दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

Bachelor of Science in Applied Life Sciences with Agrochemicals and Pest Management
or
Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management with Dissertation/Academic Projects/ Entrepreneurship
or
Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management with Dissertation/Academic Projects/ Entrepreneurship (Discipline-1 Major)
or
Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management with Dissertation/Academic Projects/ Entrepreneurship (Discipline-1 Major & Discipline-2 Minor)

Under UGCF-2022 based on NEP-2020
(*Effective from Academic Year 2022-23*)

Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Syllabus for Semester I and II is complete and finalized

Syllabus for Semester III to VI is subject to minor changes

Syllabus for Semester VII and VIII is yet to be decided

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Undergraduate Curriculum Framework – 2022

Preamble

The Preamble of the Undergraduate Curriculum Framework - 2022 underlines the historical perspective, philosophical basis, and contemporary realities of higher education as enshrined in the National Education Policy (NEP) 2020 and endeavours to synchronize these cornerstones while charting the road ahead for the state of higher education.

The University of Delhi, a premier institution for teaching, learning, and research in higher education, acclaimed nationally and internationally, has nurtured the quest for reaching the peak in every sphere of education, in its true sense, in the process of its contribution to nation-building. Being a Central University, mandated to act as the torchbearer in expanding the horizons of human resource development through expansion of higher education, it has always paid adequate premium towards constructive and meaningful innovation as a regular feature in its undergraduate curriculum development over the years.

A reflection of such sustained and continued endeavour is amply exemplified in the successive revision of undergraduate curricular framework over the decades and especially in the last two decades, keeping pace with the emerging trends in higher education in the new millennium globally and its critical importance in enriching the youth of our nation, well equipped with the prevailing priorities of skill development through innovative and practical oriented teaching-learning more than anything else.

To actualise the noble objective, as succinctly brought out in the National Education Policy 2020, the university has endeavoured to explore the possibility of further restructuring and refinement of its undergraduate curriculum framework in line with the objective and underlying philosophy of the NEP 2020 to capture the imagination of the youth of our nation which depicts the contemporary realities of our demographic advantage globally.

The resultant outcome of this comprehensive exercise undertaken by the university is the Undergraduate Curriculum Framework-2022 (UGCF-2022) which not only underlines the heart and soul of the NEP 2020 in letter and spirit but also goes on to create a teaching-learning framework at the undergraduate level to attract the young minds towards research, innovation, apprenticeship, social outreach, entrepreneurship and such similar areas of human knowledge and endeavours while imbibing the truly charged academic environment of the university and its constituent colleges.

1. UGCF-2022: Definitions and Abbreviations

(a) Academic credit – An academic credit is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

(b) Courses of study – Courses of the study indicate pursuance of study in a particular discipline. Every discipline shall offer four categories of courses of study, *viz.* Discipline Specific Core (DSC) courses, Discipline Specific Elective (DSE) courses, Skill Enhancement Courses (SECs) and Generic Elective (GE) courses. Besides these four categories of courses, a student will also select Ability Enhancement Courses (AECs) and Value-Added Courses (VACs) from the respective pool of courses offered by the University.

(i) Discipline Specific Core (DSC): Discipline Specific Core is a course of study, which should be pursued by a student as a mandatory requirement of student's programme of study. In B.Sc. (Hons) Applied Life Sciences with Agrochemicals and Pest Management (ALS-ACPM) programme, DSCs are the core credit courses of Chemistry, Botany and Zoology with some papers of agrochemicals and pest management (See Table 2) that would be studied by the student, with multiple exit options as per NEP 2020. A student will study three DSC Courses each, in Semesters I to VI (Table 3). In semesters VII and VIII, a student has to study one DSC course in each semester from ***any one*** of the three disciplines - Chemistry or Botany or Zoology, and not a combination of these.

(ii) Discipline Specific Elective (DSE): The Discipline Specific Electives (DSEs) are credit courses of Chemistry, Botany and Zoology. From semester III to semester VI, there are 12 DSE courses comprising four courses each from Botany, Chemistry and Zoology disciplines (Table 4). A student has an option of choosing one DSE course either from Botany, Chemistry or Zoology in each of the semesters III to VI (Table 4). In semesters VII and VIII, the student has an option of choosing a maximum of three DSE courses from any one of the disciplines - Chemistry or Botany or Zoology, and not a combination of Chemistry/ Botany/ Zoology.

(iii) Generic Elective (GE): Generic Electives is a pool of courses offered by various disciplines of study which is meant to provide multidisciplinary or interdisciplinary education to students. In case a student opts for DSEs beyond the student's discipline specific course(s) of study, such DSEs shall be treated as GEs for that student. In semesters I, II, V and VI, a student has to compulsorily study one GE course from a pool of courses offered by the institution. However, in semesters III and IV a student has an option of choosing either a DSE course in Chemistry/Botany/Zoology or a GE course of any discipline offered by the institution. Similarly, in semester VII and VIII a student can exercise an option of

choosing a maximum of two Generic elective courses out of a combination of DSE and GE courses.

Students are advised to select their DSE / GE / SEC courses in consultation with Faculty based on their subject preferences, selection of major and minor disciplines (if opted for) and also mandatory / preferred requirements of credits (if any) in specific subject areas for higher courses of study in University of Delhi and other institutions.

(iv) Ability Enhancement course (AEC), Skill Enhancement Course (SEC) & Value-Added Course (VAC).

These three courses are a pool of courses offered by all the Departments in groups of odd and even semesters from which a student can choose. A student who desires to make Academic Project/Entrepreneurship as Minor has to pick the appropriate combination of courses of GE, SEC, VAC, & Internship/Apprenticeship/Project/ Community (IAPC) which shall be offered in the form of various modules as specified in the scheme of studies.

- ***AEC courses*** are the courses based upon the content that leads to knowledge enhancement through various areas of study. They are Language and Literature and Environmental Science and Sustainable Development which are mandatory for all disciplines. Every student has to study "Environmental Science and Sustainable Development" courses I and II of two credits each in the first year (I/II semester) and the second year (III/IV semester), respectively. The AEC pool consists of credit courses in languages listed in the Eighth Schedule of the Constitution of India, as updated from time to time.

- ***SEC*** are skill-based courses in all disciplines and are aimed at providing hands-on training, competencies, proficiency and skills to students. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction. Any SEC paper can be opted by a student. A student will study one Skill Enhancement Course of 2 credits each in all the semesters, from semester I to VI. It is to be noted that in semesters III, IV, V and VI, students can choose either one SEC paper or can join any Internship/ Apprenticeship/ Project (following two credit system).

- ***VAC* courses** are common pool of courses offered by different disciplines and aimed towards personality building, embedding ethical, cultural & constitutional values; promote critical thinking, Indian Knowledge Systems, scientific temperament, communication skills, creative writing, presentation skills, sports & physical education and team work which will help in all-round development of students.

2. Features of UGCF-2022

The Undergraduate Curriculum Framework- 2022 (UGCF) is meant to bring about systemic change in the higher education system in the University and align itself with the NEP 2020. The objectives of the NEP 2020 have been reflected in the following features of UGCF:

a) Holistic Development

Holistic development of the students shall be nurtured through imparting life skills in initial years. These life skill courses shall include courses on 'Environment and Sustainable Development Studies', 'Communication Skills', 'Ethics and Culture', 'Science and Society', 'Computational Skills', 'IT & Data Analytics', and similar such skills which shall make the students better equipped to deal with the life's challenges.

Academic Flexibility

Flexibility to the students to determine their learning trajectories and pursuance of programmes of study has been well ingrained in the UGCF. The Framework allows students to opt for one, two, or more discipline(s) of study as a core discipline(s) depending on student's choice. He/she has been provided the option of focusing on studying allied courses of student's selected discipline(s) (DSEs) or diversifying in other areas of study of other disciplines. Students have also been provided with the flexibility to study SECs or opt for Internships or Apprenticeship or Projects or Research or Community Outreach at an appropriate stage. In the fourth year, students are provided flexibility to opt for writing a dissertation (on major, minor, or combination of the two) or opt for Academic Projects or Entrepreneurship depending upon their choice and their future outlook, post completion of their formal education.

b) Multiple Exits/ Re-entry/ Academic Bank of Credit (ABC)/ Academic Outreach

Given the extent of plurality of the Indian society and the diverse background to which students belong, multiple exits and provision of re-entry have been provided at various stages of the undergraduate programme to accommodate their requirement and facilitate them to complete their studies depending upon their priorities of life. The earning and accumulation of credits in the Academic Bank of Credit (ABC), and the flexibility to redeem the requisite credit for award of appropriate Certificate / Diploma/ Degree, as the per the norms laid down by the UGC and the University, shall be made available to the students to provide the opportunity for lifelong learning as well as for availing academic outreach beyond the superstructure of the programme of study in another University / Institution at the national /international level depending upon individual choice of the student(s).

c) Multidisciplinary Education

UGCF has incorporated multidisciplinary education by providing an opportunity to study multidisciplinary courses. In the B.Sc. (Hons.) Applied Life Sciences with Agrochemicals and Pest Management course, students can study DSC, DSE and SEC courses of Chemistry, Botany and Zoology. More importantly, a student can choose to study Generic Elective (GE) Courses in any discipline offered by the college. Further, a student pursuing a multidisciplinary course of study may obtain a Major and a Minor in two different disciplines if she/he completes the credit requirements.

The framework does not maintain/support hierarchy among fields of study/disciplines and silos between different areas of learning. As long as a student fulfils the pre-requisites of a course of study, he/she shall be able to study it. Modules or systems of study shall be meaningfully laid down so as to guide the students in choosing the track/academic paths for the desired outcome.

d) Multilingualism

One of the significant hallmarks of the framework is a provision of pursuing multilingualism while studying any other discipline as core subject(s), which has no bearing with any language and linguistics. Semesters I and II of the programme provide an opportunity to the students to study languages which are enshrined under the eighth schedule of the Constitution of India, thereby providing students opportunities for their holistic development, including the ability to acquire proficiency in a language beyond their mother tongue.

e) Research and Innovation

The framework provides a mandatory programme on research methodologies as one of the discipline specific elective (DSE) courses at the VI & VII semester for students who opt for writing dissertation on major or minor or interdisciplinary in the VII and VIII semesters. Dissertation/Academic Project/Entrepreneurship in the 4^{th} year shall commence from VII semester and conclude in VIII semester. Detailed outcomes of each track chosen out of these three options shall be notified and assessment at the end of VII and VIII semesters shall be done accordingly.

Further, provision for internship/apprenticeship/project/community outreach from semester III to semester VI provides ample opportunity to the students to explore areas of knowledge/activity beyond the four walls of the classroom and reach out to the world outside without any dilution of the academic feature of the course of study pursued by the student. This also acts a precursor for students to take up academic project or entrepreneurship at a later stage in VII & VIII semester. Such an initiative will help in skill development and laying a strong foundation for research and thus contribute towards overall national development through the development of skilled manpower and innovation.

f) Intra- and Inter-university Mobility

Intra and inter University mobility of students is another element of critical importance which has been ingrained in the framework. A student, by virtue of such mobility, will be able to make lateral movement within the University as well as from the University to any other Institution and vice-versa. Such an attribute allows a student maximum flexibility in terms of pursuance of education with special reference to higher education and enables him/ her to achieve goal of life, the way he/she perceived it.

Based on the aforementioned features of UGCF-2022, the University expects maximum involvement of the student fraternity in utilizing the benefits of such a flexible yet rigorous curriculum framework at the undergraduate level and reaping the benefits of it through enrichment of their skills in their area of interest which will eventually help them in gaining employment, entrepreneurship, start-ups and various other ways of a dignified life and living as a global citizen with comparable skills and innovative ideas befitting to the contemporary global demands. The university expects the youthful nation to reap the maximum benefits out of the UGCF-2022 in developing skilled manpower to harness the youthful energy at one hand and expand the permeation of the skilled workforce globally, taking the demographic advantage on the other hand.

3. Introduction to Undergraduate Degree course in Applied Life Sciences with Agrochemicals and Pest Management

As per the recommendations of UGCF 2022, the undergraduate degree course in Applied Life Sciences with Agrochemicals and Pest Management is a six/ eight semester course spread over three/ four academic years. The teaching – learning process is student-centric and it involves both theory and practical components. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. Besides the DSCs of three different disciplines i.e., Chemistry, Botany and Zoology, a student can opt courses from the syllabus comprising of DSEs, GEs, SECs, AECs and VACs thereby bringing out the multidisciplinary approach and adherence to innovative ways within the curriculum framework. Moreover, it allows a student maximum flexibility in pursuing his/ her studies at the undergraduate level to the extent of having the liberty to eventually design the degree with multiple exit options depending upon the needs and aspirations of the student in terms of his/ her goals of life, without compromising on the teaching-learning process, both in qualitative and quantitative terms. This will suit the present day needs of students in terms of securing their paths towards higher studies or employment.

4. Programme Duration and Exit Options

The minimum credit to be earned by a student per semester is 18 credits and the

maximum is 26 credits. ***However, students are advised to earn 22 credits per semester***. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load and to learn at student's own pace. However, the mandatory number of credits have to be secured for the purpose of award of *Undergraduate Certificate/ Undergraduate Diploma/*Appropriate *Bachelor of Science degree in* Applied Life Sciences with Agrochemicals and Pest Management *as listed in* ***Table 1.***

Table 1: Qualification Type and Credit Requirements

S. No.	Type of Award	Stage of Exit	Mandatory credits to be secured for the award
1	*Undergraduate Certificate in Applied Life Sciences with Agrochemicals and Pest Management.*	After successful completion of Semester II	44
2	*Undergraduate Diploma in Applied Life Sciences with Agrochemicals and Pest Management.*	After successful completion of Semester IV	88
3	*Bachelor of Science in Applied Life Sciences with Agrochemicals and Pest Management.*	After successful completion of Semester VI	132
4	*Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management with Dissertation/Academic Projects/Entrepreneurship*	After successful completion of Semester VIII	176
5	*Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management. with Dissertation/Academic Projects/Entrepreneurship (Discipline- 1Major)*	After successful completion of Semester VIII	176
6	*Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management with Dissertation/Academic Projects/Entrepreneurship (Discipline-1Major) & (Discipline-2 Minor)*	After successful completion of Semester VIII and credit requirements for Major and Minor	176

Major discipline

A student pursuing four-year undergraduate programme in Applied Life Sciences with Agrochemicals and Pest Management shall be awarded B.Sc. (Honours) in Applied Life Sciences with Agrochemicals and Pest Management degree with Major in Chemistry/Botany/Zoology on completion of VIII Semester, if he/she secures **at least 80 credits in Chemistry/Botany/Zoology** out of the total of 176 credits. He/she shall study 6 DSCs and at least 3 DSEs in the respective discipline (Chemistry/Botany/Zoology) in the first six semesters and 2 DSCs, 6 DSEs and write dissertation in respective discipline (Chemistry/Botany/Zoology) in the VII and VIII semesters.

Minor discipline

A student of B.Sc. (Hons.) Applied Life Sciences with Agrochemical and Pest Management may be awarded Minor in a discipline (Chemistry/Botany/Zoology), on completion of VIII Semester, if he/she earns minimum 28 credits from six DSCs and One DSE of that discipline.

For instance, a student who pursues 4 years B.Sc. (Hons.) Applied Life Sciences with Agrochemicals and Pest Management, if he/she earns minimum 80 credits in Chemistry from 8 DSCs and at least 9 DSEs from Chemistry and writes dissertation on a topic of chemistry discipline, then he/she will earn Major in Chemistry. Such a student shall get a minor in Botany/Zoology, if he/she earns minimum 28 credits from 6 DSCs and 1 DSE of Botany/Zoology.

5. Programme Objectives

The undergraduate degree course in Applied Life Sciences with Agrochemicals and Pest Management aims to provide students with the following knowledge/skills:

- ***(i)*** In-depth knowledge in Chemistry, Botany and Zoology along with the applications in agrochemicals and pest management through understanding of key concepts, principles, theories and manifestations of the three disciplines.
- ***(ii)*** Acquaintance of thorough knowledge and expertise in applied and specialized disciplines by hands-on training and practicals.
- ***(iii)*** A deep understanding of skills required to solve some challenges related to agricultural practices.
- ***(iv)*** Innovate and acquire competency to solve day-to-day problems faced by farmers and agriculturists.
- ***(v)*** Development of new strategies to mitigate the loss to agricultural produce caused by pest and pathogens.
- ***(vi)*** To keep abreast of global scientific developments in the field by providing latest knowledge and skills in basic and applied disciplines.
- ***(vii)*** Competence and skills in solving both theoretical and applied problems in different disciplines.
- ***(viii)*** A conducive learning environment that ensures holistic cognitive development of students.
- ***(ix)*** Development of critical and analytical thinking, scientific reasoning, problem- solving skills, communication skills and teamwork.
- ***(x)*** Moral and ethical awareness, leadership qualities and innovation.
- ***(xi)*** Multi-cultural competence and multi-linguism.
- ***(xii)*** Knowledge and skill to undertake higher studies in chemistry, botany, zoology and related areas thereby enabling students'

employment/entrepreneurship.

(xiii) Sufficient subject matter competence and enable students to prepare for various competitive exams, such as IIT-JAM, GATE, GRE, UGC-CSIR-NET/JRF, ASRB-NET/JRF, ICAR (JRF/SRF), OUAT, CUET for PG, Ph.D. Entrance in DU, IARI, ICAR etc. Agricultural Scientists, and Civil Services Examinations.

6. Programme Outcomes

The programme learning outcomes of the undergraduate degree course in Applied Life Sciences with Agrochemicals and Pest Management are as follows:

- **In-depth knowledge**: The student will acquire knowledge and understanding of the fundamental concepts, principles and applications in the core areas of Botany, Chemistry, Zoology along with information about agrochemicals and pests infesting agricultural crops. The core papers will provide in-depth knowledge of the subject. A wide choice of elective courses offered to the student will provide additional understanding of the concepts studied in core papers and in the applied areas of agrochemicals and pest management.
- **Hands-on/ Laboratory Skills**: Comprehensive laboratory exercises will impart experiential learning and strengthen experimental, analytical, computational and instrumentation skills. Visits to training institutes and field-work will strengthen the observation as well as perception skills and enhance the ability to explore opportunities for future endeavours. The students will learn essential skills for collating, evaluating, analysing and presenting information, ideas, concepts and quantitative and/or qualitative data.
- **Research skills:** The course provides an opportunity to students to inculcate research aptitude and hone their innovation skills through internship/apprenticeship/ project work/community outreach/dissertation/Entrepreneurship. It will enable the students to demonstrate skills in literature survey, information management, data analysis and research ethics.
- **Role of Applied Life Sciences**: The course on Applied Life Science with Agrochemicals and Pest Management will equip students in addressing issues and problems of the agriculture sector of the country. The students will develop awareness and appreciation for the significant role played by Botany, Chemistry and Zoology in conjunction in resolving issues of crop productivity and sustainable development.
- **Communication and IT Skills:** Various DSCs, DSEs, SECs, GEs and AECs have been designed to enhance student's ability to write methodical, logical and precise reports. The courses will, in addition, guide the student to communicate effectively through oral/poster presentations, writing laboratory/project reports and dissertations. Several IT based papers in DSEs

- and SECs will enable students to develop expertise in general and subject-specific computational skills.
- **Lateral Thinking**: The programme will develop the ability to apply the underlying concepts and principles of core subjects of Botany, Chemistry and Zoology in conjunction with Agrochemistry, Agrobotany and Pest Management beyond the classrooms to its field applications, innovation and creativity in agriculture and agro-based industries.
- **Competence and Job Opportunities**: The skills acquired by students during the programme will provide varied opportunities for their career progression at different exit points. They will be able to join agricultural institutes and agro-based industries. They will also have an option to join research groups of entomologists, chemical/biochemical analysts, scientific advisers for identification of crop diseases and management of pest outbreaks. They can pursue higher studies as well as research and will be competent to have their own startups as entrepreneurs.

7. Programme Structure – List of Courses.

The detailed framework of undergraduate degree programme in ALS-ACPM is provided **in Table 2.**

Table 2

Structure of Undergraduate Programme in ALS-ACPM under UGCF-2022

Semester	Discipline Specific Core (DSC) (4)[$]	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)	Ability Enhancement Course (AEC) (2)	Skill Enhancement Course (SEC) (2)	Internship/ Apprenticeship/ Project/ Community Outreach (IAPC) (2)	Value Addition Course (VAC) (2)	Total Credits
I	DSC-1 ALS BOT DSC 01 BOTANY-I **(2T+2P)** DSC-2 ALS CHEM DSC 01 CHEMISTRY-I **(2T+2P)** DSC-3 ALS ZOO DSC 01 ZOOLOGY-I **(2T+2P)**	N/A	Choose one from a pool of courses **GE-1** **(2T+2P)**	Choose one **AEC** from a pool of courses	Choose one **SEC** from a pool of courses **(0T+2P)/ (1T+1P)**	N/A	Choose one **VAC** from a pool of courses	**22**
	DSC-4 ALS BOT DSC 02 BOTANY-II **(2T+2P)** DSC-5		Choose one from a pool of	Choose one **AEC** from a	Choose one **SEC** from a		Choose one **VAC** from	

II	ALS CHEM DSC 02 CHEMISTRY-II **(2T+2P)** DSC-6 ALS ZOO DSC 02 ZOOLOGY-II **(2T+2P)**	N/A	courses **GE-2** **(2T+2P)**	pool of courses	pool of courses **(0T+2P)/ (1T+1P)**	N/A	a pool of courses	**22**
Students on exit shall be awarded *Undergraduate Certificate in Applied Life Sciences with Agrochemicals and Pest Management* after securing the requisite 44 credits in Semester I & II.								**Total = 44**
III	DSC-7 ALS BOT DSC 03 BOTANY-III **(2T+2P)** DSC-8 ALS CHEM DSC 03 CHEMISTRY-III **(2T+2P)** DSC-9 ALS ZOO DSC 03 ZOOLOGY-III **(2T+2P)**	Choose one from a pool of courses **DSE-1 (2T+2P)** Chemistry/Botany/Zoology **OR** **GE-3 (2T+2P)**		Choose one **AEC** from a pool of courses	Choose one **SEC** **(0T+2P)/ (1T+1P)** OR **IAPC****		Choose one **VAC** from a pool of courses	**22**
IV	DSC-10 ALS BOT DSC 04 BOTANY-IV **(2T+2P)** DSC-11 ALS CHEM DSC 04 CHEMISTRY-IV **(2T+2P)** DSC-12 ALS ZOO DSC 04 ZOOLOGY-IV **(2T+2P)**	Choose one from a pool of courses **DSE-2 (2T+2P)** Chemistry/Botany/Zoology **OR** **GE-4 (2T+2P)**		Choose one **AEC** from a pool of courses	Choose one **SEC** **(0T+2P)/ (1T+1P)** OR **IAPC****		Choose one **VAC** from a pool of courses	**22**
Students on exit shall be awarded *Undergraduate Diploma in Applied Life Sciences with Agrochemicals and Pest Management* after securing the requisite 88 credits after completion of Semester IV.								**Total = 88**
V	DSC-13 ALS BOT DSC 05 BOTANY-V **(2T+2P)** DSE-14 ALS CHEM DSC 05 CHEMISTRY-V **(2T+2P)** DSC-15 ALS ZOO DSC 05 ZOOLOGY-V **(2T+2P)**	Choose one from a pool of courses **DSE-3** **(2T+2P)** Chemistry/ Botany/ Zoology	Choose one form a pool of courses **GE-5** **(2T+2P)**	N/A	Choose one **SEC** **(0T+2P)/ (1T+1P)** OR **IAPC****		NA	**22**

VI	DSC-16 ALS BOT DSC 06 BOTANY-VI **(2T+2P)** DSC-17 ALS CHEM DSC 06 CHEMISTRY-VI **(2T+2P)** DSC-18 ALS ZOO DSC 06 ZOOLOGY-VI **(2T+2P)**	Choose one from a pool of courses **DSE-4** *** **(2T+2P)** Chemistry/ Botany/ Zoology	Choose one form a pool of courses **GE-6** **(2T+2P)**	N/A	Choose one **SEC** **(0T+2P)/ (1T+1P)** OR **IAPC****	NA	**22**
Students on exit shall be awarded *Bachelor of Science in Applied Life Sciences with Agrochemicals and Pest Management* after securing the requisite 132 credits on completion of Semester VI.							**Total = 132**
VII	DSC-19 ALS BOT DSC 07 BOTANY-VII **OR** DSC-19 ALS CHEM DSC 07 CHEMISTRY-VII **OR** DSC-19 ALS ZOO DSC 07 ZOOLOGY-VII	Choose three DSE courses **(DSE-5, DSE-6, DSE-7)** #**OR** Choose two DSE# and one GE course **(DSE-5, DSE-6, GE-7)** **OR** Choose one DSE# and two GE courses **(DSE-5, GE-7, GE-8)**	N/A	N/A	N/A	Dissertation on Major (6) **OR** Dissertation on Minor (6) **OR** Academic project/ Entrepreneurship (6)	**22**
VIII	DSC-20 ALS BOT DSC 08 BOTANY-VIII **OR** DSC-20 ALS CHEM DSC 08 CHEMISTRY-VIII **OR** DSC-20 ALS ZOO DSC 08 ZOOLOGY-VIII	Choose three DSE courses **(DSE-8, DSE-9, DSE-10)** #**OR** Choose two DSE# and one GE course **(DSE-7, DSE-8, GE-8)** **OR** Choose one DSE# and two GE courses **(DSE-6, GE-9, DSE-10)**	N/A	N/A	N/A	Dissertation on Major (6) **OR** Dissertation on Minor (6) **OR** Academic project/ Entrepreneurship (6)	**22**
Students on exit shall be awarded *Bachelor of Science (Hons.) Applied Life Sciences with Agrochemicals and Pests Management with Dissertation/Academic Projects/ Entrepreneurship or Bachelor of Science (Hons.) Applied Life Sciences with Agrochemicals and Pests Management with Dissertation/Academic Projects/ Entrepreneurship (Discipline-1 Major) or Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management with Dissertation/Academic Projects/ Entrepreneurship (Discipline-1 Major & Discipline-2 Minor)* after securing the requisite 176 credits on completion of Semester VIII.							**Total = 176**

$ Value inside parenthesis signifies credits of that course. T stands for Theory credits, P stands for Practical credits.

* There shall be choice in Semesters III and IV to either choose a DSE course from a pool of DSE courses offered by Chemistry, Botany and Zoology disciplines OR a GE course from a pool of GE courses offered by all the disciplines in the college. A DSE course, if chosen from a discipline

other than Chemistry, Botany and Zoology, will be considered as a GE course.

