits; marketing process and functions: 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 channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. 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 in marketing; speculation & hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for innovations in agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. 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.

### Suggested Readings

- Acharya, S.S. and Agarwal, N.L. 2006. *Agricultural Marketing in India*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Chinna, S. S. 2005. *Agricultural Economics and Indian Agriculture*. Kalyani Pub, N Delhi.
- Dominic Salvatore. *Micro Economic Theory*.
- Kohls Richard, L. and Uhl Josheph, N. 2002. *Marketing of Agricultural Products*. Prentice-Hall of India Private Ltd., New Delhi.
- Kotler and Armstrong. 2005. *Principles of Marketing*. Pearson Prentice-Hall.
- Lekhi, R. K. and Singh, J. 2006. *Agricultural Economics*. Kalyani Publishers, Delhi.
- Memoria, C.B., Joshi, R.L. and Mulla, N.I. 2003. *Principles and Practice of Marketing in India*. Kitab Mahal, New Delhi.
- Pandey, M. and Tewari, D. 2004. *Rural and Agricultural Marketing*. International Book Distributing Co. Ltd, New Delhi.
- Sharma, R. 2005. *Export Management*. Laxmi Narain Agarwal, Agra.

## SKILL ENHANCEMENT COURSES

(Indicative Activities/ Learning areas)

### Operation and Maintenance of Farm Machinery

**4 (0+4)**

- 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

**4 (0+4)**

- 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 of 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      4 (0+4)**

- 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

### **Fabrication, Operation and Maintenance of Renewable Energy Gadgets**

**4 (0+4)**

- 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 chullah, 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

### **Operation and Maintenance of Drones Used for Agricultural Applications**

**4 (0+4)**

- 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 implications of drone use in farming

### **Machine Vision, Sensors and Sensor Architectures**

**4 (0+4)**

- Overview of machine vision systems and their applications, Importance of sensors in machine vision, Basic principles of image processing and analysis
- Classification of sensors based on various criteria (type of measurement, operating principle, etc.), Overview of common sensor types: optical sensors, proximity sensors, temperature sensors, pressure sensors, etc.
- Comparison of different sensor technologies in terms of accuracy, response time, cost, and suitability for specific applications
- Components of a sensor system (sensor element, signal conditioning circuitry, interface electronics, etc.)
- Sensor characteristics: sensitivity, resolution, linearity, hysteresis, etc.
- Considerations in sensor selection and integration for specific applications
- Basics of image acquisition: sensors, lenses, lighting, Image processing techniques: filtering, edge detection, segmentation, feature extraction, etc., Role of algorithms in image analysis and interpretation
- Components and architecture of a typical machine vision system, Integration of sensors and vision systems for industrial automation and quality control

- Applications of machine vision in various industries (manufacturing, automotive, pharmaceuticals, etc.)
- Principles of 3D vision and depth sensing technologies, Types of 3D sensors: stereo vision, structured light, time-of-flight, etc.
- Applications of 3D vision in robotics, metrology, object recognition, etc.
- Examples of multisensor systems in real-world applications
- Overview of smart sensors and their capabilities (self-calibration, self-diagnosis, etc.), Integration of sensors into IoT (Internet of Things) platforms
- Case studies of IoT applications in agriculture
- Introduction to sensor networks, Communication protocols for sensor networks (Bluetooth, Zigbee, LoRaWAN, etc.)
- Basics of embedded vision systems, Integration of sensors and vision processing capabilities into embedded systems
- Applications of embedded vision in autonomous vehicles, drones, consumer electronics, etc.
- Real-world examples of sensor systems and machine vision applications, Hands-on exercises and projects involving sensor integration and image processing, Industry visits or guest lectures from professionals working in the field
- Emerging trends in sensor technology and machine vision, Challenges in developing advanced sensor systems (miniaturization, power efficiency, cost reduction, etc.), Ethical and societal implications of widespread sensor deployment and data collection

### **Design of Solar PV Systems Using Softwares**

**4 (0+4)**

- 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**

**4 (0+4)**

- 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**

**4 (0+4)**

- 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**

**4 (0+4)**

- 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**

**4 (0+4)**

- 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

### **Repair and maintenance of pumps and irrigation systems**

**4 (0+4)**

- 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**

**4 (0+4)**

- 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

### **Application of Remote Sensing and GIS for Agricultural Water Management**

**4 (0+4)**

- 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**

**4 (0+4)**

- 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

### **Geophysical Survey and Investigations for Groundwater Exploration and Installation of Tube Well/ Bore Well** **(0+4)**

- 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

### **Installation and Maintenance of Rooftop Rainwater Harvesting System** **4 (0+4)**

- 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 Structures** **4 (0+4)**

- 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

**Construction, Management and Maintenance of protected cultivation structures** **4 (0+4)**

- 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

**Agro Processing Methods, Equipment Operation and Maintenance** **4 (0+4)**

- 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 dal 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** **4 (0+4)**

- 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 and Value Addition and Cold Chain Logistics**

**4 (0+4)**

- Primary processing of fruits and vegetables
- Operation and maintenance of washer and graders
- Study of refrigeration system and freezing equipment
- Operation of precooling 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**

**4 (0+4)**

- 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**

**4 (0+4)**

- 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

### **ONLINE COURSES**

The students will have to take a minimum of 6 credits of online courses, (as per UGC guidelines for online courses) as a partial requirement for the B. Tech. (Agricultural Engineering) program.

The online courses can be from any field such as Engineering, Basic Sciences, Humanities, Psychology, Anthropology, Economics, Business Management, Languages including foreign language, Communication skills/ Music, etc. and can be taken from NPTEL, mooKIT, edX, Coursera, SWAYAM or any other portal.

The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses.

The courses will be non-gradual as separate certificates would be issued by institutes offering the courses. These can be taken any time during the 3<sup>rd</sup> and 4<sup>th</sup> years of the UG programme.

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.