** There shall be choice in Semesters III and IV to choose either one 'SEC' or in the alternative 'Internship/Apprenticeship/Project/Community Outreach (IAPC)' in each Semester of two credits each.

*** '**Research Methodology'** shall be offered as one of the DSE courses in VI and VII Semesters. Students can opt for it either in VI or VII semester. However, a student pursuing multidisciplinary studies in three core disciplines shall choose research methodology in VI semester if the student wishes to Major in one of the three disciplines in the fourth year. If a student wishes to study Research Methodology course offered by another discipline (as one of its DSEs), it may be allowed if the other discipline is a Minor discipline for the student. Such a Research Methodology course opted for in another discipline will be considered as a GE course for the student.

In semesters VII and VIII, a student will have the option to choose DSE courses from any one of the discipline Chemistry/Botany/Zoology, and not a combination of these disciplines. The following choices will be available in VII and VIII semesters:

(i) to choose three DSEs of 4 credits each either from Chemistry or Botany or Zoology (not a combination of these disciplines)

OR

(ii) to choose two DSEs of 4 credits each either from Chemistry or Botany or Zoology (not a combination of these disciplines) and one GE of 4 credits

OR

(iii) to choose one DSE of 4 credits either from Chemistry or Botany or Zoology and two GEs of 4 credits each.

7.1 Semester-wise Distribution of Discipline Specific Core (DSC) Courses

A student will study three DSC Courses each, in Semesters I to VI (Table - 2 & 3). In semesters VII and VIII the student has to study one DSC in each semester from any one of the disciplines - Chemistry or Botany or Zoology, and not a combination of these three disciplines.

The semester wise distribution of DSC courses over eight semesters is listed in **Table 3**.

Table 3

Semester-wise Distribution of Discipline Specific Core (DSC) Courses

DISCIPLINE SPECIFIC CORE COURSES –18 (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
	ALS BOT DSC 01	Microbial World and Plant Diversity	T=2 P=2

I	ALS CHEM DSC 01	Inorganic Chemistry	T=2 P=2
	ALS ZOO DSC 01	Animal forms and Structure	T=2 P=2
II	ALS BOT DSC 02	Economic Botany	T=2 P=2
	ALS CHEM DSC 02	Soil Fertility, Fertilizers and Micronutrients	T=2 P=2
	ALS ZOO DSC 02	Entomology	T=2 P=2
III	ALS BOT DSC 03	Genetics and Molecular Biology	T=2 P=2
	ALS CHEM DSC 03	Organic Chemistry	T=2 P=2
	ALS ZOO DSC 03	Cell Biology and Biochemistry	T=2 P=2
IV	ALS BOT DSC 04	Plant Pathology	T=2 P=2
	ALS CHEM DSC 04	Fundamentals of Agrochemistry	T=2 P=2
	ALS ZOO DSC 04	Agricultural Pests	T=2 P=2
V	ALS BOT DSC 05	Plant Physiology and Metabolism	T=2 P=2
	ALS CHEM DSC 05	Physical Chemistry	T=2 P=2
	ALS ZOO DSC 05	Animal Physiology and Metabolism	T=2 P=2
VI	ALS BOT DSC 06	Plant Biotechnology – Concepts and Applications	T=2 P=2
	ALS CHEM DSC 06	Analytical Techniques in Chemistry	T=2 P=2
	ALS ZOO DSC 06	Immunology and Immunotechnology	T=2 P=2

Note: DSC courses for semester VII and VIII will be decided and intimated later.

7.2 Details of Discipline Specific Elective (DSE) Courses

The DSE courses will be offered to students from all the three disciplines *viz*., Chemistry, Botany and Zoology in each of the semesters; III, IV, V, and VI as listed below in **Table 4**. The DSE courses are distributed in Pool A (Pool for Odd Semesters) and Pool B (Pool for Even Semesters), to be offered to students in odd and even semesters, respectively as specified in the Table 4. A student studying in semester III and V will have an option of choosing any DSE course of student's choice as floated by the college from Pool A. Similarly, a student studying in semester IV and VI will have an option of choosing any DSE course of student's choice as floated by the college from Pool B. It is to be noted that the college will offer at least one DSE course from each of the three disciplines i.e., Botany,

Chemistry and Zoology. There shall be choice in Semesters III and IV to either choose a DSE course from a pool of DSE courses offered by Chemistry, Botany and Zoology disciplines OR a GE course from a pool of GE courses offered by all the disciplines in the college. A DSE course if chosen from other discipline except Chemistry, Botany and Zoology, such a course will be considered as a GE course. In semesters VII and VIII a student will have the option to choose DSE courses from any one of the discipline Chemistry/Botany/Zoology, and not a combination of these disciplines.

Table 4

Details of Discipline Specific Elective (DSE) Courses

	DSE COURSES –13 (4 Credits)		
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
III	ALS BOT DSE 01	Ecology, conservation and Restoration	T=2 P=2
	ALS CHEM DSE 01	Introduction to Heterocyclic Chemistry	T=2 P=2
	ALS ZOO DSE 01	Concepts and Applications of Biostatistics and Bioinformatics	T=2 P=2
IV	ALS BOT DSE 02	Crop Genetics and Plant Breeding	T=2 P=2
	ALS CHEM DSE 02	Organic Chemistry in Pesticide Synthesis	T=2 P=2
	ALS ZOO DSE 02	Developmental Biology of Animals	T=2 P=2
V	ALS BOT DSE 03	Developmental Biology of Plants	T=2 P=2
	ALS CHEM DSE 03	Nanotechnology in Agriculture	T=2 P=2
	ALS ZOO DSE 03	Integrated Pest Management	T=2 P=2
VI	ALS BOT DSE 04	Plant Systematics	T=2 P=2
	ALS CHEM DSE 04	Medicinal Chemistry	T=2 P=2
	ALS ZOO DSE 04	Social and Beneficial Insects	T=2 P=2
	ALS BOT DSE RM 05	Research Methodology in Botany	T=2 P=2
	ALS CHEM DSE RM 05	Research Methodology in Chemistry	T=2 P=2
	ALS ZOO DSE RM 05	Research Methodology in Zoology	T=2 P=2

7.3 Details of Skill Enhancement Courses (SECs)

To enhance the skills required for advanced studies, research and employability of students various Skill Enhancement Courses will be offered to students as listed in **Table 5**.

The SEC courses will be offered to students from all the three disciplines *viz*., Chemistry, Botany and Zoology in each of the semesters; I, II, III, IV, V, and VI as listed below in Table 5. The SEC courses are also distributed in Pool A (Pool for Odd Semesters) and Pool B (Pool for Even Semesters), to be offered to students in odd and even semesters, respectively as specified in the Table 5. A student studying in semester I, III and V will have an option of choosing any SEC course of student's choice as floated by the respective college from Pool A. Similarly, a student studying in semester II, IV and VI will have an option of choosing any SEC course of student's choice as floated by the college from Pool B. It is to be noted that the college will offer at least one SEC course from each of the three disciplines i.e., Botany, Chemistry and Zoology in each semester.

There shall be a choice in Semesters III, IV, V and VI to either choose an SEC course from a pool of SEC courses offered by Chemistry, Botany and Zoology disciplines OR to choose Internship/Apprenticeship/Project/Community Outreach (IAPC).

Table 5

Details of Skill Enhancement Courses

SEC COURSES (2 Credits each - 0T+2P)		
COURSE CODE	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
POOL FOR ODD SEMESTER		
ALS BOT SEC 01	Biofertilizers	T=0 P=2
ALS BOT SEC 02	Mushroom Cultivation Technology	T=0 P=2
ALS BOT SEC 03	Horticulture and Floriculture	T=0 P=2
ALS CHEM SEC 01	Green Methods in Chemistry	T=0 P=2
ALS CHEM SEC 02	Laboratory Techniques in Chemistry	T=0 P=2
ALS ZOO SEC 01	Biotechnology in Insect Pest Control	T=0 P=2
ALS ZOO SEC 02	Insect Toxicology	T=0 P=2
ALS ZOO SEC 03	Apiculture	T=0 P=2

	POOL FOR EVEN SEMESTER	
ALS BOT SEC 04	Ethnobotany*	T=0 P=2
ALS BOT SEC 05	Bio-nanotechnology*	T=0 P=2
ALS BOT SEC 06	Intellectual Property Rights	T=0 P=2
ALS CHEM SEC 03	Dyes: Types, Colour and Constitution	T=0 P=2
ALS CHEM SEC 04	Pesticide Formulations and Equipment Used	T=0 P=2
ALS ZOO SEC 04	Sericulture	T=0 P=2
ALS ZOO SEC 05	Lac Culture	T=0 P=2
ALS ZOO SEC 06	Non-Insect Pests and their Control	T=0 P=2
ALS ZOO SEC 07	Tools and Techniques for Pest Control	T=0 P=2

***: Cannot be offered to students with some combinations of DSC/DSE/GE/SEC paper.**

7.4 Details of Generic Elective (GE) Courses

Generic Elective courses provide multidisciplinary or interdisciplinary education to students. Various GE courses will be offered which may be opted by students as listed below in **Table 6**.

Table 6

Details of Generic Elective (GE) Courses

GE COURSES (4 Credits each)		
COURSE CODE	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
POOL FOR ODD SEMESTER		
ALS BOT GE 01	Agricultural Botany and Weed Science	T=2 P=2
ALS BOT GE 02	Plant Quarantine and Seed Health Technology	T=2 P=2
ALS BOT GE 03	Plant Cell and Tissue Culture Techniques*	T=2 P=2
ALS BOT GE 04	Recombinant DNA Technology and Proteomics*	T=2 P=2
ALS CHEM GE 01	Bioinorganic Chemistry	T=2 P=2
ALS CHEM GE 02	Chemistry of Carbohydrates, Nucleic Acids and Lipids	T=2 P=2
ALS ZOO GE 01	Agricultural Pests of Crops**	T=2 P=2

ALS ZOO GE 02	Insect Vectors and Diseases	T=2 P=2
ALS ZOO GE 03	Techniques for Insect Collection, Rearing and Preservation	T=2 P=2
POOL FOR EVEN SEMESTER		
ALS BOT GE 05	Hydroponics and Organic Farming	T=2 P=2
ALS BOT GE 06	Informatics and Statistics for Biology and Allied Sciences*	T=2 P=2
ALS BOT GE 07	Genetically Modified Plants*	T=2 P=2
ALS CHEM GE 03	Chemistry of Amino acids, Proteins and Enzymes	T=2 P=2
ALS CHEM GE 04	Conductance and Chemical Kinetics	T=2 P=2
ALS ZOO GE 04	Animal Cell Culture Techniques	T=2 P=2
ALS ZOO GE 05	Locust and its management	T=2 P=2
ALS ZOO GE 06	Beneficial Insects and their Products**	T=2 P=2
ALS ZOO GE 07	Insect Ecology	T=2 P=2

***: Cannot be offered to students with some combinations of DSC/DSE/GE/SEC papers.**

****: Only for General Pool; Not offered for ALS-ACPM students.**

In addition to the courses highlighted above, the selection of GE/SEC courses would be governed by the other combinations of DSC and DSE courses studied by the student to ensure that a student does not select courses with significant overlap in course contents.

7.5 Details of Ability Enhancement Courses (AECs)

A student has to study one AEC course each in first four semesters of the programme. The AEC courses include environmental studies and language courses. The pool of courses is offered by the University.

7.6 Details of Value-Added Courses (VACs)

A pool of value-added courses will be provided by the University.

8. Teaching-Learning Process

The undergraduate programme in Applied Life Sciences with Agrochemicals and Pest Management is designed to provide students with a sound theoretical background, practical training in all aspects of Applied Life Sciences. It will help them develop an appreciation of the importance of Applied Life Sciences in different contexts. The programme includes foundational as well as in-depth courses that span the interdisciplinary approach in Applied Life Sciences. Along with the above Core Courses there are DSEs, GEs, SECs, AECs and VACs which address the need of the

hour.

These courses will be delivered through the conventional chalk and talk method, laboratory work, projects, case studies, field work, seminars, hands-on training/workshops in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles and ICT enabled teaching-learning tools (PowerPoint presentations, audio visual resources, e-resources, models, softwares, simulations, virtual labs etc).

Students will be encouraged to carry out short term projects and participate in industrial and institutional visits and outreach programmes. They will be introduced to scientific reasoning and discovery, innovative problem-solving methodologies, online quizzes, surveys, critical analysis etc. to develop convergent and divergent thinking abilities.

The laboratory training complements the theoretical principles learned in the classroom and includes synthesis of molecules, measurement of chemical properties and phenomenon, hands-on experience with modern instruments, computational data analysis, modeling and laboratory safety procedures.

Different pedagogies such as experiential learning, participative learning, project-based learning, inquiry-based learning, peer-led instruction and ICT pedagogy integration instruction (blended flipped learning) will be adopted wherever possible. Students will be encouraged to work in groups to develop their interpersonal skills like communication and team work.

Students diligent and active participation/ engagement in industrial visits/ internships/ Academic Projects/ Dissertations will lay a strong foundation for a successful career in academics, industry, research, entrepreneurship and community outreach.

9. Assessment Methods

The primary objective of assessment will be to assess the learning outcomes of the course in tune with the broad outcomes of strengthening core theoretical knowledge base, practical laboratory skills, and research. Assessment will be based on continuous evaluation (class test, presentation, group discussion, quiz, assignment etc.) and end of semester examination of University of Delhi.

(i) Internal Assessment or Continuous Evaluation: During a semester, students' mastery of the various learning outcomes as described in the syllabus will be assessed through class tests, assignments, group assignments, laboratory record files, project reports, quizzes, MCQs, presentations etc. Each theory paper will have 25% marks for internal assessment. The component of internal assessment for each practical paper will be 50 % marks. The critical analysis of internal assessment/ continuous evaluation outcomes will provide opportunities to improve the teaching-learning process by focusing on the areas that need conceptual strengthening, laboratory exposure or design of new experiments, and

research.

(ii) End of Semester University Examinations: The summative end-semester Delhi University examinations will be conducted for both theory and practical courses. Each theory paper will have 75% marks and each practical paper will be of 50% marks for end of semester examination of the University.

Scheme of Examination-

A four-credit course has a total of 100 marks and a two-credit course is of 50 marks. The distribution of 100 marks for each of DSC (2T+2P) /DSE (2T+2P)/GE (2T+2P) course having four credits along with distribution of 50 marks for each of SEC course in 0T+2P/1T+1P and VAC course in 2T+0P format is given in **Table-7**.

Table 7: Distribution of total marks for each of DSC/ DSE/ SEC/ GE/ VAC courses in different credit formats.

Types of Paper	**Credit Format of Papers**	**Theory Component**	**Practical Component**
Discipline Specific Core (DSC)	**2T + 2 P**	**Theory: 50 Marks** **Internal assessment:** 12 Marks: Class Test: 05 Marks Assignment/presentation/Quiz/group discussion: 05 Marks Attendance: 02 Marks **End Semester Theory Examination:** 38 Marks	**Practical: 50 Marks** **Practical Examination:**25 Marks: Experiment: 20 Marks Viva Voce/ Written Test: 05 Marks **Continuous Evaluation:** 25 Marks Performance Assessment: 15 Marks Record File: 10 Marks
Discipline Specific Elective (DSE)	**2T + 2 P**	**Theory: 50 Marks** **Internal assessment:** 12 Marks: Class Test: 05 Marks Assignment/presentation/Quiz/group discussion: 05 Marks Attendance: 02 Marks **End Semester Theory Examination:** 38 Marks	**Practical: 50 Marks** **Practical Examination:** 25 Marks: Experiment: 20 Marks Viva Voce/ Written Test: 05 Marks **Continuous Evaluation:** 25 Marks Performance Assessment: 15 Marks Record File: 10 Marks
Skill Enhancement Course (SEC)	**0T + 2 P**	NA	**Practical: 50 Marks** **Practical Examination:** 25 Marks: Experiment: 20 Marks Viva Voce/ Written Test: 5 Marks **Continuous Evaluation:** 25 Marks: Performance Assessment: 15 Marks Record File: 10 Marks

Skill Enhancement Course (SEC)	**1T + 1 P**	**Theory: 25 Marks** **Internal assessment:** 06 Marks: Class Test: 2.5 Marks Assignment/presentation/Quiz/group discussion: 2.5 Marks Attendance: 01 Marks **End Semester Theory Examination:** 19 Marks	**Practical: 25 Marks** **Practical Examination:** 12.5 Marks: Experiment: 10 Marks Viva Voce/ Written Test: 2.5 Marks **Continuous Evaluation:** 12.5 Marks Performance Assessment: 7.5 Marks Record File: 5 Mark
GE	**2T + 2 P**	**Theory: 50 Marks** **Internal assessment:** 12 Marks: Class Test: 05 Marks Assignment/presentation/Quiz/group discussion: 05 Marks Attendance: 02 Marks **End Semester Theory Examination:** 38 Marks	**Practical: 50 Marks** **Practical Examination:**25 Marks: Experiment: 20 Marks Viva Voce/ Written Test: 05 Marks **Continuous Evaluation:**25 Marks Performance Assessment: 15 Marks Record File: 10 Marks
VAC	**2 T + 0 P**	**Theory: 50 Marks** **Internal assessment:** 12 Marks: Class Test: 05 Marks Assignment/presentation/Quiz/group discussion: 05 Marks Attendance: 02 Marks **End Semester Theory Examination:** 38 Marks	NA

10. Scheme of Examination

Minimum acceptable level of academic standards

The minimum acceptable level of achievement that a student must demonstrate to be eligible for the award of academic credit or a qualification is the minimum acceptable level of academic standards. The Letter Grades and Grade Points which shall be used to reflect the outcome of assessment process of the student's performance is indicated in **Table - 8**.

TABLE 8: Letter Grades and Grade Points

Letter Grade	Grade point
O (outstanding)	10
A+ (Excellent)	9
A (Very good)	8
B+ (Good)	7
B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
AB (Absent)	0

Computation of the grade cut offs on a 10-point grading system

The results for the all the Undergraduate courses under the UGCF-2022 shall be based on a 10-point grading system with Letter Grades as per the formula prescribed by the University Grants Commission in the computation of the grade cut offs as shown in **Table 9.**

Table 9: The computation of the grade cut offs on a 10-point grading system with Letter Grades.

Letter Grade	Numerical Grade	Formula	Computation of **Grade** Cut **off**
0 (Outstanding)	10	$m \geq \bar{X} + 2.5\ \sigma$	the value of $\bar{X}$ + 2.5 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 2.5 σ or90% whichever is lower
A+ (Excellent)	9	$\bar{X} + 2.0\ \sigma \leq m < \bar{X} + 2.5\ \sigma$	the value of $\bar{X}$ + 2.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 2.0 σ or80% whichever is lower
A (Very Good)	8	$\bar{X} + 1.5\ \sigma \leq m < \bar{X} + 2.0\ \sigma$	the value of $\bar{X}$ + 1.5 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 1.5 σ 70% whichever is lower
B+ (Goods	7	$\bar{X} + 1.0\ \sigma \leq m < \bar{X} + 1.5\ \sigma$	the value of $\bar{X}$ + 1.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 1.0 σ or 60% whichever is lower
B (Above average)	6	$\bar{X} \leq m < \bar{X} + 1.0\ \sigma$	the value of $\bar{X}$ a to be taken into account for grade computation will be Actual $\bar{X}$ or 50% whichever is lower
C (Average)	5	$\bar{X} - 0.5\ \sigma \leq m < \bar{X}$	the value of $\bar{X}$ - 0.5 σ a to be taken into account for grade computation will be Actual $\bar{X}$ - 0.5 σ or 40% whichever is lower
P (Pass)	4	$\bar{X} - \sigma \leq m < \bar{X} - 0.5\ \sigma$	the value of $\bar{X}$ - 1.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ - 1.0 σ or 30% whichever is lower

m is the marks obtained by a student in a particular paper in that semester.

$\bar{X}$ is the average of marks obtained by all the students appeared in that particular paper in that semester. σ is the standard deviation.

11.

SYLLABUS FOR UNDERGRADUATE PROGRAMME IN APPLIED LIFE SCIENCES WITH AGROCHEMICALS AND PEST MANAGEMENT

(BOTANY)

Course Code: ALS BOT DSC 01
Course Title: Microbial World and Plant Diversity
Discipline Specific Core Course (DSC)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

To make students aware about the diversity of plants and microbes present on the planet and their evolutionary relationships.

Learning Outcomes:

This course will impart basic knowledge on:

- the diversity of plants and microbes.
- their general characteristics.
- various groups of plants and their evolutionary relationships.
- basic principles and concepts of evolution that contribute to diversity.

Theory:

Unit 1. Origin of life: **Lectures: 02**

Principles and concepts of evolution and classification (up-to six kingdoms)

Unit 2. Bacteria: **Lectures: 03**

General characteristic features, cell structure, wall-less forms (L-forms and Mycoplasma), asexual reproduction and modes of gene transfer (conjugation, transformation and transduction), a brief introduction to Archaebacteria.

Unit 3. Viruses: **Lectures: 02**

General characteristic features, replication, RNA virus (structure of TMV), DNA virus (structure of T-phage), Lytic and Lysogenic life cycle (Lambda phage).

Unit 4. Algae: **Lectures: 03**

General characteristic features, Reproduction, Classification of Lee (only up to groups). A brief account of *Volvox* and *Polysiphonia*.

Unit 5. Fungi: **Lectures: 04**

General characteristic features, Reproduction, Classification (Webster and Weber, 2007), A brief account of *Rhizopus*, *Penicillium*, and *Agaricus*.

Unit 6. Bryophytes: Lectures: 04

General characteristic features and reproduction, adaptation to land habit, broad classification, Evolutionary trends in Bryophytes. Brief account of *Marchantia* and *Funaria*.

Unit 7. Pteridophytes: Lectures: 04

General characteristic features and reproduction, broad classification, Evolutionary trends in Pteridophytes, affinities with Bryophytes. A brief account of *Equisetum* and *Pteris*.

Unit 8. Gymnosperms: Lectures: 04

General characteristic features and reproduction, broad classification, evolutionary trends in Gymnosperms, affinities with Pteridophytes. A brief account of *Pinus*.

Unit 9. Angiosperms: Lectures: 04

General characteristic features and reproduction, concept of natural, artificial and phylogenetic system of classification, APG-IV (a brief reference), affinities with Gymnosperms.

Practical:

1. To study structure of TMV and Bacteriophage (electron micrographs/models).
2. To study Gram negative and positive bacteria through Gram's Staining Technique.
3. To study Bacteria through Electron Micrograph, Binary fission, Conjugation, Root nodules through digital resources /specimen.
4. To study morphology of *Volvox* and *Polysiphonia* through temporary preparations and slides.
5. To study *Rhizopus*, *Penicillium and Agaricus* through temporary preparations, specimens and slides.
6. To study *Marchantia* (morphology, WM of rhizoids and scales) and *Funaria* (morphology WM of rhizoids and leaf) through temporary preparations, specimens and slides
7. To study *Equisetum* (morphology, WM of spores) and *Pteris* (morphology, tease mount of sporangia and spores) through temporary preparations, specimens and slides.
8. To study *Pinus* (morphology of dwarf shoot, needle anatomy, male and female cones, WM pollen grains through temporary preparation/s, specimens and slides.
9. To study variation in leaf venations in dicots and monocots (at least two specimens

each).

10. To study the types of inflorescence in angiosperms (through specimens).
11. To study the types of fruits in angiosperms (through specimens).

Suggested Readings:

1. Campbell, N.A., & Reece, J. B. (2008). *Biology* (8th ed.). Pearson Benjamin Cummings,
2. Evert, RF., & Eichhorn, S.E. (2012). *Raven Biology of Plants* (8th ed.). W.H. Freeman and Company.
3. Bhatnagar, S.P., & Moitra, A. (1996). *Gymnosperms*. New Age International (P) Ltd Publishers.
4. Kumar, H.D. (1999). *Introductory Phycology* (2nd ed.). Affiliated East-West. Press Pvt. Ltd.
5. Pelczar, M.J. (2001). *Microbiology* (5th ed.). Tata McGraw-Hill Co.
6. Puri, P. (1985). *Bryophytes*. Atma Ram and Sons.
7. Sethi, I.K., & Walia, S.K. (2018). *Text book of Fungi and Their Allies* (2nd Ed.). MedTech Publishers.
8. Tortora, G.J., Funke, B.R., & Case. C.L. (2007). *Microbiology*. Pearson Benjamin Cummings.
9. Vashishta, P.C., Sinha, A.K., & Kumar, A. (2010). *Pteridophyta*. S. Chand & Co Ltd.
10. Singh, G. (2019). *Plant Systematics- An Integrated Approach* (4^{th} ed.). CRC Press, Taylor and Francis Group.
11. Blackmore, S., & Crane, P. (2019). *How Plants Work – Form, Diversity, Survival* (Illustrated ed.). Princeton University Press;
12. Ingrouille, M., & Eddie, B. (2006). *Plants: Evolution and Diversity*. Cambridge University Press.

Additional Readings:

1. Parihar, N.S. (1991). *An Introduction to Embryophyta*, Pteridophytes (Vol. II). Central Book Depot.
2. Singh, V., Pandey, P.C., & Jain, D.K. (2001). *A Text Book of Botany*. Rastogi and Co.
3. Webster, J., & Weber, R. (2007). *Introduction to Fungi*. Cambridge University Press.

Keywords:

Evolution, Bacteria, Viruses, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT DSC 02
Course Title: Economic Botany
Discipline Specific Core Course (DSC)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To familiarize students with the economic importance of diverse plant species and train them in identifying plants of economic importance through field visit/s, live plant specimens, herbarium specimens and digital resources.
- To make students understand the importance of various plant parts and derived products used as food, fibres, medicines, oils and other economically important products.
- To acquaint students with the processing of various economically important plant resources and train them to identify and analyses nutrients using simple microchemical tests.

Learning Outcomes:

- This course would provide students with information about the economic importance and products derived from plants and their roles in our daily lives.
- Students will learn to perform micro-chemical tests to study presence of various components.
- Students will explore the regional diversity in food crops and other plants and their ethnobotanical importance.

Theory:

Unit 1. Introduction and Origin of Cultivated Plants: **Lectures: 02**

Importance of Plant Resources; Vavilov's concept for the Origin of cultivated plants; Centers of Origin (Primary and Secondary); Centers of diversity, Harlan's concept of gene pools.

Unit 2. Cereals: **Lectures: 04**

Wheat (Origin, Evolution of Wheat; (tetra- & hexaploid), Morphology, Production, Cultivation and Economic importance of hexaploid wheat); Rice (Origin-Monophyletic and

Polyphyletic, Production, Morphology, Cultivation, Comparison between *indica* and *japonica* Rice, Parboiling, Economic Importance); Millets, man-made cereal (*Triticale*) and Pseudocereals, Green revolution (briefly)

Unit 3. Legumes: **Lectures: 03**

General account (Nutritive Value of Pulses, Protein Malnutrition, Lathyrism, Favism, Ecological Importance); Chick pea, and Groundnut (Production, Morphology and Economic Importance). Fodder legumes and green manure crops.

Unit 4. Sugars and Starches: **Lectures: 03**

Sugar-Different sources of sugar, Sugarcane (Morphology, Ratooning, Nobilization, Uses of products and by- products); Starch- sources, types of starch grain, Potato (Morphology, Tuber Anatomy, Seed Tubers vs True Potato Seeds and Economic uses).

Unit 5. Spices, Condiments & Flavorings: **Lectures: 03**

General Account (Spices, Condiments, Culinary Herbs and Essences, with examples), Importance of Spices, Clove (Morphology, Anatomy of part used and Economic importance) and Black Pepper (Morphology, Anatomy of part used and Economic importance).

Unit 6. Beverages: **Lectures: 02**

Types of Beverages (Alcoholic and Non-Alcoholic) with examples, Tea and Coffee (Morphology, Varieties, Chemistry and Economic Importance)

Unit 7. Fibres and Fibre-yielding plants: **Lectures: 03**

Classification of Fibres based upon their Origin (surface fibres, bast fibres, and leaf fibres, with examples); Jute (morphology, extraction and economic importance), Cotton (*Gossypium* species, morphology and economic importance)

Unit 8. Oil-Yielding Plants: **Lectures: 03**

Fatty Oils and Essential Oils, Comparison between Fatty Oils and Essential Oils; Fatty Oils (Classification with examples, keeping quality), Coconut and Mustard (Morphology and Economic Importance); Essential Oils (General characteristics, and Economic Importance, with examples).

Unit 9. Medicinal and Drug-Yielding Plants: **Lectures: 02**

Brief Account of Therapeutic Drugs with Examples; Morphology, Chemical Constituents, Economic Importance of *Cinchona, Rauwolfia, Digitalis.*

Unit 10. Fumigator & Masticatory: **Lectures: 02**

Tobacco **(**Morphology, species - *Nicotiana tabacum* & *N. rustica*), Products, Economic Importance and Health Hazards).

Unit 11. Rubber: **Lectures: 01**

Para Rubber - *Hevea brasiliensis* (Morphology, Tapping of latex, Products and Economic Importance).

Unit 12. Vegetables and Fruits: **Lectures: 02**

General account with common examples.

Practical:

1. **Cereals**:

   Wheat (Habit Sketch, L.S/T.S. grain, W.M. starch grains, Micro-chemical tests), Rice (Habit Sketch, Study of paddy and grain, W.M. starch grains, Micro- chemical tests). Millets (anyone) and Pseudocereals (any one) (specimens/digital resources and grains).

2. **Legumes**:

   Chickpea, Groundnut (Habit, Fruit, Seed structure, Micro-chemical tests).

3. **Sugars and Starches**:

   Sugarcane (Habit Sketch, Products and By-products, Cane Juice-Micro - chemical tests); Potato (Habit Sketch, Tuber morphology, T.S. tuber to show localization of starch grains, W.M. starch grains, Micro-chemical tests).

4. **Spices**:

   Clove and Black pepper (Habit and sections L.S./T.S.).

5. **Beverages**:

   Tea (Plant specimen, Tea leaves), Coffee (Plant specimen, Beans).

6. **Fibres**:

   Jute (Specimens/digital resources of Jute, T.S. stem, Test for cellulose and lignin on section of stem and fibre). Cotton (Specimen, W.M. seed to show lint and fuzz; W.M. fibre, Test for cellulose).

7. **Vegetable Oil-Yielding Plants**:

   Fatty Oils: Coconut; Habit (photograph), Fruit, T.S. nut, Mustard; (Habit- specimen, seeds).

8. **Essential Oils:**

   Extraction methods (Specimen/ digital resources), Habit Sketch of Rose, Jasmine, *Vetiver* sp., (specimens/photographs).

9. **Drug-Yielding plants:**

Habit - Fever Bark Tree, Poppy, Foxglove (Specimens/ Photographs).

10. **Fumigatory Material:**

Nicotiana sp. (specimens/photographs), Tobacco Products.

11. **Rubber:**

Para Rubber - Habit, Tapping of latex (Specimen/photograph), Rubber Products.

Suggested Readings:

1. Kochhar, S.L. (2012). *Economic Botany in Tropics.* MacMillan & Co.
2. Kochhar, S.L. (2016). *Economic Botany – A Comprehensive Study* (5th Ed.). Cambridge University Press.
3. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*. The Netherlands: Kluwer Academic Publishers.
4. Chrispeels, & M.J., Sadava, D.E. (1994). *Plants. Genes and Agriculture*. Jones & Bartlett-Publishers.
5. Berg L, (2008). *Introductory Botany: Plants, People, And the Environment*. Thomson Brooks/Cole.
6. Cook F.E.M. (1995). *Economic Botany: Data Collection*. Standard Royal Botanic Garden, Kew, Richmond.

Keywords:

Cultivated plants, Plant products of economic value, Cereals, Legumes, Starches & Sugars, Spices, Oils & Fats, Drug yielding plants, Natural rubber, Fibres.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End

semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT SEC 01
Course Title: Biofertilizers
Skill Enhancement Elective Course – (SEC)
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

To make the students understand:

- the concept of biofertilizers and develop the skills for handling the microbial inoculants.
- the growth and multiplication conditions of useful microbes such as *Rhizobium*, cyanobacteria, mycorrhizae, *Azotobactor* etc, and their role in mineral cycling and nutrition to plants.
- various methods of decomposition of biodegradable waste and their conversion into compost; application of this knowledge in their daily lives.

Learning Outcomes:

On successful completion of this course, a student will be able to:

- visualize and identify different types of microorganisms using a compound microscope.
- understand the classification of microorganisms according to their shape/ structure for morphological identification. Prepare and sterilize different types of culture media.
- isolate microorganisms from environmental samples and culture them in aseptic conditions.

Practical:

1. Introduction to rhizobia symbiosis - Study of *Rhizobium* and its isolation from root nodules of leguminous plants by Gram staining method.
2. Study of different bio-composting and vermicomposting methods.
3. Compost quality assessment and its role in soil nutrition - Test for pH, NO_3^-, SO_4^{2-}, Cl^- and organic matter of different composts.
4. Introduction to Arbuscular mycorrhiza - Study of arbuscular mycorrhiza fungi from plant roots by staining methods.
5. Isolation of arbuscular mycorrhizal spores from rhizosphere soil.

6. Study structure of *Anabaena* and *Azolla* - Isolation of *Anabaena* from *Azolla* leaf.
7. Study various biocontrol methods and their applications, Pheromone trap, *Trichoderma*, *Pseudomonas*, Neem etc.
8. Project on any one of the following topics: *Rhizobium* technology, AMF technology, Organic farming, Biocomposting, Vermicomposting, *Azolla* culture. The design of the project should be such that it includes continuous work of at least 6 weeks and a dissertation submission/presentation/CE - continuous evaluation.

Suggested Readings:

1. Kumaresan, V. (2005). *Biotechnology.* Saras Publication.
2. Sathe, T.V. (2004). *Vermiculture and Organic Farming.* Daya publishers.
3. Subha, R. N. S. (2018). *Soil Microbiology* (5th ed.). MedTech Publishers.
4. Khosla, R. (2017). *Biofertilizers and Biocontrol Agents for Organic Farming*, Kojo Press.

Additional Readings:

1. Azotobacter - Isolation and characterization -- https://youtu.be/1Z1VhgJ2h6U.
2. Rhizobium - Identification and characterization - https://youtu.be/jELlo-pMvc4.
3. 3-Days Online Workshop on Arbuscular Mycorrhizal Fungi_ Biodiversity, Taxonomy and Propagation 19-2 (2022-01-20 at 02_27 GMT-8) – https://youtu.be/LKzK4IuSRc4.
4. Vayas, S.C, Vayas, S., & Modi, H.A. (1998). *Bio-fertilizers and organic Farming*. Akta Prakashan.
5. Gopal, B. (2011) *Communicating Scientific Principles of Ecology: A manual on Waste Management*. Publisher: National Institute of Ecology.

Keywords:

Rhizobium, *Azotobacter*, Inoculum, Cyanobacteria, Nitrogen fixation, *Azolla*, AMF, Mycorrhizae.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT SEC 02
Course Title: Mushroom Cultivation Technology
Skill Enhancement Elective Course – (SEC)
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

To make students aware about:

- Mushrooms as food source.
- Medicinal and nutritional value of mushrooms.
- Techniques of growing mushrooms.

Learning Outcomes:

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

- understand the techniques for cultivation of various edible mushrooms.
- gain sufficient knowledge and expertise for establishment of small / large scale industries for mushroom cultivation.

Practical:

1. To study the principle and operation of laboratory instruments viz., Autoclave, Incubator, Laminar Air Flow.
2. To study edible mushrooms (*Agaricus, Pleurotus, Flammulina, Boletus, Lentinula, Calocybe, Volvariella, Morchella*).
3. To study poisonous mushrooms *(Amanita, Psilocybe, Coprinopsis*).
4. To study medicinal mushrooms (*Ganoderma, Ophiocordyceps, Chaga, Hericium*).
5. Preparation of various types of composts.
6. Preparation of nutrient media used for cultivation of mushrooms.
7. Preparation of Spawn.
8. To study the cultivation technique of *Agaricus* mushroom.
9. To study the cultivation technique of *Pleurotus* mushroom.
10. To study the cultivation technique of *Calocybe / Volvariella* mushroom.
11. To study the nutritional and market value of mushrooms, and post-harvest technologies like packaging and preservation.

12. Various requirements for setting up a mushroom cultivation unit ("kuccha" or cemented house).
13. Entrepreneurship and Government policies related to mushroom cultivation.
14. Visit to an Institute or Mushroom cultivation Centre (Report to be submitted).

Suggested Readings:

1. Bahl, N. (2015). *Hand Book on Mushroom* (Page no. 1-166). Oxford & IBH Publishing Company.
2. Russell, S. (2014). *The Essential Guide to Cultivating Mushroom*. Storey Publishing
3. Zied, D. C., & Gimenez, A. P. (2017) *Edible and Medicinal Mushroom*. John Wiley & Sons Ltd.
4. Chang, S.T., Miles, P.G. (2004) *Mushrooms Cultivation, Nutritional Value, Medicinal effect and Environmental Impact*. CRC Press.
5. Fletcher, J.T., & Gaze, R.H. (2007). *Mushroom Pest and Disease Control*. CRC Press.
6. Ahlawat, O.P., & Tewari, R.P. (2007). *Cultivation Technology of Paddy Straw Mushroom (Volvariella volvacea)*. National Research Centre for Mushroom (Indian Council of Agricultural Research).
7. Rai, R.D., & Arumuganathan, Y. (2008). *Post-Harvest Technology of Mushrooms*. National Research Centre for Mushroom (Indian Council of Agricultural Research).
8. Singh, M., Vijay, B., Kamal, & S., Wakchaure, G.C. (2011). *Mushrooms Cultivation, Marketing and Consumption*. Publishers: Directorate of Mushroom Research (ICAR).

Keywords: Spawning, Composting, Harvesting, Casing.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End

semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: BOT SEC 03
Course Title: Horticulture and Floriculture
Skill Enhancement Elective Course – (SEC)
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To acquaint students with the basic principles, concepts and importance of Horticulture and Floriculture.
- To teach students about production, utilization and improvement of Horticultural and Floriculture crops
- To teach students about horticultural and flowering plants that can be grown in different seasons in Delhi/NCR
- To make students aware about exotic flowering plants of ornamental value and their propagation in laboratories and greenhouses.
- To provide information about employment, business opportunities and other avenues in the Horticulture and Floriculture sector.

Learning Outcomes:

- Students would be able to identify the horticultural crops and ornamental flowering plants in Delhi-NCR.
- Students will get familiar with the methods of preparing soil and other cultivation and propagation methods.
- Students will know about employment opportunities and other avenues in this industry.
- Students would be able to design/create gardens and learn the art of landscape design
- Students will get familiar with the methods of preparing soil and other cultivation and propagation methods adopted for growing hedges, climbers, vegetable, fruit and fruit yielding plants.
- Students will be aware of modern practices of maintaining nurseries, green houses and innovative practices in maintenance, harvesting and storage.

Practical:

1. Introduction to Horticulture and Floriculture, garden tools, equipment and safety.
2. Lawn making and lawn care: recognizing soils and drainage systems, types of grasses.
3. Choosing the appropriate plants (species selection) for plantation in different seasons and locations (Outdoor, roof-top, balcony, rock gardens); Flowering annuals, herbaceous perennials, vines and climbers, ornamental trees, bulbous and foliage plants, cacti and succulents.
4. Vegetable Garden: Sowing, raising seedlings, transplantation methods; choosing the right vegetables for the season.
5. Seed germination, viability tests and comparison of other parameters of seeds (stored from different years/different temperatures).
6. Weeding, manuring, and irrigation methods used in lawns, parks, and vegetable gardens.
7. Propagation and plant care: propagation by layering, cutting and other methods.
8. Study of diversity in shape, size, and colour of flowers (including basic botany, nomenclature, common name and general uses).
9. Identification and preparation of an inventory of wild herbaceous flowering plants, climbers, shrubs, and trees around the campus.
10. Study the various physico-chemical soil properties for understanding different soils/soil-types.
11. Methods of preparation of floral beds, soil preparation and fumigation methods.
12. Methods of seed sowing and raising flowering plants through seeds, bulbs and vegetative methods in planters, containers and in outdoor environments. Role of light, plant growth regulators and nutrients in blooming and flowering.
13. Harvesting methods to increase the shelf life of flowers, post-harvest care and marketing platforms for the floriculture industry.
14. Field visit to nearby nursery/garden to understand basic aspects of Garden design.
15. Project Report on any five flowering plants that are grown commercially, their share in the global market, methods used for selling the products and importance of the floriculture industry in job creation.

Suggested Readings:

1. Edmondson, J. L., Cunningham, H., Densley Tingley, D.O., Dobson, M., Grafius, D., Leake, J., McHugh, N., Nickles, J., Phoenix, G., Ryan, A., Stovin, V., Taylor

Buck, N., Warren, P., & Cameron, D. (2020). The hidden potential of urban horticulture. *Nature Food*, 1, 155–159.

2. Musser E., Andres. (2005). *Fundamentals of Horticulture*. McGraw Hill Book Co.
3. Sandhu, M.K. (1989). *Plant Propagation*. Bangalore: Wile Eastern Ltd.
4. Bird, C. (2014). *The fundamentals of horticulture: Theory and practice.* Cambridge University Press.
5. Randhawa, G.S., & Mukhopadhyay, A. (1986). *Floriculture in India*. Allied Publishers.
6. Larson, R. A. (2012). *Introduction to Floriculture*. Elsevier.

Additional Resources:

1. Pal, S. L. (2019). Role of plant growth regulators in floriculture: An overview. J. *Pharmacogn. Phytochem*, 8, 789-796.
2. The Practical Gardener (1994). Reader's Digest Special Volume.

Key Words:

Horticulture, Landscaping, Vegetable Gardening, Floriculture, Ornamentals, Vegetative Propagation, Harvesting.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT SEC 04
Course Title: Ethnobotany
Skill Enhancement Elective Course – (SEC)
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To know about plants which are used by the local communities, tribals & ethnic groups and learn about their nutritive and medicinal value.

Learning Outcomes:

- Students would understand the treasure, value and usefulness of natural products and their efficient use by the local communities as food and medicine and their conservation practices.

Practical:

1. Collection, identification and preparation of herbarium of three ethno-botanically important plants with appropriate references.
2. Preparation of crude extract of ethno-botanically important plants with appropriate references (any method to be used).
3. Herbal preparation: -
    (a) Extract of Tulsi leaves.
    (b) Ointment from Neem Leaves.
    (c) Ayurvedic tooth powder.
    (d) Face pack preparation from various herbs.
    (e) Preparation of Triphla.
    (f) Kwath of Triphla.Powder.
    (g) Preparation of diabetes controlling powder formulation.
    (h) Preparation of herbal shampoo.
4. Study of the following plants used in daily life by ethnic people and village folks for food, shelter and medicine.
    (a) Food- *Artocarpus, Corypha, Phoenix* (wild dates)
    (b) Shelter- *Bambusa, Ochlandra and Calamus*

(c) Medicine- *Curcuma, Trichopus zeylanicus, Alpinia galanga, Azadiractha indica, Ocimum sanctum, Vitex negundo, Gloriosa superba, Tribulus terrestris, Pongamia pinnata, Cassia auriculata, Indigofera tinctoria, Rauvolfia sepentina.*

A report to be submitted.

5. Extraction of drugs (Reserpine, Artemisin, Gugulipid, Cocain, Strychnine from ethnobotanically important plants.
6. Estimation of antioxidant activity of the herbal drug.

Suggested Readings:

1. Jain, S.K. (2010) *Manual of Ethnobotany*. Scientific Publishers.
2. Martin, G.J. (1995) *Ethnobotany: A Methods Manual*. Chapman Hall
3. Cunningham, A.B. (2001) *Applied Ethnobotany: People, Wild Plant Use and Conservation*. Earth scan, London.
4. Young, K.J. (2007) *Ethnobotany*. Infobase Publishing, New York.
5. Schmidt, B.M., Cheng, D.M.K. (Eds.) (2017). *Ethnobotany: A Phytochemical Perspective.* John Wiley & Sons Ltd. Chichester, UK.
6. Research papers from various Scientific Journals for case studies.

Keywords: Alkaloids, flavonoids, tannins, terpenoids, saponins, glycosides, Biopiracy, TKDL, Nutritional Ethnobotany, Ethnopharmacology.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT SEC 05
Course Title: Bio-nanotechnology
Skill Enhancement Elective Course – (SEC)
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

This course on Bionanotechnology has been designed to introduce students to the field of Nanotechnology in order to.

- gain knowledge and hands-on practical experience through some carefully chosen experiments that collectively illustrate the practice of synthesizing, organizing, visualizing and measuring a range of nanomaterials.
- emphasize the bottom-up building block philosophy for making nanoparticles using the methods of biological/chemical synthesis.
- make students aware about the interaction of various nanomaterials with biomolecules, microbes and plants along with nanoformulation of natural products.

Learning Outcomes:

- Students will be able to learn about synthesis of nanomaterial with the help of various biological material.
- Students will learn about basic techniques for synthesis and characterization of nanoparticles.
- Students will understand the interaction of nanoparticles with microbes, cells and plants.
- They will be able to learn and appreciate nanoformulations of active natural products.

Unit 1.

Introduction: Introduction to Nanoscale, Nanoscience and Nanotechnology, Properties of materials: Bulk materials *vs* nanomaterials. Nano in Nature, Classification of nanomaterials: 0D, 1D, 2D and 3D and types of nanomaterials, Concept of surface area to volume ratio; Preparation of nanomaterials: scaling up approach, scaling down approach, Nanocomposites: Types of nanocomposites, Solution, colloids and suspensions.

Practical:

1. To study the Tyndall effect. (Solutions, colloids and suspensions are distinguished by the size of dispersed particles and their macroscopic properties. Colloids have dispersed particles with sizes between 1 and 1000 nm, making them nanoparticles. In this size range, the particles will not settle out of the mixture, and the Tyndall effect will be evident.)
2. Verification of Beer-Lambert law and determination of concentration of unknown solution by UV-Visible spectrophotometer.

Unit 2.

Synthesis of nanomaterials: Chemical synthesis, Physical synthesis and Biosynthesis, Role of Microbes in Nanotechnology: Microbial synthesis of nanomaterials - Concepts and introduction: Bacteria-mediated nanomaterials synthesis – Methodology, Mechanism and applications, Fungi-mediated nanomaterials synthesis – Methodology, Mechanism and applications, Plants and Plant products and their extract mediated synthesis of nanomaterials, Advantages of microbial/biogenic nanomaterials synthesis methods. Biogenic fabrication of metal/metal oxide nanomaterials by bacteria.

Practical:

1. Biogenic synthesis of metal/metal oxide nanomaterials by fungi/yeast or plant extracts.
2. Waste fruit peel-mediated green synthesis of biocompatible gold nanoparticles.
3. Microwave-assisted green synthesis of colloidal silver nanoparticles.

Unit 3.

Green synthesis of nanomaterials: synthesis and applications, Biowaste utilization. Biofertilizers and Biopesticides encapsulated metal and polymer nanoparticles, Study of enzyme involved in the synthesis of nanomaterials and immobilization of enzyme on nanoparticles.

Practical:

1. Synthesis of carbon dots using plant/algal/natural carbon source.
2. Biogenic synthesis of magnetic nanoparticles and their separation using Permanent magnet.
3. Preparation of neem extract/neem oil loaded nano-formulations.
4. Isolation of enzymes involved in the biosynthesis of nanomaterials.
5. Preparation of nano-fertilizer blend from banana peels.

Unit 4.

Principles and methods of techniques for characterization of nanomaterials: Electron microscopy, Spectroscopic Techniques, X-ray based techniques, Thermogravimetry-Differential Thermal analysis, Dynamic light scattering, Photo-luminance, freeze drying and lyophilization.

Practical:

1. To study various techniques used for the characterization of nanomaterials and interpretation of data related to these techniques by digital images and graphs.
2. To study the effect of pH, temperature and concentration of plant extract on the synthesis of metal nanoparticles.
3. To determine entrapment efficiency of biopesticide in nanoparticles using UV-visible spectroscopy.

Unit 5.

Biological interaction studies of nanomaterials with microbes and applications of Nanomaterials: Molecular electronics and nano electronics, Quantum electronic devices, CNT based transistor and Field Emission Display, biological applications, Biochemical sensor, Membrane based water purification, Nano-diagnostics, Nano-agriculture.

Practical:

1. Biological synthesis of Zinc nano-fertilizers and study of their effect on seeding growth.
2. Evaluation of antimicrobial activity of nanomaterials by minimum inhibitory concentration and by disc-diffusion assay.
3. To study the photocatalytic activity of biosynthesized metal nanoparticles.

Suggested Readings:

1. Anal, A. K. (2018). *Bionanotechnology: Principles and Applications*. CRC press, Taylor & Francis Group.
2. Norde, W. (2011) *Colloids and Interfaces in Life Sciences and Bionanotechnology* (2nd ed.). CRC press, Taylor & Francis Group.
3. Good, D. S. (2004) *Bionanotechnology: Lessons from Nature*. Wiley-Liss Inc.
4. Singh R. P., & Singh K. R. B. (2022) *Nanomaterials in Bionanotechnology: Fundamentals and Applications, Series Title: Emerging material and Technologies.* CRC press, Taylor & Francis Group, Boca Raton, London.

Keywords:

Nanotechnology, Nanomaterials, Green synthesis, UV-visible, Metal nanoparticles, Biosynthesis.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT SEC 06
Course Title: Intellectual Property Rights
Skill Enhancement Elective Course – (SEC)
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To have knowledge about rules, regulations, laws and processes of patents, copyright trademarks and concepts of traditional knowledge and protection of plant varieties.

Learning Outcomes:

- Students would have a deep understanding of patents, copyrights and their importance.
- They will get an insight about the importance of traditional knowledge, bio-prospecting, and biopiracy.
- They would gain the knowledge of farmers rights and the importance of indigenous plant varieties, concept of novelty and biotechnological inventions.

UNIT 1.

Introduction to Intellectual Property Right (IPR) - Concept, history, kinds, importance, IPR in India and world, Genesis and scope, some important examples. Patents - Introduction, rights, criteria, procedure for obtaining pa tents, infringement; Copyright - Introduction, works protected under copyright law, rights, transfer of copyrights and infringement.

Practical:

1. Patent search
2. Trademark search
3. Copyright infringement (Plagiarism check by Urkund and other available software/s)

UNIT 2.

Geographical indications: Introduction, justification, international position, multilateral treaties, national level, Indian position.

Practical:

4. Geographical Indicators (i) Food: Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese (ii) Handlooms: Kota Doria, Banarasi Sari, Muga Silk, Kanchipuram Silk (iii) Industry: Mysore-Agarbatti, Goa-Feni, France-Champagne) (iv) Natural resources: Makrana marbles. Two examples from each category

UNIT 3.

Protection of traditional knowledge, Introduction, concept of traditional knowledge, holders, issues concerned, Bio-prospecting and Bio-Piracy, Sui-Generis regime, Traditional knowledge on the International Arena, at WTO, at national level, Traditional knowledge of Digital Library Industrial designs and Integrated Circuits - Introduction, rights, assignments, Infringements, defenses of design infringement, integrated circuits. Protection of Plant Varieties - Plant Varieties Protection - Objectives, justification, international position, Plant variety protection in India, rights of farmers, breeders and researchers, national gene bank, benefit sharing, Protection of Plant Varieties and Farmer's Rights Act, 2001.

Practical:

5. Biopiracy: Neem, turmeric, basmati rice.
6. Industrial designs- Jewellery design, Chair design, Car design, Bottle design, Aircraft design,
7. IPR e-diary

Suggested Readings:

1. Gupta, R. (2011) *Plant Taxonomy: Past Present and Future*. TERI Press.
2. Gupta, R., Rajpal, T. (2012) Concise Notes on Biotechnology. Delhi: Mc Graw Hill.
3. Acharya, N.K. (2001) Text Book on Intellectual Property Rights.

Additional Resources:

1. Bhandari, M.K. (2017). *Law Relating to Intellectual Property Rights (IPR).* Central Law Publications.
2. Gogia, S.P. *On Intellectual Property Rights (IPR).* Asia Law House.

Keywords:

Patent, Trademark**,** Copyright infringement**,** Geographical Indicators, Biopiracy, Industrial designs.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education

resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT GE 01
Course Title: Agricultural Botany and Weed Science
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

To gain the knowledge on:

- Requirement of the conditions for seed germination.
- Growth hormones, plant development and flowering conditions.
- Weeds and methods to control weeds.

Course Learning Outcomes:

After completion of this course the students would be able to understand the following:

- How is the quality of seeds assessed and how are suitable conditions created for seed germination?
- How is growth, flowering and fruiting in plants managed through the application of hormones?
- Weed biology, ecology and management of weeds in commercial crops

Theory:

Unit 1. Seed Physiology: **Lectures: 04**

Seed dormancy types, factors, mechanism and methods for breaking dormancy, seed viability, seed vigour and seed germination.

Unit 2. Physiology of Crop Growth and Yield: **Lectures: 05**

Growth, methods of growth analysis, factors affecting growth, concept of phytotronics and Fertilizers (Nitrogen, Phosphorus, biofertilizers).

Unit 3. Regulation of Growth and Development: **Lectures: 04**

Role of hormones in plant growth and development, growth retardant.

Unit 4. Reproductive Physiology and Senescence: **Lectures: 06**

Physiology of flowering, Photoperiodism, vernalization, physiology of fruit ripening, senescence and regulation of senescence.

Unit 5. Biology of Weeds: **Lectures: 04**

Ecology of weeds, competition, reproduction of weeds. Allelopathy and Invasive Plants.

Unit 6. Crop Management Practices: **Lectures: 07**

Mechanical, Cultural, Biological and Chemical Weed control. Some obnoxious weeds and their management, Integrated pest management (IPM).

Practical:

1. To study the effect of ethylene on shelf life of cut flowers. / To study the effect of cytokinin on leaf senescence.
2. To test the viability of weed seeds.
3. To study the allelopathic effects of weeds on germination of crop seeds.
4. To study the effect of herbicides on seed germination and seedling growth of weeds.
5. Determination of pH and analysis of a soil sample for carbonates, chlorides, sulphates, organic matter and base deficiency by rapid field tests.
6. To perform qualitative test for Nitrogen (NH^{4+}, NO^{3-}, urea) in a fertilizer and soil sample.
7. Demonstration / use of digital resources for the mechanisms used in herbicide application.
8. Field trip to a crop land to study weeds.
9. Submission of any two properly dried and mounted weed specimens with herbarium label.

Suggested Readings:

1. Ashton, F. M., & Monaco, T. J. (2002). *Weed Science: Principles and Practices.* John Wiley and Sons. Inc.
2. Hopkins, W.G. (1995). *Introduction to plant physiology.* John Wiley and Sons. Inc.
3. Taiz, L., & Zeiger, E. (2006). *Plant Physiology* (5th ed.). Sinauer Associates, Inc.
4. Mandal, R.C. (1990). *Weeds, weedicides and weed control: Principle and Practice.* Agro Botanical Publishers.
5. Rao, V. S. (1999). *Principles of Weed Science*. Oxford and IBH Publishers.
6. Subramanian, S. (2017). *All about weed control.* Kalayani publishers.

Keywords:

seed dormancy, crop growth, plant growth hormones, photoperiodism, allelopathy, weeds, management practices.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT GE 02
Course Title: Plant Quarantine and Seed Health Technology
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To acquaint the students with the Plant Quarantine Information System (PQIS).
- To familiarize the students with knowledge of export and import policies of Germplasm, Transgenic or Genetically Modified Organisms and live organisms.
- To impart knowledge about the importance of seed pathology including mode and mechanism of transmission of pathogens.
- To strengthen student's knowledge in field of quality, conditioning, drying and storage of seeds along with various acts and regulations related to seeds.

Learning Outcomes:

- Plant Quarantine Order and Amendments, and Issuance of Export and Import Permit.
- Procedures of Plant quarantine inspection for clearance.
- The need of quarantine for Germplasm, Transgenic or Genetically Modified Organisms, live insects and microbial cultures, plants, vegetative plants propagating materials and plant products.
- The laws associated with various acts of plant quarantine.
- Core competency in basic understanding about seeds, seed pathology, management and procedure for healthy seed production and seed storage.

Plant Quarantine

Theory:

Unit 1. Introduction: **Lectures: 02**

Plant quarantine: Definition, General principles of Plant Quarantine, Introduction and objectives of Plant Quarantine Information System (PQIS).

Unit 2. Imports: **Lectures: 05**

Plant Quarantine Order and Amendments, Issuance of the Import Permit, import inspection and clearance, Procedures of Post Entry Quarantine (PEQ) inspection, Permits required for import of Germplasm, Transgenic or Genetically Modified Plants, Plant parts and Plant products, Requirements for Import of Wood and Timber, Special conditions for Import of plant species.

Unit 3. Exports: **Lectures: 04**

Export inspection and certification procedure, Post-entry Quarantine, Appeal and Revision, Power of Relaxation, Commodities not requiring Plant Quarantine clearance.

Unit 4. Phytosanitary Measures: **Lectures: 03**

Phytosanitary Agreement, National Standards for Phytosanitary Measures, Accredited Treatment Facilities, Quarantine disinfestation treatment, International Standards on Phytosanitary Measures (ISPMs).

Unit 5. Laws: **Lectures: 04**

The Plant Quarantine Order 2003 - Amendments, International Plant Protection Convention, WTO-SPS Agreement.

Seed Health Technology

Theory:

Unit 6. Importance and concept: **Lectures: 03**

Introduction and economic importance of seed pathology in seed industry, mode and mechanism of transmission of seed-borne pathogens and microorganisms.

Unit 7. Seed Quality and Health: **Lectures: 04**

Classes of seeds and Seed Quality, Seed Cleaning, Seed Treating, Seed Coating and Pelletizing, Seed certification and tolerance limits, Role and Principles of seed Conditioning. Seed moisture, Drying seed and Dehumidified Drying.

Unit 8. Seed Regulations and Management: **Lectures: 05**

Role of microorganisms in seed quality deterioration, different methods for seed health testing and detection of microorganisms, Production of toxic metabolites affecting seed quality, Management and procedure for healthy seed production and seed storage, Seed Act and Regulations.

Practical:

1. Detection and identification of pathogens, pests and microorganisms by isolation and growth on different nutrient media.
2. Learning various techniques (Mechanical cleaning, hot water treatment, alcohol wash) for salvaging of infested/ infected/ contaminated germplasm.
3. To perform the Tetrazolium test (TTC) for seed viability.
4. To determine the moisture content of dry seeds by Soaked examination and Incubation test.
5. To inspect dry seeds and perform washing test to assess seeds' health.
6. To learn the technique of surface sterilization of seeds.
7. Evaluation of seed health of different Pulses by Incubation methods.
8. Detection of *Botrytis cinerea* in *Helianthus annuus* (Sunflower) seeds.
9. Detection of *Ustilago tritici* in *Triticum aestivum* by embryo count method.
10. A visit to the Plant quarantine station and preparation of field report.

Suggested Readings:

1. Muthaiyan, M.C. (2009). *Principles and Practices of Plant Quarantine*. Allied publisher Pvt. Ltd.
2. Ebbels, D.L. (2003). *Principles of Health and Quarantine*, CABI Publishing.
3. Lawrence O. Copeland & Miller B. McDonald (2001). *Principles of Seed Science and Technology* (4th ed.). Springer Science + Business Media, LLC.
4. S.G. Elias, L.O. Copeland, M.B. McDonald & R.Z. Baalbaki (2012). *Seed Testing: Principles and Practices*, Michigan State University Press.
5. Khare, D., & Bhale M. S. (2014) *Seed Technology* (2ndEd.). Scientific Publishers.
6. Gregg (B. R.) B. and Billups G. L. (2010) *Seed Conditioning Technology, Advanced-level Information for Managers, Technical Specialists & Professionals* (Volume 2, Part A) Science Publishers.

Additional Readings:

1. https://plantquarantineindia.nic.in/PQISMain/Default.aspx
2. https://plantquarantineindia.nic.in/PQISPub/html/Laws.htm
3. http://www.nbpgr.ernet.in/Divisions_and_Units/Plant_Quarantine.aspx
4. Dubey S.C. & Gupta K. (2016). Plant Quarantine system for PGR in India. *Indian J. Pl. Genet. Resour*, 29, 410-413.
5. *Validated Seed Health Testing Methods: International Rules for Seed Testing manual* (2022).

6. *Seed Quality Assurance: Seed Toolkit,* (2018) The Food and Agriculture Organization of the United Nations and Africa (Module: 3).

Keywords:

Plant quarantine, PQIS, Imports, Export inspection, Phytosanitary, WTOSPS, seed, industry, Seed Quality, Seed certification, Seed moisture, Drying seed, Dehumidified Drying, Seed Act and Rules, seed health testing, healthy seed production, Seed storage.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT GE 03
Course Title: Plant Cell and Tissue Culture Techniques
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

To give students knowledge of techniques used in plant tissue culture and its applications.

Learning Outcomes:

The students will:

- learn the basic concepts, principles and processes in plant cell and tissue culture.
- gain the ability to apply concepts and principles of plant cell and tissue culture in biotechnological and agricultural fields.
- understand the role of cell and tissue culture in plant improvement.
- gain knowledge and expertise to become an entrepreneur by establishing their own plant tissue culture lab.

Theory:

Unit 1. Historical perspective and terminology used in tissue culture:

Lectures: 03

Introduction to Plant Tissue Culture Technique, Contributions of Haberlandt, Reinert and Steward, Murashige and Skoog, Cocking, Guha and Maheshwari, Morel and Martin. Terminology: Cell culture, tissue culture, organ culture, explant, callus, totipotency, plasticity, dedifferentiation and re-differentiation, regeneration, subculture, somaclonal variants.

Unit 2. Media Preparation and Sterilization: **Lectures: 05**

Media composition - role of organic and inorganic nutrients, vitamins, hormones and supplements. Preparation of nutrient medium. Sterilization of medium, containers and small equipment (steam, dry, filter, UV light, alcohol and flame). Collection and sterilization of plant material, maintenance of aseptic conditions by use of autoclave and laminar flow chamber.

Unit 3. Micropropagation: **Lectures: 05**

Selection of plant material, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis. Advantages.

Unit 4. Protoplast culture: **Lectures: 05**

Protoplast isolation (mechanical and enzymatic), role of osmoticum, culture, purification, viability test and protoplast fusion (spontaneous, induced), selection of fused protoplasts, applications. Somatic hybrids and Cybrids.

Unit 5. *In vitro* Haploid and Triploid Production: **Lectures: 04**

Haploids - Anther culture and microspore culture, Applications. Triploids - Endosperm culture and Applications.

Unit 6. Applications of Tissue culture: **Lectures: 08**

Embryo rescue, Artificial seeds, virus elimination, secondary metabolite production, Cryopreservation, Germplasm conservation.

Practical:

l. (a) Equipment used in tissue culture: autoclave and laminar air flow chamber.
   (b) Preparation of Murashige & Skoog's (MS) medium.
   (c) Demonstration of *in-vitro* sterilization and inoculation methods using leaf and nodal explants.
2. Study of anther, embryo and endosperm culture.
3. Study of micropropagation, somatic embryogenesis & artificial seeds.
4. Isolation of protoplasts.
5. Visit to a plant tissue culture laboratory and submission of field report.

Suggested Readings:

1. Bhojwani, S. S. (1990). *Plant Tissue Culture: Applications and Limitations, Developments in Crop Science* (1st ed., Volume 19). Elsevier Science.
2. Bhojwani, S.S, & Bhatnagar, S.P. (2011). The Embryology of Angiosperms (5 ed.). Vikas Publication House Pvt. Ltd.
3. Bhojwani, S. S., & Dantu, P. K. (2013). *Plant Tissue Culture: An Introductory Text.* Springer.
1. Bhojwani, S. S., & Razdan, M. K. (1996). *Plant Tissue Culture: Theory and Practice* (Revised Ed.). Elsevier.
2. Newmann, K.-H., Kumar, A., & Imani, J. (2020). *Plant Cell and Tissue Culture: A Tool in Biotechnology* (2nd Ed.). Springer.

Additional Readings:

1. Park, S. (2021). *Plant Tissue Culture: Techniques and Experiments* (4th Ed.). Elsevier
2. Razdan, M. K. (2019). *Introduction to Plant Tissue Culture* (3rd Ed.). CBS / Oxford & IBH
3. Gamborg O. L & Phillips G. C. (Eds.). *Plant Cell, Tissue and Organ Culture: Fundamental Methods.* Springer-Verlag
4. Smith, R. H. (2013). *Plant Tissue Culture: Techniques and Experiments* (3rd Ed.). Elsevier.
5. Stewart, C.N. Jr. (2016). *Plant Biotechnology and Genetics: Principles, Techniques and Applications* (2nd Ed.). Wiley.
6. Trigiano, R. N. (2011). *Plant Tissue Culture, Development, and Biotechnology*. CRC Press.

Keywords:

Tissue culture, micropropagation, organogenesis, totipotency, protoplast isolation, culture and fusion, somatic embryogenesis, artificial seeds, cryopreservation, germplasm conservation.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT GE 04
Course Title: Recombinant DNA Technology and Proteomics
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To illustrate the use of modern techniques for the manipulation and analysis of DNA sequences.
- To learn to clone, analyse and modify the genetic material
- To understand the applications of recombinant DNA technology for the generation of commercial biotechnological products of diverse usage.
- To gain knowledge about biosafety and ethical concerns associated with recombinant DNA technology.
- To acquaint the students with proteome and its analysis
- To train students in strategizing research topics employing genetic engineering techniques.

Learning Outcomes:

Students would learn about

- technical know-how on modern techniques involved in manipulation and analysis of nucleic acids, Gene cloning for the creation of genetically modified organisms (GMOs).
- details of restriction endonucleases, marker and reporter genes, the repertoire of various vectors, construction of genetic libraries, screening methods and gene identification.
- applications of PCR, hybridization techniques and sequencing in basic and applied experimental biology.
- biosafety and ethical issues associated with rDNA technology
- designing and conducting experiments involving genetic manipulation.

Theory:

Unit 1. Introduction to Recombinant DNA technology and Gene cloning:

Lectures: 05

Introduction to rDNA and Genetic Engineering, Restriction endonucleases - Discovery, Nomenclature and applications of Type I - Type IV, Gene cloning - steps and applications,

Bacterial transformation, strategies for selection and screening, Introduction to marker and reporter genes (GUS, GFP and Luciferase).

Unit 2. Vectors in gene cloning and transfer: **Lectures: 09**

Plasmids (pBR322, pUC18/19, Blue-white screening and α-complementation); Lambda based vectors and derivatives (Insertion vectors, replacement vectors, cosmids, phagemids); Artificial Chromosomes (BACs and YACs), plant transformation vectors (Ti plasmid), Gene construct, Protein Expression Vectors for use in *E. coli*. Construction of genomic and cDNA libraries, screening methods for locating the desired gene (Replica plating, Complementation screening, Heterologous gene probe-based hybridizations). Biosafety concerns.

Unit 3. Polymerase chain reaction (PCR), nucleic acid hybridization and sequencing technologies: **Lectures: 07**

PCR technique and its applications, RT-PCR, Hybridization based assays (Southern blotting and hybridization and detection of RFLPs), Northern and Western blotting and hybridization, Restriction maps: construction and importance in navigating genomes, Sanger's di-deoxy chain termination method of sequencing and autoradiography and fluorescence dye chemistry, slab gel-based electrophoresis (semi-automated) to capillary-based gel electrophoresis (automated sequencing).

Unit 4. Proteomics: **Lectures:09**

Introduction and Scope of Proteomics, Post-translational modifications, Protein separation techniques - Electrophoresis (PAGE, SDS-PAGE, 2D-gel electrophoresis) and Column chromatography, Protein identification through Mass Spectroscopy - principle, ionization (MALDI, MALDI-TOF, ESI), Structural Proteomics - through NMR and X-ray crystallography, protein-protein interaction.

Practical:

1. Isolation of genomic and plasmid DNA from bacteria.
2. Quantification of extracted DNA by DPA (Diphenylamine) method.
3. Estimation of proteins by Lowry's method.
4. Restriction digestion and AGE (Agarose gel electrophoresis) of DNA.
5. Restricting Mapping of linear and circular DNA.
6. Study of techniques using digital resources/demonstration: PCR, RT-PCR, Real-time PCR, Southern, Northern and Western blotting and hybridization.
7. Study of techniques using digital resources/demonstration: SDS-PAGE, 2D-PAGE, MALDI, NMR, X-ray crystallography.

8. Study of applications of rDNA technology using digital resources/ in silico studies: recombinant insulin, interferon and human growth hormone.
9. Demonstration of equipment used in rDNA technology: Thermocycler, Laminar air flow, Autoclave, Incubator shaker, Refrigerated centrifuge.

Suggested Readings:

1. Green, M.R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual* (4th Ed.). Cold Spring Harbor.
2. Wink, M. (2011). *An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology* (2nd Ed.). Wiley.
3. Glick B.R., & Patten C.L. (2022). *Molecular Biotechnology: Principles & Applications of Recombinant DNA* (6th Ed.). ASM Press.
4. Snustad, D. P., & Simmons. M.J. (2012). *Principles of genetics* (6th ed.). John Wiley & Sons.
5. Brown, T.A. (2010). *Gene cloning and DNA analysis: an introduction.* John Wiley & Sons.
6. Primrose, S. B., & Twyman, R. (2009). *Principles of gene manipulation and genomics.* Wiley.
7. Howe, C. J. (2007). *Gene cloning and manipulation*. Cambridge University Press.
8. Liebler D. C. (2002) *Introduction to Proteomics: Tools for the New Biology*. Humana Press Inc.
9. Scopes R. K. (1994) Protein Purification: Principles and Practice, Springer.
10. Albala J.S. & Smith I.H. (Eds.). (2003). *Protein Arrays, Biochips and Proteomics: The Next Phase of Genomic Discovery* (1st ed.). CRC Press. https://doi.org/10.1201/9780203911129.

Additional Readings:

1. Burell, M.M. (1993). *Enzymes of Molecular Biology*. Humana Press.
2. Eun, H.M. (1996). *Enzymology. Primer for Recombinant DNA Technology*. Academic Press.
3. Primrose, S. B., Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.). Wiley-Blackwell.
4. Lehninger, A. L., Nelson, D.L., & Cox, M.M. (2017) *Principles of Biochemistry* (7th ed.). W.H. Freeman and company.

5. Cooper, T.G., (1977; Reprint 2011) *The Tools of Biochemistry*. Wiley India Pvt. Ltd.

Keywords:

Gene cloning, Recombinant DNA (rDNA), Vectors, Genetic libraries, Blotting techniques, PCR, RFLPs, DNA sequencing, Biosafety concerns, Ethical issues.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT GE 05
Course Title: Hydroponics and Organic Farming
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To provide knowledge and expertise of various aspects of hydroponics, aeroponics and organic farming to the students.
- To make students economically self-reliant by growing and marketing organic herbs, vegetables, micro greens and fruits.

Learning Outcomes:

- Students will develop a thorough understanding of the concept of Hydroponics, Aeroponics and Organic farming.
- Students will be trained in establishing a hydroponic facility. Students will learn the development of various organic products such as biopesticides, biofertilizers and biogrowth promoters.
- Students will understand various government policies in marketing of hydroponic and organic produce.
- Students will understand Good Agricultural Practices associated with protected agriculture.

Theory:

Unit 1. Introduction to Protected Agriculture: **Lectures: 02**

Types of Protected Agriculture (hydroponics, aquaponics and organic farming), definition history, terminology, importance and advantages over traditional agriculture, limitations and challenges.

Unit 2. Plant Growth Requirements and Media formulations: **Lectures: 05**

Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen - DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters - mineral nutrient requirements, deficiencies, toxicities,

growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media - types, properties, uses, nutrient formulae, preparation of solutions, solid Media and nutrient film.

Unit 3. Hydroponic growing systems: **Lectures: 07**

Basic concepts and designs (closed and open systems techniques Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), Systems layout, Strengths and weaknesses of various systems, site considerations, componentry, nutrient delivery, pumping, Principles of aeroponics.

Unit 4. Hydroponics associated pest and diseases: **Lectures: 04**

Hydroponics associated pests - mites, thrips, whiteflies, leaf miners; Identification and management of diseases - bacterial, fungal and viral diseases; safety practices (Good Agricultural Practices (GAP) and Integrated Pest Management (IPM).

Unit 5. Organic farming and its management: **Lectures: 08**

Introduction to Organic farming and associated management practices (nutritional requirements, pest, diseases, weeds); use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas*, neem oil, garlic etc.) in management, Different concepts of organic farming – Natural farming, Biodynamic farming, Permaculture and Zero Budget Farming

Unit 6. Produce Marketing and Policies **Lectures: 04**

Marketing of the produce, Government institutes and policies related to protected farming (hydroponics and organic farming).

Practical:

1. Study of various instruments used in hydroponics.
2. Preparation of growth media for hydroponics.
3. Estimation of NPK, DO, TDS, pH of growing media
4. Study of techniques used in hydroponics (Circulating methods such as Nutrient Film Technique (NFT), Deep Flow Technique (DFT), Dutch bucket; Non circulating methods such as Root dipping, Floating, Capillary action; Aeroponics such as root mist and fog feed techniques.
5. Demonstration of construction of a sustainable hydroponic unit.
6. Perform rapid tests for estimation of NPK in different soil samples (at least three).
7. Bulk density and porosity of soilless media e.g., coco-peat, perlite, vermiculite, expanded clay, rockwool (any two media).

8. Study of suitable conditions for Hydroponics - quality, light intensity, photoperiod and temperature.
9. Demonstration of growing a leafy vegetable/ fruity vegetable/ medicinal herb/aromatic plant in Hydroponics solution.
10. Study of traditional organic inputs and formulation of biofertilizer.
11. Preparation of biopesticides, plant health promoters like *Panchgavya*, *Beejamrut* etc.
12. Field visit to organic farm/hydroponic farm and submission of visit report.

Suggested Readings:

1. Schwarz, M. (1995). *Soilless Culture Management, Advanced Series in Agricultural Sciences* (vol. 24). Springer, Berlin, Heidelberg.
2. Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., & Pragnya, P. (2018). *Hydroponics Technology for Horticultural Crops*. Tech. Bull. TB-ICN188/2018. Publ. by I.A.R.I.
3. Misra S., Misra S., & Misra R.L. (2017). *Soilless Crop production*. Daya Publishing House, Astral International (P) Ltd.
4. Palaniappan S. P., & Annadurai K. (2018). *Organic Farming: Theory & Practice*. Scientific Publisher.
5. Goddek, S., Joyce, A., Kotzen, B., & Burnell, G.M. (2019). *Aquaponics Food Production Systems*. Springer, Cham.

Additional Readings:

1. Jones, J. B. (2014). *Complete Guide for Growing Plants Hydroponically*. CRC Press.
2. Vayas, S.C, Vayas, S., Modi, H.A. (1998). *Bio-fertilizers and organic Farming*. Akta Prakashan.
3. Jones, J. Benton (2005). *Hydroponics: A Practical Guide for the Soilless Grower* (4^{th} Edition). CRC Press.
4. Roberto, K. (2003). *How to Hydroponics* (4th Ed.). The Future Garden press.

Keywords:

Hydroponics, Aquaponics, Organic Farming, Dissolved Oxygen-DO, Total Dissolved Solid – TDS**,** Good Agricultural Practices (GAP) and Integrated Pest Management (IPM), Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education

resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT GE 06
Course Title: Informatics and Statistics for Biology and Allied Sciences
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To build an understanding *in silico*/computational approaches in various aspects of understanding biology and biological research.
- To build analytical skills and integrate the principles of statistical analyses for robust interpretation of biological observations.

Learning Outcomes:

The student will understand

- the basics of bioinformatics and develop awareness of the interdisciplinary nature of this field.
- learn about biological databases, sequence retrieval, alignment, and phylogenetic analysis using various tools.
- understand the basic concept of sampling methods, data classification, presentation and statistical analysis.

Theory:

Unit 1. Introduction to Bioinformatics: **Lectures: 03**

Historical background, Aims and scope, bioinformatics in Genomics, Transcriptomics, Proteomics, Metabolomics, Systems biology and drug discovery, Applications and Limitations in bioinformatics.

Unit 2. Biological databases: **Lectures: 04**

Introduction to biological databases - Primary, secondary and composite databases. Study of following databases: NCBI (GenBank, PubChem, PubMed and its tools (BLAST)), introduction to EMBL, DDBJ, UniProt, PDB and KEGG.

Unit 3. Basic concepts of Sequence alignment: **Lectures: 04**

Similarity, identity and homology. Concepts of alignment (gaps and penalty); Alignment – pairwise and multiple sequence alignments.

Unit 4. Molecular Phylogeny: **Lectures: 04**

Introduction to Molecular Phylogeny, methods of construction of phylogenetic trees: maximum parsimony (MP), maximum likelihood (ML) and distance (Neighbor-joining) methods.

Unit 5: Biostatistics: **Lectures: 02**

Biostatistics – definition, Basics of descriptive and inferential statistics; Limitations and applications of biostatistics.

Unit 6: Data types and presentation: **Lectures: 03**

Primary and secondary data; Sampling methods (in brief); tabulation and presentation of data

Unit 7: Descriptive Statistics: **Lectures: 04**

Measures of central tendency - mean, median, and mode; Measures of dispersion - range, standard deviation, and standard error.

Unit 8: Correlation and Regression: **Lectures: 03**

Types and methods of correlation, Introduction to simple regression equation; similarities and dissimilarities between correlation and regression.

Unit 9: Statistical inference: **Lectures: 03**

Hypothesis – (simple hypothesis), student's t test, chi-square test.

(Note: Numerical based questions of unit 7, 8 and 9 should be covered only in practical).

Practical:

1. Biological databases (NCBI, EMBL, UniProt, PDB)
2. Literature retrieval from PubMed
3. Sequence retrieval (protein and gene) from NCBI (formats - FASTA, GenBank and GenPept formats)
4. Protein Structure retrieval from PDB (in pdb format) and visualization by viewing tools (Ras Mol/ J mol/Mol*/Swiss 3D Viewer/Pymol)
5. Multiple sequence alignment (MEGA/Clustal omega)
6. Construction of phylogenetic tree (PHYLIP/ MEGA/ Clustal omega).
7. Making of Bar diagrams, Pie chart, Histogram, Frequency polygon, Cumulative frequency curve (any four) in the given data set using Microsoft Excel
8. Calculation of mean, mode, median, standard deviation and standard error (through manual calculation and using Microsoft Excel) (use only ungrouped data)

9. Calculation of correlation coefficient values by Karl Pearson's /Spearman Rank methods (through manual calculation and using Microsoft Excel)
10. Student's t-test (using Microsoft Excel only), chi square test (Manual and using Microsoft Excel).

Suggested readings:

1. Ghosh, Z., & Mallick, B. (2008). *Bioinformatics – Principles and Applications* (1st ed.). Oxford University Press.
2. Baxevanis, A.D., Ouellette, B.F., John (2005). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd ed.). Wiley & Sons, Inc.
3. Roy, D. (2009). *B* (1st ed.). Narosa Publishing House.
4. Andreas, D., Baxevanis, B.F., Francis, & Ouellette. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins* (3rd ed.). John Wiley and Sons.
5. Khan, I.A., & Khanum, A. (2004). Fundamentals of Biostatistics (5th ed.). Ukaaz publications.
6. Campbell, R.C. (1998). *Statistics for Biologists*. Cambridge University Press

Additional Readings:

1. Pevsner, J. (2009). *Bioinformatics and Functional Genomics* (2nd ed.). Wiley Blackwell.
2. Xiong, J. (2006). *Essential Bioinformatics* (1st ed.). Cambridge University Press.
3. Mount, D.W. (2004). *Bioinformatics: Sequence and Genome analysis* (2nd ed.). Cold Spring Harbor Laboratory Press, USA.
4. Zar, J.H. (2012). *Biostatistical Analysis* (4^{th} ed.). Pearson Publication.
5. Pandey, M. (2015). *Biostatistics Basic and Advanced*. M V Learning.

Keywords:

GenBank, PubChem, PubMed, BLAST, EMBL, Multiple Sequence Alignment, Measures of Central Tendency, Measures of Dispersion, Student's t-test.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

Course Code: ALS BOT GE 07
Course Title: Genetically Modified Plants
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- To illustrate the use of modern techniques for genome analysis and manipulation
- To understand the strategies involved and the need for developing transgenic crops
- To gain knowledge about biosafety and ethical concerns associated with Genetically Modified DNA.
- To train students in strategizing research topics employing genetic engineering techniques.

Learning Outcomes:

Students would learn about modern techniques involved in the manipulation of nucleic acids and creation of genetically modified organisms (GMOs).

- Applications of PCR, hybridization techniques and sequencing.
- Commercial application of Genetically Modified Plants in research, agriculture and human health.
- biosafety and ethical issues associated with Genetic engineering.
- designing and conducting experiments involving genetic manipulation of plants.

Theory:

Unit 1. Introduction to Transgenics: **Lectures: 02**

First and Second-generation transgenic crops. Terminology: Transgenics, Transgene, Genetic transformation, recombinant DNA, Putative Transgenic, Stable gene integration. Gene Construct. Introduction to selectable marker (*npt II, hpt, spt*) and reporter (*GUS, GFP* and Luciferase) genes.

Unit 2. Gene Isolation and Genetic Transformation: **Lectures: 10**

Methods for gene isolation - Direct selection, construction and screening of genomic and cDNA libraries (Replica plating, Complementation screening, heterologous gene probe-based hybridizations); Gene transfer methods - Direct (*Agrobacterium* mediated transformation,

molecular basis of T-DNA transfer); Indirect methods (Electroporation, Microinjection and Particle Bombardment). Screening for putative transgenics through PCR and Southern blotting. Gene expression analyses at transcriptional level (Northern blotting, DNA microarrays) and translational level (Western blotting, ELISA). Generation of marker-free transgenics. Chloroplast transformation.

Unit 3. Transgenics for Resistance to Biotic and Abiotic Stress:

Lectures: 09

Biotic stress - Strategies for developing Insect resistant plants (Bt toxin, protease inhibitor, *α-amylase* inhibitor and other protein genes), Virus resistant plants (Coat protein mediated protection, Pokeweed antiviral protein, *RNaseIII*, micro-RNA and other viral genes), Fungal and Bacterial disease resistant plants (Genes for PR proteins like *Chitanase*, β-1,3 *Glucanase*, Thaumatin like, Osmotin; Antimicrobial proteins like Ribosome Inactivating Proteins, Lectins, Lysozyme; Phytoalexins etc.); Abiotic Stress - Strategies for overcoming Oxidative, Salt & Drought, Chilling stress through transgenics approach. Herbicide Resistance - Strategies, Roundup Ready Soybean.

Unit 4. Transgenics for Improved Quality and Other Traits: Lectures: 03

Engineering for shelf-life (Antisense *Polygalacturanase* gene, *SAM hydrolase*) and nutritional quality (β-carotene production). Transgenics as bioreactor - plantibodies and edible vaccines. Biodegradable Plastics.

Unit 5. Safety and Ethical Issues: Lectures: 06

Field testing and commercialization, Rules and Regulations for handling rDNA/ GMOs, Terminator technology, Ethics: Impact and safety, moral, social, regulatory & ethical issues.

Practical:

1. Isolation of plasmid DNA from bacteria
2. Isolation of genomic DNA from plant (Cauliflower head/ *Brassica* seedlings)
3. Preparation of competent cells in *E. coli*.
4. Transformation of *E. coli* cell by $CaCl_2$ method and calculation of transformation efficiency.
5. Restricting Mapping of linear and circular DNA.
7. Study of direct and indirect gene transfer methods by photographs: Electroporation, Microinjection and Particle Bombardment, Ti-plasmid mediated gene transfer

8. Study of techniques using digital resources/ demonstration: PCR, Southern, Northern and Western blotting, ELISA, DNA Microarray.
9. Study of Sequencing techniques (Whole Genome Shot Gun Approach, Clone by Clone Sequencing, Sanger's Dideoxy Sequencing) through digital resources.
10. Study of Genetically Modified Plants using digital resources: Bt-Cotton, Golden rice, Flavr Savr tomato, Round-up Ready Soybean
11. Visit to a research laboratory/field.

Suggested Readings:

1. Brown, T. A. (2016) *Gene Cloning and Analysis: An Introduction.* Wiley-Blackwell Publishing.
2. Chrispeels M.J., & Sadava D. E. (1994). *Plants, Genes and Agriculture.* Jones and Bartlett Publishers.
3. Glick B.R., & Patten C.L. (2022). *Molecular Biotechnology: Principles & Applications of Recombinant DNA* (6th Ed.). ASM Press.
4. Green, M.R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual* (4^{th} Ed.). Cold Spring Harbor.
5. Wink, M. (2011). *An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology* (2nd Ed.). Wiley.
6. Primrose, S. B., & Twyman, R. (2009). *Principles of gene manipulation and genomics.* Wiley.
7. Howe, C. J. (2007). *Gene cloning and manipulation.* Cambridge University Press.

Additional Readings:

1. Primrose, S. B., & Twyman, R. (2006) *Principles of Gene Manipulation and Genomics* (7th ed.). Wiley-Blackwell.
2. Dale J. W., Schantz M. V. and Plant N. (2011) *From Genes to Genomes: Concepts and Applications of DNA Technology.* John Wiley & Sons.

Keywords:

Transgenic plants, gene transfer, Gene library, Blotting techniques, biotic and abiotic stress resistant, plantibodies, edible vaccine, Biosafety concerns, Ethical issues.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education

resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Assessment Methods:

Performance of the students will be evaluated on the basis of regular class test, presentations and assignments as a part of internal assessment during the course, as per the curriculum. There would be a continuous evaluation of laboratory exercises and the record files. End semester university examination will be held for both theory and practical components. In practical, assessment will be done based on continuous evaluation and performance in the practical examination.

12.

SYLLABUS FOR UNDERGRADUATE PROGRAMME IN APPLIED LIFE SCIENCES WITH AGROCHEMICALS AND PEST MANAGEMENT

(CHEMISTRY)

Course Code: ALS CHEM DSC 01
Course Title: Inorganic Chemistry
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

The course introduces the students to basics of coordination chemistry and organometallics which are of immense importance to biological systems. Nomenclature, isomerism, bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system. In organometallic chemistry, the students are introduced to classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species with special emphasis on metal carbonyls.

Learning Outcomes:

By the end of the course, the students will be able to:

- Understand term like; ligand, chelate, coordination number. Systematic naming of coordination compounds.
- Learn various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Understand meaning of the terms Δo, Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Analyse IR data to understand the extent of back bonding in metal carbonyls.

Theory:

Unit 1. Introduction to Coordination compounds: **Lectures: 06**

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving

simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination number 4 and 6.

Unit 2. Bonding in Coordination compounds: **Lectures: 14**

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes, Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields, Crystal field stabilization energy (CFSE), concept of pairing energy, Factors affecting the magnitude of Δ, Spectrochemical series, Splitting of d orbitals in tetrahedral symmetry, Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry, Jahn-Teller distortion.

Unit 3. Organometallic chemistry: **Lectures: 10**

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, sigma, pi and multicentre bonds), Structure and bonding of methyl lithium and Zeise's salt, Structure and bonding of ferrocene, mononuclear and polynuclear carbonyls of 3d metals, 18-electron rule as applied to carbonyls, π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Practical:

1. Estimation of Mg^{2+} by direct complexometric titration using EDTA.
2. Estimation of Zn^{2+} by direct complexometric titration using EDTA.
3. Estimation of Ca^{2+} by direct complexometric titration using EDTA.
4. Estimation of total hardness of a given sample of water by complexometric titration.
5. Determination of the composition of the Fe^{3+}-salicylic acid complex/Fe^{2+}-1, 10- phenanthroline complex in solution by Job's method.
6. Determination of the composition of the Fe^{3+}-salicylic acid complex/Fe^{2+}-1,10-phenanthroline complex in solution by mole ratio method.
7. Preparation of the following inorganic compounds:
    a) Tetraamminecopper (II) sulphate
    b) Potassium trioxalatoferrate (III) trihydrate
    c) Chrome alum
    d) Cuprous chloride
    e) Manganese (III) phosphate ($MnPO_4.H_2O$)

f) Potash alum

g) Acetylacetonate complex of Cu^{2+} and Fe^{3+}

Suggested Readings:

Theory:

1. Huheey, J.E., Keiter, E.A., Keiter, R. L., & Medhi, O.K. (2009). *Inorganic Chemistry- Principles of Structure and Reactivity.* Pearson Education.
2. Shriver, D. D., Atkins, P., & Langford, C.H. (1994). *Inorganic Chemistry* (2nd Ed.). Oxford University Press.
3. Atkins, P.W., Overton, T.L., Rourke, J.P., Weller, M.T., & Armstrong, F.A. (2010), Inorganic *Chemistry* (5th Ed.). W. H. Freeman and Company.
4. Cotton, F.A. Wilkinson, & G. Gaus, P.L. *Basic Inorganic Chemistry* (3rd Ed.). Wiley India.
5. Douglas, B.E., McDaniel, D.H., & Alexander, J.J. (1994). *Concepts and Models of Inorganic Chemistry*. John Wiley & Sons.
6. Greenwood, N.N.; Earnshaw, A. (1997). *Chemistry of the Elements* (2nd Ed.). Elsevier.
7. Sahoo, et al. *Inorganic Chemistry*. PHI Learning Private Limited.

Practical:

1. Jeffery, G.H., Bassett, J., Mendham, J., & Denney, R.C. (1989). *Vogel's Textbook of Quantitative Chemical Analysis*. John Wiley and Sons.
2. Marr, G., & Rockett, B.W. (1972). *Practical Inorganic Chemistry*. Van Nostrand Reinhold.

Keywords:

Crystal field theory, Dq, CFSE, Nomenclature, Valence bond theory, Crystal field theory, Magnetic properties, 18 electron rule, metal carbonyls, hapticity.

Teaching Learning Process:

- Conventional chalk and board teaching.
- Class interactions and discussions.
- Power point presentation on important topics.

Assessment Methods:

- Presentations by Individual Student/ Group of Students.
- Class Tests at Periodic Intervals.
- Written assignment(s).
- End semester University Theory Examination.

Course Code: ALS CHEM DSC 02
Course Title: Soil Fertility, Fertilizers and Micronutrients
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

This course is designed to make students aware of soil fertility, role of different plant nutrients, fertilizers and their use. Soil is the natural resource for many nutrients which are required during the growth and development of plants. Fertilizers are applied to the soils as supplementary nutrients, and they also contribute to the enhancement of the growth of plants.

Learning Outcomes:

Students will be able to understand about the different types of soils, soil composition, important physical properties of soil and fertilizers. They may be able to apply this knowledge for agriculture purpose to get better crop productivity.

Theory:

Unit 1. Lectures: 6

Nature, origin, composition, and types of soil. Chemistry of weathering of soils and clay minerals. Soil acidity, salinity, and alkalinity. Liming of soil. Introduction to soil fertility and productivity. Factors affecting soil fertility and productivity. Organic matter (OM), Cation exchange capacity (CEC), Anion exchange capacity (AEC) of agricultural soils.

Unit 2. Lectures: 8

Plant nutrients- Definition, classification of nutrients as: Primary nutrients, Secondary nutrients, Macronutrients (N, P, K, Ca, Mg, S) and Micronutrients (Cl, Fe, B, Mn, Zn, Cu, Mo, Ni): Properties, uses and deficiency symptoms of nutrients. Definition and uses of beneficiary elements (Co, Na, Si, Se and V). Nitrogen cycle, Nitrification, denitrification, and ammonification.

Unit 3. Lectures: 12

Functions and forms of Nitrogen, Phosphorous and Potassium in plants. Available nitrogen, phosphorous and potassium in fertilizers.

Nitrogen fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, sodium nitrate, ammonium chloride and their uses. Slow-release fertilizers. Neem coated urea (NCU)

Sulphur coated urea (SCU) and polymer coated urea (PCU). Manufacturing of urea by Haber-Bosch process. Synthesis of ammonium nitrate, calcium ammonium nitrate, sodium nitrate and ammonium chloride.

Phosphorous fertilizers: Rock phosphate, Bone meal, basic slag, super phosphate of lime, single super phosphate, triple super phosphate, ammonium phosphates: manufacturing and uses.

Potassium fertilizers: Potassium nitrate, potassium chloride, potassium sulphate: synthesis and uses.

Unit:4 **Lectures: 4**

Complex fertilizers and Mixed fertilizers. Advantages of NPK fertilizers. Introduction to Organic Manures and Biofertilizers, Residual effect of Fertilizers and impact on Environment.

Practical:

1. To determine soil texture by different size of sieves.
2. To determine moisture content in given soil sample.
3. To determine bulk density of given soil sample.
4. To determine water retention capacity of soil sample.
5. Estimation of organic matter in given soil sample volumetrically.
6. Qualitative estimation of nitrogen, phosphorous, potassium and calcium carbonate in given soil sample.
7. Determination of conductivity of given soil sample.
8. Determination of acidity of soil using pH meter.
9. To determine the phenolphthalein alkalinity and total alkalinity of given soil sample volumetrically.
10. To determine total phosphate in given fertilizer sample volumetrically.
11. Qualitative analysis for the type of fertilizer in a given sample.
12. To determine concentration of nitrate, ammonia and phosphate by spectrophotometer with the help of calibration curve.

Suggested Readings:

Theory:

1. Havlin, J. L., Tisdale, S. L., Nelson, W. L., & Beaton, J. D. (2016). *Soil fertility and fertilizers*. Pearson Education India.

2. Tandon, H.L.S. (2008). *Fertilizers and Their Composition, Characteristics, Quality, Transformations and Applications*. Fertiliser Development Consultation Organisation.
3. Langdon R., Elsworth, Paley, & W.O., Nova. (2008). *Fertilizers: Properties, Applications and Effects*. Science Pub.
4. Chopra, S. L., & Kanwar, J. S. (1976). *Analytical Agricultural Chemistry*. Kalyani Publishers. 5. Das, P. C., (2015). *Manures and fertilizers*. Kalyani Publishers Pvt. Ltd.
6. Nagornny, V. D., & Raghav, J. S. (2015). *Soil Fertility Management*. Kalyani Publishers Pvt. Ltd.
7. Snyder H. (2008). *The Chemistry soils and Fertilizers*. Easton, Pa., The Chemical Publishing Co.

Practical:

1. Gupta A. K., & Varshney M. L. (2007). *Practical manual for Agriculture Chemistry*. Kalyani Publishers Pvt. Ltd., New Delhi.
2. Handbook of agriculture. Indian Council of Agricultural Research.
3. Yawalker, K.S., Agrawal, J.P., & Bokde, S. (1992). Manures and Fertilizers. Agri-Horticultural Publishing House, Nagpur (Maharashtra).

Keywords:

Soil fertility, Fertilizers, Primary nutrients, Secondary nutrients, Macronutrients Micronutrients, Organic Manures, Residual effect and Environmental impact.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods:

Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Course Code: ALS CHEM SEC 01
Course Title: Green Methods in Chemistry
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

This course is designed to make the students aware of chemistry that is good for human health and the environment. By gaining thorough knowledge of the green chemistry principles, students would be able to think of suitable remediation technologies for the cleaning up of hazardous substances. Also, students would be able to design, develop and run chemical processes in a sustainable way.

Learning Outcomes:

By the end of this course, students will be able to:

- Think to design and develop materials/ processes that reduce the use and generation of hazardous substances in industry.
- Know how injudicious use of chemicals can have an adverse/potentially damaging effect on humans and the environment.
- Get ideas of innovative approaches to environmental and societal challenges.
- Critically analyse the existing traditional chemical pathways/processes and creatively think about bringing environmentally benign reformations in these protocols.
- Convert biomass into valuable chemicals through green technologies.

Practical:

1. Definition and Importance of green chemistry. Introduction to the prevention of waste/ by products and waste/ pollution prevention hierarchy.
   (a) Provide the scheme for the traditional as well as green method for the synthesis of ibuprofen and ask them to calculate and compare the amount of waste generated in both the processes.
2. Principle and calculation of atom economy. Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
   (a) Preparation of propene by two methods can be studied
      (i) Hoffman elimination
      (ii) Dehydration of propanol

(b) The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

3. Prevention/ minimization of hazardous/ toxic products reducing toxicity. Risk = (function) hazard x exposure.
   (a) Nitration of salicylic acid using Ca $(NO_3)_2$ as a green method.
   (b) Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.
   (c) Preparation of dibenzalacetone by cross aldol condensation reaction using base catalysed green method.
   (d) Acetylation of primary aromatic amine using the green method.
4. Use of Green solvents and comparison of greenness of solvents:
   (a) Explain about supercritical fluids with special reference to carbon dioxide.
   (b) Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.
   (c) Introduction to water as a solvent for chemical reactions. preparation of Manganese (III) acetylacetonate using green method.
   (d) Advantages and application of solventless processes in organic reactions.
      (i) Benzil- Benzilic acid rearrangement in solid State under solvent-free condition.
      (ii) Mechanochemical solvent free, solid–solid synthesis of azomethine using p- toluidine and o-vanillin/p-vanillin.
5. Energy requirements for reactions – alternative sources of energy: use of microwaves and photochemical energy.
   (a) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
   (b) Microwave-assisted ammonium formate-mediated Knoevenagel reaction: p-anisaldehyde, ethyl cyanoacetate, ammonium formate.
6. Selection of renewable starting material rather than depleting, Illustrate with few examples such as biodiesel and polymers from renewable resources (such as green plastic).
   (a) Preparation of biodiesel from waste cooking oil and characterization.
7. Importance of using catalytic reagents in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
   (a) Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

(b) Rearrangement of diazoaminobenzene to p-aminoazobenzene using K10 montmorillonite clay.

8. Students should be asked to prepare a presentation/project based on any of the following topics:
   (a) Bhopal Gas Tragedy and safer route to carbaryl synthesis.
   (b) Flixiborough accident and safer route to cyclohexanol.
   (c) Use of Surfactants for SC-CO2 for precision cleaning and dry cleaning of garments replacing PERC.
   (d) A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards.
   (e) Healthier Fats and oils by Green Chemistry: Enzymatic Interesterification for production of No Trans-Fats and Oils.
   (f) Synthesis of anti-tuberculosis drug Paramycin from waste water stream
   (g) Syntheses of vitamin D3 using photochemical energy.
   (h) Greener Manufacturing of Sitagliptin Enabled by an Evolved Transaminase.
   (i) Microwave assisted solvent free synthesis of aspirin.
   (j) Synthesis of 6-Aminopenicillanic Acid (6-APA) from penicillin G using biocatalyst.

Suggested Readings:

Theory:

1. Anastas, P.T., & Warner, J.C. (2014). *Green Chemistry: Theory and Practice*. Oxford University Press.
2. Lancaster, M. (2016). *Green Chemistry: An Introductory Text* (3rd Ed.). RSC Publishing.
3. Cann, M.C., & Connely, M. E. (2000). *Real-World cases in Green Chemistry*. American Chemical Society, Washington.
4. Matlack, A.S. (2010). *Introduction to Green Chemistry* (2nd Ed.). CRC Press.
5. Alhuwalia, V.K.; & Kidwai, M.R. (2012). *New Trends in Green chemistry*. Kluwer Academic Publishers, Springer.
6. Sidhwani, I. T., & Sharma, R.K. (2020). *An Introductory Text on Green Chemistry*. Wiley India Pvt Ltd.
7. Etzkorn, F.A. (2019). *Green Chemistry: Principles and Case Studies*. Royal Society of Chemistry.

Practical:

1. Kirchoff, M., Ryan, M.A. (2002). *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC.
2. Sharma, R.K., Sidhwani, I.T., Chaudhari, M.K. (2013), Green Chemistry Experiments: A monograph, I.K. International Publishing House Pvt Ltd. New Delhi.
3. Pavia, D.L., Lamponam, G.H., Kriz, G.S.W. (2006), Introduction to organic Laboratory Technique- A Microscale approach, 4th Edition, Brooks-Cole Laboratory Series for Organic chemistry.
4. Sidhwani, I.T.; Saini, G.; Chowdhury, S. Wealth from Waste: *A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated.* University of Delhi, Journal of Undergraduate Research and Innovation, Volume 1, Issue 1, February 2015, ISSN: 2395-2334.
5. Sharma, R. K., Gulati, S., Mehta, S. (2012), Preparation of Gold Nanoparticles Using Tea: A Green Chemistry Experiment, Journal of Chemical Education, 89 (10), 1316-1318.

Keywords:

Waste production, Problem and prevention; Emerging green technologies, Green Catalysts, Green Solvents, Green Energy, Photo-oxidation technologies, Industry-academia collaboration, Circular economy.

Teaching Learning Process:

- Interactive Classes
- Experiential Learning
- Power point presentations
- Visit to pharmaceutical industries and green chemistry laboratories
- Interesting and inspiring short videos and movies on green chemistry
- Activities related to green chemistry would be conducted in classrooms that would enhance the critical thinking of students and help them redesign experiments in a greener way

Assessment Methods:

- Conventional Class tests, Open Book tests, Graded Assignments, Online tests - objective or subjective, Quizzes, Presentation on a topic in front of the classmates and performing a new experiment based on the concepts learned in the course.

Course Code: ALS CHEM SEC 02
Course Title: Laboratory Techniques in Chemistry
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

The course presents an introduction to Chemistry Laboratory and working skills among the students. The course will help to impart knowledge, enhance skill learning and make students aware to follow safety measures.

Learning Outcomes:

By the end of this course, students will be able to handle the chemicals, apparatus and equipment in a safe and correct manner. Students will able to carry out chemistry laboratory work confidently.

Practical:

1. Safety Measures in Chemistry Laboratory:
   (a) To instruct students about Do's and Don'ts to be followed while working in a chemistry laboratory.
   (b) To illustrate Common Safety Symbols and their description for given set of chemicals.
   (c) To demonstrate the use of fire extinguisher.
   (d) To make students familiar with Hazard based on storage, handling, and disposal of chemicals.
   (e) To make students aware of the steps to be taken in the event of an accident in chemistry laboratory due to:
      (i) Inhalation
      (ii) Spilling
      (iii) Cut or burn injury
      (iv) Swallowing
2. Standard Operations in Chemistry Laboratory:
   (a) To make students familiar with Common Laboratory Apparatus and their use:
      (i) Glassware.
      (ii) Burners.

(iii) Heating Baths.

(iv) Electric Hot Plates, Electric Heating Mantles, electric oven.

(v) Mechanical and magnetic stirrer.

(vi) Sand Bath and Ice Bath.

(vii) Melting point and boiling point apparatus.

(viii) Centrifugal machine.

(ix) Vacuum pumps.

(x) Test tube holder, pair of tongs, spatula.

(xi) Desiccator.

3. Basic experimental techniques in Chemistry Laboratory:

(a) Correct usage and maintenance of a balance.

(b) Handling, Cleaning and drying of Glassware.

(c) Use, handling and Calibration of thermometers.

(d) Use, handling and Calibration of volumetric flask, pipette, burette.

(e) Preparation of standard solutions.

(f) To understand the use of different forms of water in Laboratory: Distilled water, De-ionized water and tap water and to carry out their conductance measurement.

(g) Filtration techniques:

(i) Types of filter paper and their applications

(ii) Use of fluted filter paper

(iii) Vacuum filtration

(h) Technique of Refluxing a reaction mixture and use of boiling chips

(i) Purification techniques:

(i) Recrystallization of given compounds using solvents like water, alcohol

(ii) Use of activated charcoal

(iii) Simple distillation for purification of liquid compounds

(iv) Drying of Solvents

(i) Introduction to chromatography:

(i) Paper and Thin layer chromatography.

(ii) Preparation of Thin Layer Chromatography (TLC) Plates.

(iii) Simple experiments for separation and identification of substances using chromatographic techniques.

Suggested Readings:

1. Skoog D.A., West D.M., Holler F.J., & Stanley R.C. (2003). *Fundamentals of analytical chemistry* (9th Ed.). Cengage Learning.
2. Mendham, J.; Denney, R.C.; Barnes, J.D.; Thomas, M.J.K. (2007). *Vogel's Quantitative Chemical Analysis* (6th Ed.). Prentice Hall.
3. Furniss, B. S., Hannaford, A. J., Smith, P. W. G., & Tatchell, A. R. (1989). *Vogel's Text Book of Practical Organic Chemistry* (5th Ed.). Longman Scientific and Technical, Longman Group Ltd.
4. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003) *Experiments in Physical Chemistry* (8th Ed.). McGraw-Hill, New York.

E. contents:

- https://iupac.org/
- https://edu.rsc.org/resources/practical/experiments

Keywords:

Safety Measures, Standard Operations, Basic experimental techniques.

Teaching Learning Process:

- Hands-on laboratory exercises
- Conventional teaching learning method.
- Engaging students in collaborative learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Presentation on good lab practices.
- Semester end University examination.

Course Code: ALS CHEM SEC 03
Course Title: Dyes: Types, Colour and Constitution
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

- This course aims to introduce the learner to the fascinating chemistry of dyes.
- To study the concept of colour and its relation to chemical structure.
- To familiarize the students with application of dyes, the type of fibres and how the dyes are attached to them.
- To familiarize the students with the synthesis of some representative dyes.
- To create an awareness about the toxicity of dyes and their effect.

Learning outcomes:

On completion of this course, the students will be able to:

- Understand the principles of colour and its relation with molecular structure.
- Analyse and classify dyes based on their chemical structure and applications.
- Describe the synthesis of various dyes and their applications.
- Learn the dyeing process of different fabrics with natural dyes/ synthetic dyes.

Practical:

1. Definition of dye, classification of dyes as natural and synthetic dyes.
   (a) Separation of a mixture of synthetic dyes by paper chromatography.
   (b) Separation of a mixture of natural dyes by paper chromatography.
   (c) Detection of Sudan dyes in red chilli powder by thin layer chromatography.
2. Colour and constitution-Relationship of colour to wave length of absorbed light, chromophores, auxochromes, bathochromic shift, hypsochromic shift, Quinonoid theory and Modern theory.
   (a) Determination of the absorbance range and λ_{max} values of some representative dyes.
3. Synthetic dyes: Classification according to their chemical structure & their mode of application on fibres- acid dyes, basic dyes, direct dyes, mordant dyes, vat dyes, chemistry of dyeing.
   (a) Dyeing of different fabrics (cotton, wool, silk) using alizarin or any other dye.

(b) Preparation of azo dye on the surface of the fabric.

(c) Study the effect of chemical mordants on the dyeing of cotton fabric with henna.

(d) To study the effect of natural mordants on the dyeing of cotton fabric with turmeric.

(e) Study the effect of different metal ions on the wool fabric dyeing with tea as a natural dye.

4. Synthesis, reactions and applications of dyes: Azo Dye-Methyl Orange; Triphenylmethane dye-Malachite green; Phthalein dye-Phenolphthalein; Natural dyes–Alizarin (Anthraquinone dye), Indigo (Indigotin dye).

(a) Preparation of azo dye-Methyl Orange.

(b) Check the indicator property of methyl orange.

(c) Preparation of triphenyl methane dye- Malachite green.

(d) Preparation of perichromic dye using *p*-amino phenol and *p*-nitro benzaldehyde

(e) Preparation of phthalein dye- Phenolphthalein.

(f) Check the indicator property of phenolphthalein.

Suggested Readings:

1. Ahluwalia, V.K., Dhingra, S., & Gulati, A. (2005). *College Practical Chemistry*. University Press.
2. Ahluwalia, V. K., & Dhingra, S. (2004). *Comprehensive Practical Organic Chemistry: Qualitative Analysis.* Universities Press.
3. Vogel, A.I. (1972). *Textbook of Practical Organic Chemistry.* Prentice-Hall
4. Mann, F.G., & Saunders, B.C. (2009). *Practical Organic Chemistry.* Pearson Education.
5. Mehta, B., & Mehta, M. (2015). *Organic chemistry.* PHI Learning Pvt. Ltd.
6. Pasricha, S., & Chaudhary, A. (2021). *Practical Organic Chemistry* (Volume I). IK International Publishing House Pvt. Ltd., New Delhi.

Keywords: Dyes, Diazotization, Colour and Constitution, Synthesis of dyes.

Teaching Learning Process:

- Teaching-Learning process is largely student-focused.
- Blend of conventional blackboard teaching and modern teaching-learning tools.
- Engaging students in collaborative learning.
- Pre-lab learning of the theoretical concept of the experiment.
- Performing the experiment, recording the data, and calculating the result.

- Interpreting the result.
- Discussing the sources of error.

Assessment Methods:

- Presentations by Individual Student/ Group of Students on relevant topics
- Continuous evaluation of laboratory work and records
- End semester University practical Examination coupled with written viva
- Internal assessment through continuous evaluation.

Course Code: ALS CHEM SEC 04
Course Title: Pesticide Formulations and Equipment used
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

Pesticide formulations are the integral part of Agro-industry. Pure pesticides are highly toxic in nature. As small quantity of pesticides is required for large cultivated areas, it is necessary to formulate the pesticides for their application in a more viable form.

Learning Outcomes:

Students will be able to learn about the various types of pesticide formulation for commercial use as well as for domestic use. They are also able to demonstrate the comprehension of chemical product use via label and *material safety data sheet* (MSDS) published.

Practical:

1. Introduction to Pesticide formulations: definition, purpose of formulations, different types of formulations e.g., Bait.
   (a) To prepare Rodent bait.
2. Important Definitions: Active Ingredient, Inert Ingredient, Adjuvant Carrier, surfactants. Type of Formulation in pesticides: emulsifiable concentrates.
   (a) To carry out preparation of emulsion of Neem oil.
   (b) To determine the Emulsion stability of given emulsifiable concentrates (EC)
3. Introduction to other formulations: Wettable powders, soluble powder, solutions, aerosols, dusts, and granules. The working, handling and use of following sprayers:
   (a) **(Demonstration):** Hand Rotatory Duster for dust formulations; to be demonstrated as Lab work and field work.
   (b) **(Demonstration):** Knap -Sack Sprayer**:** Capacity 16 L, shoulder mounted, manually operated, for crops up to 7-8 ft. height; to be demonstrated as Lab work and field work.
4. **(Assignment work):** To be performed as lab -work along with formulation studied side by side:
   (a) Data table for international codes for the formulation type.
   (b) To draw pictograms and indicate:
      (i) Advice, Warning, and their meaning
      (ii) Colour Codes and their meaning

(c) To prepare label with colour identification band and warning symbol as per toxicity Data (LD_{50}) following Government of India Recommendations (*see* reference-2).

(d) To make a sketch of pesticide label from provided formulation data as per standard protocol.

5. **(Demonstration)**: Spraying equipment to be introduced in the lab for their working, handling and use in the field work.

(a) Battery Sprayer (Knapsack): Capacity 18 L, shoulder mounted, Lightweight telescopic lance Battery operated Battery Power: 12 V (12 AH), Suitable for spraying pesticides at farms, gardens and agriculture land.

(b) Foot Sprayer: manually operated with foot; With lance and nozzle for ground crops, With high jet gun for trees.

(c) Rocking sprayer: manually operated with hand; With lance and nozzle for ground crops, With high jet gun for trees.

(d) Power sprayer: shoulder mounted, with 28 cc engine; With lance and nozzle for large fields, With high jet gun for trees.

(e) Hand compressor sprayer: manually operated, pressure sprayer for pest control in homes, buildings and small fields.

(f) Types of nozzles to be introduced in the Lab: nozzles with different size and hole diameter available as an attachment with these sprayers. Used for effective application of herbicides in the field.

Suggested Readings:

1. Agrochemicals-Pesticide formulations | IUPAC https://agrochemicals.iupac.org.
2. Report of the committee on manner of labelling of pesticides as per toxicity Dated August,20I9 Ministry of Agriculture & Farmers Welfare Government of India No. 24-01/2019-ClR.I.
3. Hall, R., Berger, P. D., & Collins, H. M. (1995). Polymers for instant dispersions for the herbicide metolachlor and other chloroacetanilides. Pesticide Formulations and Application Systems, 14, 157.
4. Foy, C. L., & Pritchard, D. W. (1996). Pesticide formulation and adjuvant technology. CRC press.
5. Knowles, D. A. (1998). *Chemistry and technology of agrochemical formulations*. Springer.

Keywords:

Pesticide Formulations, Wettable powders, Solutions, Emulsifiable, concentrates, Aerosols, Dusts and Granules, Pesticide labels, Symbols, pictograms, Sprayers and equipment.

Teaching Learning Process:

- Hands-on laboratory exercises.
- Conventional teaching learning method.
- Engaging students in collaborative learning.

Assessment Methods:

- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Presentation on good lab practices.
- Semester end University examination.

Course Code: ALS CHEM GE 01
Course Title: Bioinorganic Chemistry
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

The purpose of the course is to introduce students to bioinorganic chemistry, currently a frontier area of chemistry providing an interface between organic chemistry, inorganic chemistry, and biology. The student would learn about the importance of inorganic chemical species, especially metals in biological systems, through discussions on topics such as the sodium-potassium pump, the applications of iron in physiology, including iron transport and storage system, role of magnesium in energy production and chlorophyll, toxicity of heavy metal ions and their antidotes.

Learning Outcomes:

By the end of this course, students will be able to

- Classify metal ions in biological systems as essential, non-essential, trace and toxic.
- Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it.
- Understand the role of metal ions such as Mg, Ca and Fe in biological systems.
- Understand the toxicity of heavy metal ions (Hg, Pb, Cd and As) in the physiological system.

Theory:

Unit 1. Introduction: **Lectures: 07**

A brief introduction to bio-inorganic chemistry. Metal ions present in biological systems and their classification on the basis of action (essential, non-essential, trace & toxic). Classification of metallobiomolecules (enzymes, transport and storage proteins and non- proteins). Brief idea about membrane transport, channels and pumps.

Unit 2. Role of Metals in Biological Systems: **Lectures: 08**

Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} and Ca^{2+} ions: Na/K pump; Ca pump, role of Mg^{2+} ions in energy production and chlorophyll. Role of calcium in bone formation.

Unit 3. Role of Iron in Biological Systems: **Lectures: 08**

Role of iron in oxygen transport and storage (haemoglobin and myoglobin), Perutz mechanism,

Cooperative effect, Bohr effect, comparison of oxygen saturation curves of haemoglobin and myoglobin, carbon monoxide. Storage and transport of iron in humans (ferritin and transferrin).

Unit 4. Bio-Inorganic Chemistry: **Lectures: 07**

Toxicity of heavy metal ions (Hg, Pb, Cd and As), reasons for toxicity and their antidotes.

Practical:

1. Preparation of Nickel-DMG complex and its estimation.
2. Estimation of Zn^{2+} using EBT / Xylenol orange as indicator
3. Estimation of Mg^{2+} by direct complexometric titrations using EDTA.
4. Estimation of Ca^{2+} by substitution method.
5. To estimate the concentration of Ca in commercially available medicines.
6. To estimate the Mg present in multivitamins (take at least two types of Vitamin tablets from the market).
7. Isolation of Chlorophyll from plant leaves and its purification.
8. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
9. Separation of Fe (III) and Al (III) using chromatographic techniques.
10. Estimation of copper as CuSCN.

Suggested Readings:

Theory:

1. Huheey, J. E., Keiter, E.A., Keiter, R. L., & Medhi, O.K. (2009). *Inorganic Chemistry-Principles of Structure and Reactivity*. Pearson Education.
2. Shriver, D. D., Atkins, P., & Langford, C.H. (1994). *Inorganic Chemistry* (2nd Ed.). Oxford University Press.
3. Cotton, F. A., Wilkinson, G., & Gaus, P. L. (2021) *Basic Inorganic Chemistry* (3rd Ed.). Wiley India.
4. Crichton, R. R. (2008). *Biological Inorganic Chemistry: An Introduction*. Amsterdam, Elsevier.
5. Kaim, W., Schwederski B., Klein, A. (2014). *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide* (2nd Ed.). Wiley.
6. Inorganic Chemistry; Sahoo, et al; PHI Learning Private Limited; ISBN 978-81-203-43085.
7. Balaram Sahoo, Nimai Charan Nayak, Asutosh Samantaray, & Prafulla Kumar Pujapanda. (2012). *Inorganic chemistry*. Prentice-Hall of India Pvt Ltd.

Practical:

- Jeffery, G.H., Bassett, J., Mendham, J., & Denney, R.C. (1989). Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Keywords:

Bioinorganic chemistry, Sodium potassium pump, chlorophyll, ATP, Hemoglobin, myoglobin, ferritin, transferrin, toxicity, heavy metal ions, antidote.

Teaching Learning Process:

- Conventional chalk and board teaching.
- Class interactions and discussions.
- Power point presentation on important topics.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students.
- End semester University Theory and Practical Examination.

Course Code: ALS CHEM GE 02
Course Title: Chemistry of Carbohydrates, Nucleic Acids and Lipids
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

This course aims to introduce the learner to the fascinating chemistry of some molecules, *i.e.,* carbohydrates, nucleic acids and lipids that work within biological systems. The basic concept of heredity, which is imparted through replication, transcription and translation processes will be discussed.

Learning outcomes:

On completion of this course, the students will be able to:

- Understand and demonstrate how structure of biomolecules (carbohydrates, nucleic acids and lipids) determine their reactivity and biological functions.
- Understand the concept of heredity through replication, transcription, and translation processes.

Theory:

Unit 1. Chemistry of Carbohydrates: **Lectures: 10**

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of the configuration of glucose (Fischer proof), the cyclic structure of glucose. Haworth projections. The cyclic structure of fructose. The linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Unit 2. Nucleosides, Nucleotides and Nucleic Acids: **Lectures: 10**

Components of Nucleic acids: Adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA (types of RNA), difference between DNA and RNA, genetic code, biological roles of DNA and RNA: replication, transcription and translation.

Unit 3. Lipids: **Lectures: 10**

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins. Properties, functions and biochemical functions of steroid hormones.

Practical:

1. Preparation of osazone of glucose, fructose and Maltose (Comparing the time of formation of the two and the shape of crystals using microscope).
2. Identification of given carbohydrates as
   a) Reducing and Non-reducing
   b) Monosaccharide and Disaccharide
   c) Aldose and Ketose
3. Estimation of glucose by Fehling's solution.
4. Determination of acid value of fats and oils.
5. Determination of the iodine number of oils.
6. Determination of the saponification number of oils.
7. Identification and separation of mixture of sugars by paper chromatography.
8. Isolation of DNA from cauliflower/ onion.
9. Estimation of DNA by diphenylamine reaction.
10. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).

Suggested Readings:

Theory

1. Vogel, A., Jeffery, G., Bassett, J., & Mendham, J. (1989). *Vogel's textbook of quantitative chemical analysis*. John Wiley and Sons.
2. Finar, I. L. (2002). *Organic Chemistry* (Volume 1 & 2). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Morrison, R. N., & Boyd, R. N. (2016). *Organic Chemistry*. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Mehta, B., & Mehta, M. (2015). *Organic Chemistry* (2nd ed.). PHI Learning Pvt. Ltd.

5. Satyanarayana, U., & Chakrapani, U. (2017). *Fundamentals of Biochemistry.* Books and Allied (P) Ltd.
6. Lehninger, A. L., & Nelson, D. L. (2009). *Principles of biochemistry*. W. H. Freeman.
7. T. W. Graham Solomons, Craig B. Fryhle, & Scott A. Snyder. (2013). *Solomons's Organic Chemistry 7th edition*. Pearson Education India.
8. Jr. Leroy G. Wade, Jan William Simek, & Maya Shankar Singh. (2019). *Organic Chemistry.* Pearson Education India.
9. Ghatak, K. L. (2014). *A textbook of organic chemistry and problem analysis*. PHI Learning.

Practical:

1. Mann, F. G., & Saunders, B. C. (2009). Practical organic chemistry. Pearson Education.
2. Dean, J. R., Jones A.M, Holmes, D., & Reed, R. (2011). Practical Skills in chemistry. Prentice-Hall.
3. Wilson, K., & Walker, J. M. (2000). Principles and techniques of practical biochemistry. Cambridge University Press.
4. Gowenlock. A.H. (1988). Varley's Practical Clinical Biochemistry. CRC Press.
5. Pasricha, S., & Chaudhary, A. (2021). Practical Organic Chemistry: Volume II. IK International Publishing House Pvt. Ltd.

Keywords:

Carbohydrates, Amino acids, Peptides, Proteins

Teaching Learning Process:

- Learning Process for the course is visualized as largely student-focused
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods:

Students' evaluation will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voice.

Course Code: ALS CHEM GE 03
Course Title: Chemistry of Amino acids, Proteins and Enzymes
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

The objectives of this course is to deliver information about biochemically significant features of the chemistry of peptides, proteins, enzymes, using suitable examples. This includes classification, reaction chemistry and biological importance of these biomolecules. This course extends the knowledge gained from synthetic organic chemistry to chemistry of biomolecules. Key emphasis is placed on understanding the structural principles that govern reactivity/physical /biological properties of biomolecules as opposed to learning structural detail. It also aims to build the concept of metabolism by the study of chemistry and energetics of biological system.

Learning Outcomes:

By the end of the course, the students will be able to:

- Learn and demonstrate how the structure of biomolecules (proteins, enzymes) determines their chemical properties, reactivity and biological uses.
- Gain an insight into mechanism of enzyme action and inhibition.
- Understand the basic principles of drug-receptor interaction and SAR.
- Understand the concept of metabolism and metabolic processes through specific examples.

Theory:

Unit 1. Amino acids, Peptides & Proteins: **Lecture: 12**

Amino Acids and Peptides -Zwitterion, isoelectric point and electrophoresis. Preparation of amino acids: Strecker synthesis and using Gabriel's phthalimide synthesis. Reactions of amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Determination of the primary structure of peptides by degradation Edman degradation (N-terminal) and C– terminal (thiohydantoin and with carboxypeptidase enzyme).

Synthesis of simple peptides (up to dipeptides) by N-protection (*t*-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. An Overview of primary, secondary, tertiary and quaternary structure of proteins.

Unit 2. Enzymes: **Lectures: 08**

Classification of enzymes and their uses (mention ribozymes). Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereo-specificity), enzyme inhibitors and their importance, and the phenomenon of inhibition (competitive and non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure – activity relationships of drug molecules, binding role of –OH group, $-NH_2$ group, double bond and aromatic ring.

Unit 3. Concept of Energy in Biosystems: **Lectures: 10**

Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD+, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle. The caloric value of food, the standard caloric content of food types.

Practical:

1. Qualitative tests for amino acids and proteins.
2. Separation and identification of mixture of amino acids by paper chromatography.
3. Study the action of salivary amylase on starch under optimum conditions and determine the enzyme activity.
4. Study the effect of temperature and pH on the activity of salivary amylase.
5. Isolation of casein from milk.
6. Estimation of protein by Lowry's method.
7. To study the effect of concentration, temperature and pH on the activity of catalase.
8. Estimation of glycine by Sorensen's method.
9. To study the titration curve of glycine and determine the isoelectric point of glycine.

Suggested Readings:

Theory:

1. Lubert Stryer, Jeremy Berg, John Tymoczko, & Gregory Gatto. (2019). *Biochemistry* (9th ed.). W.H. Freeman.
2. Lehninger, A. L., & Nelson, D. L. (2009). *Principles of biochemistry*. W. H. Freeman.
3. Finar, I. L. (2007). *Organic chemistry* (Vol 1 & 2). Pearson education.
4. Mehta, B., & Mehta, M. (2015). *Organic Chemistry* (2nd ed.). PHI Learning Pvt. Ltd.
5. T. W. Graham Solomons, Craig B. Fryhle, & Scott A. Snyder. (2013). *Solomons's Organic Chemistry* (7th ed.). Pearson Education India.
6. Ghatak, K. L. (2014). *A textbook of organic chemistry and problem analysis*. PHI Learning.

Practical:

1. Dean, J. R., Jones A.M, Holmes, D., & Reed, R. (2011). *Practical Skills in chemistry*. Prentice-Hall.
2. Wilson, K., & Walker, J. M. (2000). *Principles and techniques of practical biochemistry*. Cambridge University Press.
3. Varley, Harold., Gowenlock, A. H., McMurray, J. R., McLauchlan, D. M., & Varley, Harold. (1988). *Varley's practical clinical biochemistry*. CRC Press.
4. Mann, F. G., & Saunders, B. C. (2009). *Practical organic chemistry*. Pearson Education.
5. Pasricha, S., & Chaudhary, A. (2021). *Practical Organic Chemistry* (Volume II). IK International Publishing House Pvt. Ltd.

Keywords:

Biomolecules, Enzymes, Mechanism of enzyme action and inhibition, SAR, Drug Receptor Theory.

Teaching Learning Process:

- The teaching learning process will involve the traditional chalk and black board method. Along with pedagogy of flipped classroom.
- Certain topics like mechanism of enzyme action and enzyme inhibition, transcription and translation etc. where traditional chalk and talk method may not be able to convey the concept, are taught through audio-visual aids.

- Students are encouraged to participate actively in the classroom through regular presentations on curriculum-based topics, peer assessment, designing games based on specific topics etc.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Assessment Methods:

- Graded assignments
- Conventional class tests
- Class seminars by students on course topics with a view to strengthening the content through width and depth.
- Quizzes
- End semester university examination.

Course Code: ALS CHEM GE 04
Course Title: Conductance and Chemical Kinetics
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

- The students will learn about electrochemical cells – electrolytic and galvanic cells, measurement of conductance and its applications, measurement of emf and its applications.

Learning Outcomes:

By the end of the course, the students will be able to:

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand different types of galvanic cells, their Nernst equations, measurement of emf, of thermodynamic properties and other parameters from the emf measurements.
- Understand the concept of rate laws e.g., order, molecularity, half-life, and their determination.

Theory:

Unit 1. Conductance: **Lectures: 08**

Conductivity, equivalent and molar conductivity, and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions, Transference number, Ionic mobility, applications of conductance measurements: determination of degree of ionization of weak electrolytes, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit 2. Electrochemistry: **Lectures: 10**

Reversible and irreversible cells, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes, Standard electrode potential, Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data,

Liquid junction potential and salt bridge, pH determination using hydrogen electrode and quinhydrone electrode.

Unit 3. Chemical Kinetics: **Lectures: 12**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, derivation of integrated rate equations for zero, first and second order reactions (for equal concentrations of reactants), half–life of a reaction, general methods for determination of order of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Practical:

Conductance

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform Conductometric titrations:
   (a) Strong acid vs strong base
   (b) Weak acid vs strong base.

Potentiometry

1. Perform the potentiometric titrations of
   (a) Strong acid vs strong base and
   (b) Weak acid vs strong base

Chemical Kinetics

1. Study the kinetics of the following reactions by integrated rate method:
   (a) Acid hydrolysis of methyl acetate with hydrochloric acid.
   (b) Compare the strength of HCl and H_2SO_4 by studying the kinetics of hydrolysis of methyl acetate.

Suggested Readings:

Theory:

1. Castellan, G. W. (2004). *Physical Chemistry* (Vol.). Narosa.
2. Kapoor, K. L. (2015). *A Textbook of Physical Chemistry* (6th ED., Vol. 1). McGraw Hill Education.

3. Kapoor, K. L. (2013). *A Textbook of Physical Chemistry* (3rd ed., Vol. 3). McGraw Hill Education.
4. Puri, B. R., Sharma, L. R., & M. S. Pathania. (2017). *Principles of Physical Chemistry*. Vishal Publishing Co.

Practical:

1. Khosla, B. D., Garg, V. C., & Gulati A. (2015). *Senior Practical Physical Chemistry*. R. Chand & Co.

Keywords:

EMF, Transference number, Kohlrausch Law and Arrhenius equation etc.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods:

Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

13.

SYLLABUS FOR UNDERGRADUATE PROGRAMME IN APPLIED LIFE SCIENCES WITH AGROCHEMICALS AND PEST MANAGEMENT

(ZOOLOGY)

Course Code: ALS ZOO DSC 01
Course Title: Animal Forms and Structure
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

Zoology is the scientific study of animal life. Animals are the most diverse creatures on this planet. This course gives knowledge about the diversity within different groups, and their interrelationships. The course is designed to understand the general characteristics, classification, basic body plan and levels of organizations in different groups of animals.

Learning Outcomes:

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

- Distinguish between major phyla of animals through characteristic features and diversity.
- Understand the fundamental differences among animal body plans among different phyla.
- Illustrate structure, function and processes related to different groups of animals.
- Observe living animals in the environment and relate observations to theory from the course.

Theory:

Unit 1: **Lectures: 02**

An introduction to the animal kingdom: Non-chordates *vs* Chordates, Coelom, Body symmetry, Levels of organization.

Unit 2: **Lecture: 01**

Protista: General characters of Protozoa; Locomotory organelles: Pseudopodia, Flagella and Cilia.

Unit 3: **Lectures: 02**

Porifera: General characters of phylum Porifera, Canal system in Porifera (in brief).

Unit 4: **Lectures: 02**

Radiata: General characters of phylum Cnidaria and Ctenophora; Polymorphism.

Unit 5: **Lectures: 02**

Helminthes: General characters of Helminthes (Platyhelminthes and Nemathelminthes).

Unit 6: **Lectures: 07**

Coelomates (Non-chordates):

General characters of phylum Annelida; Metamerism.

General characters of phylum Arthropoda; Vision in insects.

General characters of phylum Mollusca; Pearl Formation.

General characters of phylum Echinodermata; Water Vascular system in starfish.

Unit 7: **Lectures: 02**

Protochordates: Salient features of Hemichordates, Urochordates and Cephalochordates.

Unit 8: **Lectures: 12**

Vertebrates: Brief description of vertebrates.

General characters of Agnatha.

General characters of Pisces; Cartilaginous and Bony fishes, Catadromous and Anadromous migration.

General characteristics of Amphibia; Adaptations for terrestrial life.

General characteristics of Reptilia; Biting mechanism of snakes.

General characteristics of Aves; Flight adaptations in birds.

General characteristics of Mammals; Brief description of prototherian, metatherian and eutherian mammals; Dentition.

Practical:

1. Study of specimens:

Non-chordates: *Euglena, Noctiluca, Paramecium, Sycon, Physalia, Tubipora, Meandrina, Taenia, Ascaris, Nereis, Heteronereis, Aphrodite, Hirudinaria, Peripatus, Limulus, Cancer, Daphnia, Julus, Scolopendra, Apis,* cockroach, termite, butterfly, *Chiton, Dentalium, Octopus, Asterias and Antedon.*

Chordates: *Balanoglossus, Herdmania, Amphioxus, Petromyzon, Sphyrna, Pristis, Hippocampus, Exocoetus, Diodon/ Tetradon, Icthyophis/ Uraeotyphlus, Bufo, Hyla,*

Salamandra, Rhacophorus, Draco, Uromastix, Naja, Viper, identification of poisonous and non-poisonous Any three common birds, *Funambulus, Loris* and Bat.

2. Study through permanent slides:
   (a) Cross section of *Sycon* and *Ascaris* (male and female).
   (b) Septal and pharyngeal nephridia of earthworm.
   (c) Placoid, cycloid and ctenoid scales of fishes.
3. Study of organ systems: (Subject to permission from animal ethics committee as per UGC guidelines/ from suitable models).
   (a) Digestive system of cockroach.
   (b) Urinogenital system of rat.

Suggested Readings:

1. Barnes, R.D. (1992). Saunders College Pub. USA.
2. Ruppert, E. E., Fox, R. S., & Barnes, R. D. (2004). *Invertebrate zoology: A functional evolutionary approach* (5th ed.). Brooks/Cole Publishing Company.
3. Campbell and Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
4. Young, J.Z. (2004). The Life of Vertebrates. III Edition, Oxford University Press.
5. Raven, P.H. and Johnson & G.B. (2004). Biology, VI Edition, Tata McGraw Hill Publications.

E- contents:

- http://vle.du.ac.in
- Animal Diversity Web (ADW); an online database of animal natural history, distribution, classification, and conservation biology. Web resource https://animaldiversity.org/
- Online Zoo; https://www.activewild.com/online-zoo/.

Keywords:

Coelomates, Chordates, Non chordates, Vertebrates, Metamerism, Coelom, Migration.

Teaching and Learning Process:

Teaching-Learning process will include delivery of lectures using boards, multimedia presentation, short documentaries on animal diversity, imparting practical based knowledge through specimens, live demonstration of diversity in surroundings.

Assessment methods:

- Continuous assessment during entire semester along with the summative assessment by the semester-end.
- Testing through multiple choice questions at the end of each lecture.
- Assess through the project-based work.

Course Code: ALS ZOO DSC 02
Course Title: Entomology
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

The course intends to introduce the students to insects, one of the most diverse group of animals on earth. The origin of insects goes back to approximately 360 million years ago which is much earlier in comparison to the origin of man. Insects form over 70% of the fauna population on the earth. These organisms occupy nearly all niches except for the deep sea. Learning of morphology and physiology of the insects gives an overview of one of the best body designs which have survived on the earth.

Learning Outcomes:

Upon completion of the course, the students will be able to:

- Identify and classify insects up to orders.
- Understand methods of collection, preservation and rearing of insects.
- Describe the morphology of head, thorax and abdomen of an insect.
- Explain the structure of various body appendages.
- Describe the anatomy and physiology of various organ systems in insects.
- Explain the concept of insect metamorphosis and its hormonal control.
- Understand the phenomenon of parthenogenetic development in insects.

Theory:

Unit 1: Lectures: 07

Taxonomy: Salient features of insects, Basis of insect classification; Outline of insect classification upto orders, Characteristics of economically important orders.

Unit 2: Lectures: 12

Morphology of insects: Segmentation in insects; Head: typical structure of head, types of head, Antenna: typical structure, modification in antennae, types of mouth parts (Biting and chewing,

sponging, piercing and sucking, siphoning and lapping), Compound eyes: structure of ommatidium, superposition and appositional images, Thoracic structures: Legs: typical structure of legs, modification in legs, modification in wings, veinations, coupling mechanisms.

Unit 3: **Lectures: 07**

Physiology of insects: Physiology of digestion, excretion, respiration, circulation, sense organs (mechano and chemoreceptors).

Unit 4: **Lectures: 04**

Reproduction and Development: Embryonic and post-embryonic development; Types of metamorphosis, Parthenogenesis

Practical:

1. Collection, dry mounting, labelling and preservation of insects.
2. Study of mouth parts: biting and chewing, sponging, piercing and sucking, siphoning and lapping type through slides/ photographs.
3. Study of different types of wings, legs and antennae through slides/ photograph of insects.
4. Study of one insect from each economically important order (Thysanura, Odonata, Orthoptera, Dermaptera, Isoptera, Hemiptera, Thysanoptera, Lepidoptera, Diptera, Siphonaptera, Hymenoptera, Coleoptera and Strepsiptera) through specimens/ photographs.
5. Visit to Entomology Division IARI, Pusa, New Delhi.
6. Submission of project report on the basis of Field/Lab visit.

Suggested Readings:

1. Imms, A. D. (1977) A General Text Book of Entomology. Chapman & Hall, UK.
2. Chapman, R. F. (1998) The insects: Structure and Function. Cambridge University Press, UK.
3. Atwal, A.S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.
4. Dennis, S. Hill. (2005) Agricultural Insect Pests of the Tropics and Their Management, Cambridge University Press
5. David, B.V. and Ananthakrishnan, T.N. (2004) General and Applied Entomology. Tata-McGraw Hill, New Delhi.
6. Duntson, P.A. (2004) The insects: Structure, Function and Biodiversity. Kalyani Publishers, New Delhi.

7. Wigglesworth, V.B. (1984) Insect Physiology. VIII Edition, Chapman & Hall, New York.

E contents:

https://swayam.gov/appliedentomology.

Keywords:

Insects, Taxonomy, Morphology, Physiology, Reproduction, Metamorphosis, Parthenogenesis.

Teaching and Learning Process:

Classroom lectures using power point presentations coupled with related photographs of insect vectors will clarify the concepts related to insects. Group discussions on various unique physiological processes in insects will develop interest among students to pursue higher studies in this field. Observations based on actual handling of insects, visit to observe insects in their natural environment and entomology museum will develop curiosity among learners about insect diversity.

Assessment Methods:

The learners/ students can be assessed in many different ways.

- Formative assessment throughout the course and summative semester-end evaluation.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and images to test their theoretical skills and promote practical knowledge.

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Course Code: ALS ZOO SEC 01
Course Title: Biotechnology in Insect Pest Control
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

The study of biotechnological control of pests provides alternative measures to traditional pest management practices against insects as they cause enormous damage to crops. This course will help the students to understand the concept of biotechnology and its application to control insect pests and their population dynamics in relation to changing environmental conditions. The students will learn about various tools and techniques of biotechnology used for controlling insect pests. This will be of help in choosing the popular and appropriate control measures to manage the pest population in nature.

Learning Outcomes:

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

- Learn about the concept of biotechnology and its application in the field of agricultural management practices.
- Understand the difference between various types of pests and their host plants and extent of damage caused by them.
- Gain knowledge about important tools and techniques of biotechnology useful for management of pests of crops, fruits, vegetables and stored grains.
- Emphasize biotechnological control measures for management of pest populations with critical evaluation in the larger context of ecologically based pest management.

Unit 1. Introduction:

Biotechnological approaches: Developments in biotechnology, Molecular taxonomy, international project on barcode of life, Host–plant resistance: Mechanism of resistance Antibiosis, Antixenosis, Tolerance.

Practical:

1. Study of tools and techniques of biotechnology.
2. Study of host plant and its insect pest (Host: Castor leaves, Pest: Lepidoptera: *Spodoptera litura*).

Unit 2. Insect Growth Regulators, Toxic proteins and Inhibitors:

JH Mimics, MH-agonist; Vegetative Insecticidal proteins, Biotin-binding proteins and plant Lectins; Enzymes: Chitinases, Proteinase Inhibitors, Bean α-Amylase, Insect immunity.

Practical:

3. Study of insect hormones and their uses for insect pest control.
4. Study of *Bt* toxins for insect pest management.

Unit 3. Techniques Used in Insect Pest Management:

Recombinant DNA technology, Molecular markers, Transgenesis, Genetic engineering of biological control agents: *Bacillus thuringiensis*, Entomopathogenic Fungi, Baculoviruses; Molecular mechanisms of pesticide resistance in insect pest

Practical:

5. Colorimetric estimation of total protein of insect haemolymph.
6. Isolation of Plasmid DNA from *E. coli.*
7. To perform SDS-Polyacrylamide Gel Electrophoresis and Western Blotting.

Unit 4. Genetically Modified Crop Plants and Insect Pest Management:

Transgenic plants: History, *Bacillus thuringiensis* and its mode of action on insects, Different subspecies of *Bt, Bt* plants, Resistance management of *Bt* crop, Perspectives and controversies of *Bt* crop; Genetic control through sterile insect techniques.

Practical:

8. Use of *Bacillus thuringiensis* and its mode of action on insects through photograph: *Bt* cotton, *Bt* crops.
9. Visit to any biotechnology lab and submission of report.

Unit 5. Applications of Biotechnology in Pest Management:

DNA barcode-based molecular taxonomy; metabolic pathways as a source of useful genes and products; Silencing of genes using RNAi approach for developing pest-resistant plants; Use of tissue culture techniques in plant protection, Use of bioinformatics for insect pest management.

Practical:

10. To understand the basics of Bioinformatics, Bar Coding and its uses for insect control.

Suggested Readings:

1. Dharam, P. Abrol. (2014). *Integrated Pest Management: Current Concepts and Ecological Perspective* (1st Ed.). Academic Press. ISBN.
2. Smith, C. M. (2005). *Plant Resistance to Arthropods – Molecular and Conventional Approaches.* Springer, Berlin.
3. Wheeler, M. B. (2013). *Transgenic Animals in Agriculture*. Nature Education Knowledge 4 (11):1.

Additional Resources:

1. Dhaliwal, G. S., & Singh, R. (Eds). (2004). Host Plant Resistance to Insects – Concepts and Applications. Panima Publications, New Delhi.
2. Maxwell, F. G. & Jennings, P. R. (Eds). (1980). Breeding Plants Resistant to Insects. John Wiley & Sons, New York.
3. Painter, R. H. (1951) Insect Resistance in Crop Plants. MacMillan, London.
4. Pedigo, L. P. (1996). Entomology and Pest Management. Prentice hall, New Delhi.

E-contents:

UGC INFONET / DU E-Resources & Sci Finder Web Version registration.

Keywords:

Biotechnology, JH mimics, rDNA technology, *Bacillus thuringiensis*, RNAi, Entomopathogens, Transgenics, Molecular taxonomy, Barcoding.

Teaching and Learning Process:

Knowledge about the concept of pest, IPM, principles of pest management, various pest control methods will be imparted through classroom lectures. Group discussion among students will stimulate their concern for a quality environment and make them aware about toxicological hazards of pesticide usage. Seminars on the related topics will enhance the learning of students to a great extent. Visits to agricultural fields will provide hands-on experience about the pest management methods used by farmers. Visits to Bio-control laboratories will give the students a chance to learn about the latest techniques used in genetic control of insects.

Assessment Methods:

The theory and practical components of the course will be assessed by.

- Continuous assessment to regularly check the student's learning and understanding of the subject. Class room discussions and tests will help in evaluating the student's grasp on the subject.
- Semester-end eexamination - Performance in the semester end examination will indicate their understanding of the concept.
- Continuous and comprehensive assessment by attendance and tests.

Course Code: ALS ZOO SEC 02
Course Title: Insect Toxicology
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

Since ages, insecticides have been used for killing insect pests of various kinds. The course deals with the biological effects of toxic chemicals on the insects and how they can metabolize these poisonous substances to develop resistance against them. The course will also emphasize on the factors affecting toxicity of insecticides and synergistic substances which can be used to increase their efficacy. This information will be important to the learner for the selection of insecticides to control pests in the field of agriculture, forestry and public health.

Learning Outcomes:

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

- Demonstrate fundamental knowledge and understanding of the principles of insecticide toxicity, and its evaluation for insect pest control.
- Explain pest resistance to insecticides and its management, and best practices for safe use of toxic insecticides as well as treatments for insecticide poisoning.
- Acquire practical skills of pest management in public buildings; like termite proofing, rodent control, etc.

Unit 1. Definition and Scope of Insecticide Toxicology:

History of chemical control, Pesticides registration, Pesticide industries and markets.

Practical:

1. Study of different Organo-phosphorous compounds used against insect pests.
2. Study of insecticide/pesticide formulation produced by industries.

Unit 2. Principles of Toxicology:

Evaluation of insecticide toxicity; Joint action of insecticides: synergism, potentiation and antagonism; Factors affecting toxicity of insecticides; Insecticide compatibility.

Practical:

3. Pesticide residues analysis of soil samples by soxhlet extraction method.
4. Video Demonstration of Gas chromatography.
5. HPLC instrument by video demonstration.
6. AAS instrument analysis.

Unit 3. Insect Growth Regulators:

Insecticides and their metabolism - phase I and phase II reactions; Pest resistance to insecticides; Mechanisms and types of resistance; Safe use of insecticides; Diagnosis and treatment of insecticide poisoning, Health hazards: carcinogenic, mutagenic and teratogenic effects.

Practical:

7. To calculate LD50/LC50 of an insecticide from data provided.
8. Study of health hazards due to insecticides.

Unit 4. Pest Management in Residential and Public Places:

Principles and methods of pest management in residential places and public buildings, Insecticides for domestic use and their safety, Pre and post-construction termite proofing of buildings, Appliances for domestic pest control; Organic methods of domestic pest management.

Practical:

9. To study the equipment used for spraying and dusting of insecticide**s.**
10. Project Report on visit to IARI, IPFT, Hindustan Insecticides Ltd., FCI complex, etc.

Suggested Readings:

1. Ishaaya, I., & Degheele, (Eds.). (1998). *Insecticides with Novel Modes of Action.* Narosa Publication. House.
2. Matsumura, F. (1985). *Toxicology of Insecticides*. Plenum Press.
3. Perry, A.S., Yamamoto, I., Ishaaya, I., & Perry, R. (1998). *Insecticides in Agriculture and Environment.* Narosa Publication. House.
4. Prakash, A., & Rao, J. (1997). *Botanical Pesticides in Agriculture.* Lewis Publication.

Additional Readings:

1. Greim, H., & Snyder, R. (ed)., (2018). *Toxicology and Risk Assessment: A Comprehensive Introduction.* John Wiley and Sons.

2. Whitford, F. (2002). *The Complete Book of Pesticide Management.* Wiley Interscience, John Wiley and Sons.
3. Chattopadhyay, S.B. (1985). *Principles and Procedures of Plant Protection.* Oxford & IBH.
4. Gupta, H. C. L. (1999). *Insecticides: Toxicology and Uses.* Agrotech. Publication.

Keywords:

Insecticides, Toxicology, Carcinogen, Mutagen, Teratogen, Pest resurgence, Synergism, Antagonism, Potentiation, Metabolism, Resistance.

Teaching and Learning Process:

Knowledge about the concept of chemical control of pests, and various factors involved will be imparted through classroom lectures. Group discussion among students will make them aware of toxicological hazards and development of insecticide resistance in pests. Seminars on the related topics will enhance the learning of students to a great extent.

Assessment Methods:

The theory and practical components of the course will be assessed in two ways.

Continuous assessment - To regularly check the students learning and understanding of the subject. Class room discussions and tests will help in evaluating the student's grasp on the subject.

Semester-end Examination - Performance in the semester end examination will indicate their understanding of the concept and its applications; while solving the related problems andwriting their answers.

Course Code: ALS ZOO SEC 03
Course Title: Apiculture
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

The course will help the student to become familiar with significance of beekeeping as an economically viable industry. It will help them understand the different species of honey bees, their biology, behaviour and role in pollination. The course would shed light on the techniques of honey bee rearing, optimization of techniques based on climate and the geographical regions, and various measures to be taken to maximize the benefits. It would help the students to understand the significance of bee keeping in diversification of agriculture for the rural communities to increase their income and create employment opportunities and at the same time develop entrepreneurial skills required for self-employment in beekeeping sector.

Learning Outcomes:

By the end of the course, the students will be able to:

- Learn about the various species of honey bees in India, their social organization and importance.
- Know about the opportunities and employment in apiculture – in public, private and government sector.
- Gain thorough knowledge about the techniques involved in bee keeping and honey production.
- Know about various products obtained from beekeeping sector and their importance.
- Develop entrepreneurial skills necessary for self-employment in beekeeping sector.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Unit 1. Biology of bees:

Historical background of apiculture, Classification and biology of honey bees, social organization of bee colony, behavioural patterns (bee dance, swarming).

Practical:

1. Study of the life history of honey bee, *Apis cerana indica*, *Apis mellifera*, *Apis dorsata*, *Apis florea*, *Melipona* sp. from specimen/ photographs - Egg, larva, pupa, adult (queen, drone, worker).
2 Study of morphological structures of honey bee through permanent slides/photographs: mouth parts, antenna, wings, sting apparatus and temporary mount of legs (antenna cleaner, mid leg, pollen basket).
3. Study of natural bee hive and identification of queen cells, drone cells and brood.

Unit 2. Rearing of Bees:

Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth; Bee Pasturage; Selection of Bee Species for Apiculture –*Apis cerana indica*, *Apis mellifera*; Bee Keeping Equipment Methods of Extraction of Honey (Indigenous and Modern) and processing; Apiary management – Honey flow period and Lean period, Effects of pollutants on honey bees.

Practical:

4. Study of artificial hive (Langstroth/Newton), its various parts and beekeeping equipment.
5. Analysis of honey – purity, biochemical analysis (Any two constituents).
6. Study of bee pasturage –
   (a) Visit to fields/gardens/orchards for studying the bee activity (role in pollination, nectar collection, videography of honey bee activity) and preparation of herbarium of nectar and pollen yielding flowering plants (floral mapping)
   (b) Preparation of mount of pollen grains from flowers.

Unit 3. Diseases and Enemies:

Bee diseases control and preventive measures: enemies of bees and their control

Practical:

7. Diagnosis of honey bee diseases: Protozoan diseases, Bacterial Diseases, Viral diseases (one each)- Symptoms, nature of damage and control.
8. Identification of honey bee enemies: Predators- insects and non-insects.

Unit 4. Bee Economy:

Products of Apiculture Industry (Honey, Bees Wax, Propolis, Royal jelly, Pollen etc.) & their uses; Modern Methods in employing artificial Beehives for cross pollination in horticultural gardens- stationary and migratory bee keeping.

Practical:

9. Submission of a few products obtained from apiculture industry.
10. Video demonstration of wax extraction and preparation of comb foundation sheets.

Unit 5. Entrepreneurship in Apiculture:

Bee Keeping Industries – Recent Efforts, Employment opportunities, Economics in small scale and large-scale beekeeping, Scope for women entrepreneurs in beekeeping sector, Study of Development programmes and Organizations involved in Beekeeping in India

Practical:

11. Visit to an apiary/honey processing unit/institute and submission of a report.

Suggested Readings:

1. Singh, S. (1962). *Beekeeping in India.* Indian Council of Agricultural Research.
2. Mishra, R. C. (1995). *Honeybees and their management in India*. Indian Council of Agricultural Research.
3. Prost, P. J. (1962). *Apiculture*. Oxford and IBH.
4. Rahman, A. (2017). *Beekeeping in India.* Indian Council of Agricultural Research.
5. Gupta, J. K. (2016). *Apiculture.* Indian Council of Agricultural Research.

Keywords:

Apiculture, Honey Bee, Bee hive, Beekeeping, Bees' wax, Royal jelly, Honey, Propolis, Comb sheets, Langstroth's hive, Newton's hive, Brood, Queen bee, Worker bee, Drones, Bee pasturage, Bee enemies, Bee Diseases and Entrepreneurship.

Teaching Learning Process:

- Blend of conventional blackboard teaching, modern teaching learning tools and computational infrastructure- based instructions and Practical training.
- Problem solving and quizzes for enhanced understanding of the concepts.
- Learning through observations of bees in nature and study of rearing technology will be assisted through visits to various apiculture institutes which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs.

- Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of bee biology will be promoted to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students.
- Field-based project activities and hands-on exposure have been added to make students aware about handling of bees and their rearing methods. Collection of plants and bee products will also help students to know the benefits of apiculture. Visit to various apiculture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

- Presentations by Individual Student/ Group of Students. This will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries.
- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones in which evaluation is held.
- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.
- Viva-voce: Viva-voce is a critical component of assessment of the practical based course.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Course Code: ALS ZOO SEC 04
Paper title -Sericulture
(Total Credits: 02 (Theory 0, Practical 02)
(Total Lectures: Theory 0, Practical 60

Objectives:

The course will make the students aware of the significance of sericulture as a profit-making enterprise. It will help the students to understand the biology of silkworms and their nutritional requirement to secrete quality silk. The course would clarify the techniques of silkworm rearing, reeling of silk and various measures to be taken to maximize the benefits. It would also help the students to know about various uses of silk and develop entrepreneurial skills required for self-employment in sericulture and the silk production sector.

Learning Outcomes:

Upon completion of the course, students should be able to:

- Learn about the history of sericulture and the silk route.
- Recognize various species of silk moths in India and exotic and indigenous races.
- Be aware of the opportunities and employment in the sericulture industry- in the public, private, and government sectors.
- Gain thorough knowledge about the techniques involved in silkworm rearing and silk reeling.
- Develop entrepreneurial skills necessary for self-employment in mulberry and seed production and be apprised about practicing sericulture as a profit-making enterprise.
- Enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions, assignments, and projects.

Unit 1. Introduction:

History (Silk route) and present status, Types of silkworms- Distribution and races, Exotic and indigenous; mulberry sericulture (*Bombyx mori*), non-mulberry sericulture (Eri, Muga, Tassar)

Practical:

1. Study of the life cycle of mulberry silkworm *Bombyx mori.*
2. Study of the sexual dimorphism in caterpillar, pupae, and adults of *Bombyx mori.*
3. Study of the life cycle of different species of non-mulberry silkworms -*Philosamia ricini, Antheraea paphia/Antheraea mylitta, Antheraea assama*.

Unit 2. Silk gland and silk:

Structure of silk gland: secretion and structure of silk

Practical:

4. Study of the structure of silk gland of mulberry silkworms.
5. Types of silk secreted by mulberry and non-mulberry silkworms.

Unit 3. Rearing of Silkworms:

Selection of mulberry variety and establishment of the mulberry garden, Rearing house and rearing appliances, Disinfectants: formalin, bleaching powder, RKO (Resham Keet Oushadh). Silkworm rearing technology: Early age and Late age rearing, Types of mountages, Harvesting and storage of cocoons, Postharvest technology- Silk reeling, Dyeing, and weaving, Ahimsa silk.

Practical:

6. Moriculture demonstration (Videos and photographs).
7. Study of rearing house and different appliances used in the rearing of mulberry silkworms.
8. Study of different types of mountages from specimens/photographs.
9. Study of the different disinfectants used in silkworm rearing houses.

Unit 4. Pests and Diseases:

Pests of silkworm: Uzi fly, dermestid beetles, and vertebrates; Pathogenesis of silkworm diseases: Protozoan, viral, fungal, and bacterial; Control and prevention of pests and diseases.

Practical:

10. Study of the parasites and predators of silkworms and their control- Uzi fly, Dermestid beetle, Vertebrates.
11. Study of silkworm diseases and their control- Pebrine, Flacherie, Grasserie, Muscardine.

Unit 5. Silk Industry and Its Importance:

Silk usage and application in the Textile and non-textile industry

Practical:

12. Analysis of silk fibre quality-Visual examination, thickness, purity.

13. Submission of a few products made of silk fibre.

Unit 6. Entrepreneurship in Sericulture:

Prospects of Sericulture in India: Sericulture industry in different states, Employment opportunities in mulberry and non-mulberry sericulture sector, Economics in small scale and large-scale silkworm rearing, Scope for women entrepreneurs in sericulture sector

Practical:

14. Submission of a report on a visit to a 'Sericulture Institute'/ 'Various Sericulture Centres in India.

Suggested Readings:

1. Yonemura, M., & Rama, Rao. N. (1951). *A Handbook of Sericulture. I. Rearing of silkworms.* Government Branch Press.
2. Ananthanarayanan, S. K. (2008). *Silkworm Rearing.* Daya Publishing House.
3. Aruga, H. (1994). *Principles of Sericulture.* CRC Press.
4. Sathe, T. V., & Jadhav, A. (2002). *Sericulture and Pest Management.* Daya Publishing House.
5. Yup-Lian, L. (1991). *Silkworm Diseases*. Food and Agricultural Organization.
6. *Manual on Sericulture*. (1976). Food and Agriculture Organisation.
7. Ullal, S. R., and Narasimhanna, M. N. (1987). *Handbook of Practical Sericulture* (3rd Ed.). CSB, Bangalore.

E-contents:

- Silkworm crop protection. (https://swayam.gov.in/courses/152-silkworm-crop-protection).
- Sericulture (http://csb.gov.in/silk-sericulture/sericulture/).
- http://csb.gov.in/publications/videos/.
- http://www.fao.org/3/x2099e/x2099e02.htm.

Keywords:

Cocoon, Disinfectant, Eri, Flacherie, Grasserie, Moriculture, Mountages, Muga, Mulberry, Muscardine, Pebrine, Rearing, Reeling, Sericulture, Silkmoth, Tasar, Textile, Uzi fly, Weaving.

Teaching-Learning Process

Information and concepts about the benefits of silkworms in human life and how these benefits can be reaped will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of silkworms in nature and study

of rearing technology will be assisted through visits to various sericulture institutes, which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including the chalk-n-talk method and e-learning will be encouraged to make students' learning more dynamic. Inquiry-based collaborative learning through presentations, debates, group discussions, and roundtables on the various aspects of silkworm biology will be promoted, to not only ensure effective learning and understanding of the concepts but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware of the handling of worms and their rearing methods. Visit to various sericulture institutes will clarify their concepts about the silkworms and their rearing technology.

Assessment Methods:

Various measures adopted will be as follows:

- Class Tests: Regular class tests will judge the grasp of the topics of the students. It includes practice sessions as well as the ones in which evaluation is held.
- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as teamwork skills among the students. Assessment of the participation of each student, analytical skills, and project outcomes will be held.
- Regular Presentations: Presentations by the students on a topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation, and response to queries.
- Viva-voce: Viva-voce is a critical component of the assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of students learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Course Code: ALS ZOO SEC 05
Course Title: Lac Culture
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

The course introduces the students to the study of various types of insect species producing lac and their life history. They will be trained to use the instruments and tools for lac cultivation and processing. The students will be taught about the useful product of lac insect.

Learning Outcomes:

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

- Identify the insect species producing lac.
- Understand the methods of cultivating, harvesting and processing of lac.
- Learn about the various host plants of lac insects and their natural enemies.

Unit 1. Study of species of Lac insects:

Structure of Lac insect (Male and Female), Life History of *Kerria lacca* (the true lac scale), *Paratachardina decorella* (the rosette lac scale), *Paratachardina pseudolobata* (the lobate lac scale); Lac host: *Zizyphus jujube* (Ber), *Ficus carica*, *Butia monosperma* (Dhak), *Acacia Arabica* (Kiker), *Albizia lebbeck* (Siris).

Practical:

1. Study the structure and life cycle of lac insect.
2. Identification of varieties of lac insect through photographs.
3. Study the various host plants of lac insects.

Unit 2. Cultivation of Lac:

Method of propagation: Pruning, Inoculation, Swarming and Harvesting of lac, Processing of lac; Lac Industry in India.

Practical:

4. Study the tools for pruning and cutting for lac cultivation (Scateur, Pruning Saw, Pruning knife)

Unit 3. Lac insect products and their uses:

Varieties of lac insect/types of lac, composition of lac. Shellac, Bleached shellac, Dewaxed bleached shellac, Aleuritic Acid (Shellac Aleuritic Powder)

Practical:

5. Various Lac products commercially available and their uses.

Unit 4. Pest of Lac insect:

Natural enemies of Lac insects; Insect enemies and Vertebrate enemies; Parasites: *Paraecthrodryinus clavicornis; Erencyrtus dewitzi; Tachardiaephagus tachardiae; Eupelmus tachardiae; Tetrasticus purpurens.* Predators: *Eublemma amabilis* Moori (white lac moth), *Holocera pulverea* Meyr (black lac moth), *Chrysopa* commonly (lac wing).

Practical:

6. Study about the natural enemies of Lac insect (Parasites & Predators) through photographs/slides.
7. Lab visits to study the production of lac and propagation of lac insect.

Suggested Readings:

1. Tembhare, D. B. (2017). *Modern Entomology*. Himalaya Publishing House Pvt. Ltd. Mumbai.
2. Awasthi, J. K. (2001). *Unified Zoology*. Shiva Lal Agarwala & Co. Educational Publishers.
3. Tembhare, D. B. (2017). Modern Entomology. Himalaya Publishing House Pvt. Ltd.
4. Kumar, Ashok and Nigam, Prem Mohan (2003). Economic and Applied Entomology. Emkay Publications.

E content:

- https://swayam.gov/appliedentomology.
- https://www.notesonzoology.com/lac-culture/lac-distribution-properties-and-products/361
- https://agrihunt.com/articles/lac-culture.

Key words: Lac insect, Cultivation of lac, Natural enemies, Host plant, Resin.

Teaching and Learning Process:

Classroom lectures using power point presentations coupled with related photographs of lac insect will clarify the concepts related to insects culture. Group discussions on various unique features of lac insects, their host plants, their natural enemies which are causing loss in lac production will develop interest among students to pursue as an entrepreneur. Visit to observe lac insectary in their natural and artificial environment will develop curiosity among learners about lac cultures and its benefits for the society.

Assessment Methods:

The assessment of students' achievement will be aligned with the course/program learning outcomes.

Formative assessment- written test/*viva voce* to check the retention of the topic.

At the end summative assessment could be done and students to be rewarded on the basis of presentations test, project reports and practical examination.

Course Code: ALS ZOO SEC 06
Course Title: Non-insect pests and their control
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

A large number of non-insect pests like mites, nematodes, rodents, birds, snails and slugs are known to damage agricultural crops. They are equally significant to insect pests in terms of nature of damage to different crops. Among the mammalian pests, rats and mice are at present the most abundant and destructive in the field as well as inside the houses and godowns. They damage practically all the field crops but some food crops like wheat, rice and groundnut seem to be their favourites. This course gives a framework for understanding the behaviour of non-insect pests and significant yield loss of different crops caused by them.

Learning Outcomes:

Upon completion of the course, students will be able to:

- To understand the characteristic features and behaviour of non- insect pests.
- Recognize major non-insects pest in Indian subcontinent based on their significant damage to different crops.
- Understand the specific life stage of the pest which cause significant loss to crop plants.

Unit I:

Introduction, habit and habitat and economic importance of non-insect pests and their management.

Unit 2:

Major mite pests of cultivated and plantation crops, Economic importance along with their management strategies. Study of Red spider mite (*Tetranychus neocaledonicus*), its damage on different crops and control measures.

Practical:

Study of habitat and morphological features of mites:

1. Study of life history of red spider mite (*Tetranychus neocaledonicus*) and spotted spider mite (*Tetranychus urticae*); damage on crops and control measures.

Unit 3:

Important species of snails and slugs as pest in India. Description of their nature of damage on agricultural crops, fruits, vegetables and ornamental plants in coastal area. Study of *Helix* spp and Indian slug species (*Macrochlymus indica*)**.** Strategies for their management.

Practical:

2. Study of common snail of agriculture crops: *Helix* spp and Indian slug species (*Macrochlymus indica*), nature of damage on agricultural crops, fruits, vegetables and ornamental plants in coastal area.

Unit 4:

Habitat, general characteristics and management of major phytonematodes. Study of Root-knot nematode (*Meloidogyne incognita*), its impact on crops and control measures.

Practical:

3. Study of Root-knot nematode (*Meloidogyne incognita*) and Wheat-gall nematode (*Anguina tritici*), impact on agricultural crops and management.

Unit 5:

Study of important bird pests of agricultural crops and their control: Rose ringed parakeet (*Psittacula krameria*) and blue rock pigeon (*Columba livia*); damage caused by them and their management.

Practical:

4. Study of important bird pests: Rose ringed parakeet (*Psittacula krameria*) and blue rock pigeon (*Columba livia*), their management and control.

Unit 6:

Status of rodents and other vertebrate pests in India. Important species of rodents and their management. Study of Indian mole-rat (*Bandicota bengalensis*) with its nature of damage and control measure.

Practical:

5. Study of importance of mammalian pests: Indian mole-rat (*Bandicota bengalensis*), Common rat (*Rattus rattus*), Indian fruit bat (*Pteropus giganteus*), common monkey (*Macaca mulatta*); impact on different crops and control measures.

6. To visit any agriculture institute and make a project report on main agriculture crops and management.

Suggested Readings:

1. Dhaliwal, G. S. (2009). *An Outline of Entomology* (2nd Ed.). Kalyani Publishers.
2. Atwal A.S. & Dhaliwal G.S. (2015) *Agricultural pests of south Asia and their management* (8th ed.). Kalyani Publishers.
3. Devasahayam H.L (2011) *Practical Manual of Entomology: Insects and Non-insect Pests*. New India Publishing Agency.

E-content:

https://www.agriculturein india.net/essay/non-insect-pests/essay-on-non-insect-pests-and-its-control-agriculture/15978.

Keywords:

Non-insect pest, mites, snails, nematodes, birds, vertebrate pests.

Teaching Learning Process:

- Learning material will be presented through a series of lectures supported by power point presentations.
- Charts, flow charts, video and open education resources.
- E-resources and laboratory training as well as case studies and field visits.
- Problem solving and quizzes to enhance understanding of the subject.

Assessment Methods:

- Continuous assessment during entire semester along with the Summative assessment by semester-end evaluations.
- Power point or blackboard presentation on related topics by students thereby increasing their knowledge and presentation skills.
- Assignments and projects on related topics; improving writing skills and academic performance of the students.
- Regular class tests for concept clarity.
- *Viva -voce* for ensuring the basic understanding and concept building.

Course Code: ALS ZOO SEC 07
Course Title: Tools and Techniques of Pest control
Total Credits: 02 (Theory 0, Practical 02)
Total Lectures: Theory 0, Practical 60

Objectives:

As India is an agriculture-based country, damage of field crops and stored food grains by pests is a cause of great concern. This course provides an insight to the students about the pests and their control by various tools, techniques and methods. Knowledge about the different pest control tactics, their principle and methodology will help in framing the appropriate management strategy for insect pest control. The students will learn how to enhance productivity even in a simple agro-ecosystem by the use of various pest controlling measures.

Learning Outcomes:

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

- Understand about pests and how they can be controlled.
- Learn about the use of different pest control techniques in a harmonious manner.
- Understand the theory and practice of different control measures.
- Understand and evaluate various control agents like parasitoids, predators and various entomopathogens.
- Understand the planning of the agricultural ecosystem to manage the pest population effectively.
- Students will gain knowledge about the concepts and tools of pest management.
- Develop skills for applying Sterile Insect Technology (SIT) in pest management.

Unit 1:

Introduction to insect pest and their types; invasive pest; pest control methods.

Practical:

1. Identification of common natural enemies of insect pests;

Parasitoids: Tea-*Telenomus* spp., Aphidius, Coffee-*Cephalonomia stephanoderis* (Betrem), *Phymastichus coffea* (La Salle) Flower crops-*Trialeurodes vaporariorum* (Westwood). Predators: Beetles, Bugs, Wasps, Flies, Praying mantis.

Weed killers: *Danaus chrysippus* (Calotropis butterfly), *Zygogramma bicolorata* (Parthenium weed killer).

2. Study of various pathogens for the control of pests: EPN's, Nucleopolyhydrosis virus (NPV), *Bacillus thuringiensis* (Bt).

Unit 2:

Principles and scope of cultural control/farm practices by various methods: clean cultivation, crop rotation, tilling of soil, fertilizing and stimulators, resistant varieties.

Practical:

3. Study of tools for the collection of common insects: Nets, Jars, sticky bands, swatting.

Unit 3:

Principles and scope of physical and mechanical control; Tools-Nets, Jars, Sticky Bands. Devices-Sprayers, dozers, traps; Techniques.

Practical:

4. Study of different physical and mechanical devices used for controlling insect pests: Sprayers- Knapsack, Hand, Foot, Hand rotary duster, Power duster; Dozers- Hopper dozers, Aphid dozers; Traps- Light, Funnel, Yellow sticky, Delta, pheromone, probe, bait, Pitfall.

Unit 4:

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control techniques- importation, augmentation and conservation, SIT, F1 Sterility. Insect growth regulators and botanicals in pest management practices (Biorational approach).

Practical:

5. Study of different biological control techniques: importation, conservation and augmentation, SIT/F1 Sterility.
6. Field/Lab/Institutional visits to learn rearing and mass production of insect pests/parasitoids and submit a report.

Suggested Readings:

1. Dhaliwal, G.S. & Arora, R. (2001) *Integrated Pest Management: Concepts and Approaches.* Kalyani Publishers.
2. Saxena, A. B. (2003) *Biological Control of Insect Pests.* Anmol Publishers.
3. Vishwanath and Agrawal, R. A. (1982) *Insect pests of crops and their control.* Bharti publications.

E-Contents:

Sciencedirect.com.

Keywords:

Pest Control, Sprayer, Dozers, Traps, Invasive pest, Cultural control, Bioagents, Augmentation, SIT/F1 sterility, IGRs.

Teaching Learning Process:

- Specimen pictures and models.
- Related photographs.
- Powerpoint presentations.
- Maximizing interaction/group discussions with the students.
- Analysis of scientific articles.
- Observation based on actual handling of insects.
- Visit to observe insects in their natural environment and entomology museums.

Assessment Methods:

Students will be assessed by the following ways:

- Assignments and projects on related topics for improving writing skills and academic performance of the students.
- Continuous assessment during entire semester along with the summative assessment by the semester-end evaluation.
- Power point or blackboard presentation on related topics by students thereby increasing their knowledge and presentation skills.
- Regular class tests for concept clarity.
- *Viva -voce* for ensuring the basic understanding and concept building.

Course Code: ALS ZOO GE 01
Course Title: Agricultural Pests of Crops
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

The study of agricultural pests focusses on identification of different types of pests, their life cycle and the harm they cause to the crops and stored grains. This course will help the students to understand the concept of insect pests and their population dynamics in relation to changing environmental conditions. The students will be taught the appropriate control measures to manage the pest population in nature so as to avoid heavy economic losses.

Learning Outcomes:

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

- Learn about the variety of important pests of crops, fruits, vegetables and stored grain.
- Understand the difference between various types of pests and extent of damage caused by them.
- Learn varied types of control measures for management of pest populations and list suitable control measures specific for each pest.

Theory:

Unit 1: Lectures: 05

Introduction and Classification of pests, Factors responsible for emergence of pest, Pest status, Pest population dynamics.

Unit 2: Lectures: 12

Bionomics and control of crop pests: Rice pest (*Leptocorisa acuta,*), Wheat pest (*Sesamia inferens*), Pulse pest (*Helicoverpa armigera*), Sugarcane pests (*Scirpophaga nivella, Pyrilla perpusilla*), Cotton pests (*Earias vitella, Pectinophora gossypiella*), Vegetable pest (*Raphidopalpa faveicollis, Leucinodes orbonalis),* Fruit pest *(Papilio demoleus)***.**

Unit 3: **Lectures: 08**

Polyphagous pests: Stored grain pests: *Sitophilus oryzae, Corcyra cephalonica, Trogoderma granarium, Callosobruchus chinensis.* Bionomics and strategies for the management of stored grain pests

Unit 4: **Lectures: 05**

Bionomics and management of Grass hopper (*Schistocerca Americana*), White grubs, Bihar hairy caterpillar and Termites.

Practical:

1. Identification of crop pests-
    (a) Rice pest: *Leptocorisa acuta,*
    (b) Wheat pest: *Sesamia inferens,*
    (c) Pulse pest: *Helicoverpa armigera,*
    (d) Sugarcane pests: *Scirpophaga nivella, Pyrilla perpusilla,*
    (e) Cotton pests: *Earias vitella, Pectinophora gossypiella, Dysdercus koenigii,*
    (f) Vegetable pest: *Raphidopalpa faveicollis, Leucinodes orbonalis,*
    (g) Fruit pest: *Papilio demoleus.*
2. Identification of stored grain insect pests: *Sitophilus oryzae, Corcyra cephalonica, Trogoderma granarium, Callosobruchus chinensis.*
3. Culture of two crop insects of economic importance and submission of culture report.
4. Study of the life history of two different insect pests (Submission of life cycle stages from culture).
5. Visit to IARI (Pusa), and other ICAR Institutes.

Suggested Readings:

1. Pedigo, L.P. (1996) *Entomology and Pest Management*. Prentice Hall.
2. S. Pradhan. *Insect Pest of Crops* (2011). National Book Trust.
3. Atwal, A.S. (1993) *Agricultural Pests of India and South East Asia*. Kalyani Publishers.
4. Dennis, S. Hill (2005) *Agricultural Insect Pests of the Tropics and Their Management*. Cambridge University press.
5. Tembhare, D. B. (2017). Modern Entomology. Himalaya Publishing House Pvt. Ltd. Mumbai.

E- contents:

- https://swayam.gov/appliedentomology.
- https://www.entsoc.org/resources/education/online-courses.

Keywords:

Pest, Bionomics, Polyphagous, Pest control.

Teaching and Learning Process:

Classroom lectures using Power point presentations enabled with related photographs of insect vectors will clarify the concepts related to insects. Group discussions on various unique physiological processes in Insects will develop interest among students to pursue higher studies in the field. Observations based on actual handling of insects and their body parts, visit to observe insects in their natural environment and entomology museum will develop curiosity among learners about insect diversity.

Assessment Methods:

The learners/ students can be assessed in many different ways:

Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation. Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc. Students would be provided feedback on their work with a view to improve their academic performance.

Course Code: ALS ZOO GE 02
Course Title: Insect Vectors and Diseases
Total Credits: 04 (Theory-02, Practical-02)
Total Lectures: Theory 30, Practical 60

Objectives:

Insect vectors spread a variety of diseases, resulting in millions of fatalities each year around the world, particularly in developing countries. The transmission by Insect-borne pathogen is increasing at an alarming rate, posing an increasing menace to human health. The transmission of disease by the insects can only be controlled and prevented by studying their biology, modalities of pathogen transmission by them, evaluating associated risk factors and by devising efficient techniques to control these insects.

Learning Outcomes:

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

- Identify different insects and classify them based on their morphology and behaviour
- Describe the host-pathogen relationships and the role of the host reservoir on transmission of parasite
- Explain various modes of transmission of parasite by insect vectors
- Recognize various possible modern tools and methodologies for laboratory diagnosis, surveillance and treatment of diseases
- Define various terms related to insect transmitted diseases such as Zoonotic, Vertical and Horizontal transmission, host specificity etc.
- Identify the risk groups and design methodology to protect them.
- Spread awareness on public health programs about insect borne diseases and their control
- Employ the use of advanced management strategies in disease control with respect to parasite evolution.

Theory:

Unit 1. Introduction to Insects: **Lectures: 08**

General Features of Insects, Classification of insects up to Orders- General features of orders, Morphological features: Head, legs and types of antennae. Types of Insects mouth parts w.r.t. feeding habits: siphoning type (butterfly), sponging type (housefly), biting and chewing type (cockroach), piercing and sucking type (mosquito), chewing and lapping type (honeybee).

Unit 2. Concept to Vectors: **Lectures: 05**

Brief introduction to Carriers and Vectors (mechanical and biological vector); Insect reservoirs; Host-vector relationship; Vectorial capacity; Host Specificity; Modes of disease transmission - vertical and horizontal transmission; Insects as vectors: General adaptations in insects to act as vectors.

Unit 3. Dipterans as disease Vectors-I: **Lectures: 05**

Dipterans as important insect vectors–Mosquitoes. Study of mosquito-borne diseases–Malaria, Dengue, Chikungunya, Filariasis, Viral encephalitis. Control and prevention/cure of diseases caused by mosquitoes.

Unit 4. Dipterans as disease vectors-II **Lectures: 04**

Dipterans as important insect vectors –Sand flies (*Phlebotomus* or *Lutzomyia*), Houseflies (*Musca domestica*); Study of sand-fly borne diseases – Leishmaniasis, phlebotomus fever; Study of house fly as important mechanical vector; Myiasis; Control and prevention/cure of diseases caused by sandfly and house fly.

Unit 5. Siphonapterans as disease vectors. **Lectures: 03**

Fleas as insect vectors; Study of flea-borne diseases – Plague, typhus fever; Control and prevention/cure of diseases caused by fleas.

Unit 6. Siphunculata as disease vectors: **Lectures: 05**

Human louse (head, body and pubic louse) as disease vectors; study of louse-borne diseases: Typhus fever, relapsing fever, vagabond's disease, Phthiriasis; Control of human louse and prevention/cure of diseases caused by them.

Practical:

1. Study of different kinds of mouthparts and legs of insects through slides/specimens.
2. Study of insect vectors through permanent slides or photographs: Mosquitoes (Aedes, Culex, Anopheles), lice [head, body (*Pediculus*), pubic (*Pthirus*)], Flea (*Xenopsylla cheopis*), sand

fly (*Phlebotomus*), house fly (*Musca domestica*).

3. Study of different diseases transmitted by the above insect vectors using photographs.
4. Project report on any one disease transmitted by an insect vector.
5. Optional field trip/Lab. visit institutes such as NIMR, NCDC.

Suggested Readings:

1. Mullen & Darden. *Medical and Veterinary Entomology* (3rd Ed.). Academic Press.
2. Service, M.W. (1980). *A Guide to Medical Entomology*. Macmillan Press.
3. Burgess, N. R. H. & Cowan, G. O. (1993). *A colour atlas of medical entomology*. Springer Science and Business Media, B. V.

E-content:

- **http://publichealth.lacounty.gov/acd/Vector.htm**
- **https://www.cdc.gov/ncezid/dvbd/index.html**

Keywords:

Vectors, Diseases, Prevention, Control, Carrier.

Teaching Learning Process:

Classroom teaching using power point presentations enabled with related photographs or specimens/slides of insect vectors, their life stages and disease diagnosis will be employed to clarify concepts. Case studies of epidemics caused by insects as vectors will be discussed to make the students aware about their importance. Visit to local diagnostic centre will provide an overview of various medical tests conducted to detect and confirm vector transmitted diseases.

Assessment Methods:

The learners/ students can be assessed in many different ways:

Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation. Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc. Students would be provided feedback on their work with a view to improve their academic performance.

Course Code: ALS ZOO GE 03
Course Title: Techniques for Insect Collection, Rearing and Preservation
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

The course aims to give knowledge to the student about the broad categories of insects. They will be taught about the various insect collection techniques as well as their preservation for future studies. They will also be trained about the maintenance of insectary and rearing of insects for their use in research as well as for commercial purposes.

Learning outcomes:

- Students will understand the use of different tools and techniques for the collection and preservation of insects belonging to various economically important insect orders.
- Students will be equipped with rearing techniques of insects.
- They will be able to set up an insectary.

Theory:

Unit 1: **Lectures: 04**

Class Insecta

Characteristics of class Insecta and outline classification upto orders

Unit 2: **Lectures: 06**

Insect collection Techniques :

Tools and techniques: Collecting bag and other containers, Insect nets, collecting jars, alcohol vials, Envelopes, Forceps, Sieve, Aspirator, various types of Traps, Berlese funnel, beating tray, Beat sheet

Unit 3: **Lectures: 08**

Insect Preservation

Dry preservation: Different types of Killing bottles- Cyanide bottle, Chloroform bottle, Ethyl acetate, Preservation in triangles, Gutting, Drying, Relaxing, Pinning (direct and micro pinning), Staging, Carding, Spreading, Setting; Wet Preservation: Ethanol and Lactic acid preservatives, Fixatives, Microscope slide mounting: stains, mountants; Mountings and preservation of individual orders; curation: labelling, insect box, Riker Mounts and cabinents, care of collection, Identification keys.

Unit 4: **Lectures: 05**

Rearing of Lepidopteran and Dipteran pests

Methods for the rearing: *Spodoptera litura*/*Helicoverpa armigera* both in natural and semi-synthetic diet, House fly and Mosquitoes.

Unit 5: **Lectures: 04**

Rearing of stored grain Insect pests

Rice meal moths (*Crcyra cephalonica)*, Red cotton bugs *(Dysdercus cingulatus)*, Pulse beetle (*Callosobruchus chinensis).*

Unit 6: **Lectures: 03**

Maintenance of Insectary Containers for rearing, rearing condition and problems: Moisture, Temperature, Light, Food, Dormancy and Diapause. Glass house Insectary, Sterilization techniques/ fumigation.

Practical:

1. Study of Insect collection equipment through specimens/ Photographs
2. Dry mounting, labelling and preservation of insects.
3. Study of insect box and it's preparation.
4. Temporary preparation of slide of microscopic insects.
5. Study of different types of traps through specimens/ photographs.
6. Culture of any one pest (agriculture/ stored grain) and submission of different life stages.
7. Visit to any Insectary and submission of project report.

Suggested Readings:

1. Atwal, A. S., & Dhaliwal, G. S. (2015). *Agricultural pest South Asia and their management* (8th Ed.). Kalyani publishers.
2. Padhan, S. (2016). *Agricultural Entomology and Pest Control*. ICAR publication.

3. Gullan, P. J., & Cranston, Peter (2004). *The Insects: An Outline of Entomology* (3rd Ed.). Edition. Blackwell publication.
4. Tembhare, D. B. (2017). *Modern Entomology*. Himalaya Publishing House Pvt. Ltd.

E-content:

https://www.ars.usda.gov/ARSUserFiles/80420580/CollectingandPreservingInsectsandMites/collpres.pdf.

https://mississippientomologicalmuseum.org.msstate.edu/collecting.preparation.methods/Collecting.methods.html.

Key words:

Insect, Rearing, Insectary, Preservation, Lepidoptera, Diptera.

Teaching and Learning Process:

Knowledge about the techniques for Insect collection, rearing and preservation will be imparted through classroom lectures/ practical class. Group discussion/field survey among students will make them aware of importance of collection, rearing methods of insect pest in controlled condition and their preservation. Seminars on the related topics will enhance the learning of students to a great extent. Visits to fields, museum and laboratories will provide a hands-on experience about the techniques of collection, rearing and preservation.

Assessment Methods:

The theory and practical components of the course will be assessed in two ways.

Continuous assessment - To regularly check the students learning and understanding of the subject. Class room discussions and tests will help in evaluating the students grasp on the subject.

Semester-end Examination - Performance in the semester end examination will indicate their understanding of the concept and its applications; while solving the related problems and writing their answers.

Course Code: ALS ZOO GE 04
Course Title: Animal Cell Culture techniques
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

The aim of the paper is to give knowledge to students about cell and tissue culture technology. Students will learn how to set up an animal cell culture laboratory. Students will be taught about the instruments and chemicals required to run and maintain a tissue culture lab. Learning of cell culture technology will train them to undertake research projects in relevant fields.

Learning Outcomes:

By the end of the course, the students will have following expertise

- To set up animal cell culture laboratory
- Instruments and chemicals required to run and maintain a tissue culture lab.
- Challenges of maintaining a cell culture laboratory and how to overcome these challenges.
- Learn about various types of media.
- Learn about the maintenance and manipulation of animal cells *in vitro*.

Theory:

Unit 1: **Lectures: 04**

Introduction to Animal cell culture; Historical background, Biology of animal cell and cell-cell interactions, good laboratory practices, Sterilization methods and techniques.

Unit 2: **Lectures: 08**

Equipment: Laminar-Flow Hood, Autoclave, Inverted Microscope, Centrifuge, Haemocytometer, Humidified CO_2 Incubator, Cryostorage Container.

Media and Buffers: Types of culture media, Physicochemical characteristics of medium - pH, O_2 CO_2 and Bicarbonate buffering, Osmolality, Temperature, Viscosity and Surface Tension.

Importance of Serum and Serum-free media, Balanced salt solutions, Antibiotics and other supplements.

Unit 3: Lectures: 10

Tissue Culture: Primary Cell Culture- Isolation of the tissue, Initiation of culture: Types of primary culture. Subculture **and** cell lines; culture of tumor cells, principles of cryopreservation of cell lines. *in vitro* transfection of animal cells-chemical method, lipid mediated gene transfer (lipofection), Electroporation. Microbial contaminants (Bacteria, Yeast, Fungi, Mycoplasma and Virus) in cell line.

Unit 4: Lectures: 08

Applications of Animal Cell Culture**:** Toxicology studies, Vaccine production, Gene therapy, Stem cell therapy, Production of recombinant proteins, Cancer Research.

Practical:

1. Packing and sterilization of glassware and plasticware for cell culture.
2. Study of different sterilization techniques used in cell culture laboratory.
3. Preparation and sterilization of culture medium, buffers and solutions.
4. Sub-culturing of cell lines.
5. Counting of cells in given cell line sample using hemocytometer.
6. To study about cytotoxicity and cell viability.
7. Demonstration of Transfection in cell lines using Photographs/Videos.
8. Demonstration of working of the following instruments:
   i) Laminar Flow Hood ii) Autoclave iii) Humidified CO_2 Incubator iv) pH Meter.
9. Project report on visit to animal cell culture labs

Suggested Readings:

1. Freshney, R. IAN. (2021). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (8th Ed.).
2. Masters, John. R. W. (2000). *Animal Cell Culture: A Practical Approach* (3rd Ed.).
3. Butler, M. (2003). *Animal Cell Culture and Technology.* (2nd Ed.).
4. Davis, John. M. (2011). *Animal Cell Culture: Essential Methods*.
5. Bhatt, Sheelendra. M. (2011). *Animal Cell Culture: Concept and Application.*

Keywords:

Cell Culture, Tissue Culture, Transfection, culture medium.

Teaching Learning Process:

Blend of conventional blackboard teaching, modern teaching learning tools and computer-based instructions and practical training. Problem solving and quizzes for enhanced understanding of the concepts. Visit to various animal cell culture labs will create interest, enhance their understanding of their basic concept.

Assessment Methods:

- Presentations by individual student/ group of students
- Class tests at periodic intervals.
- Written assignment(s)
- End semester University theory examination.

Course Code: ALS ZOO GE 05
Course Title: Locust and its management
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

The course aims to apprise the students of locust as one of the most dangerous pests of agricultural crops. It focusses on identification of locust, reasons of their swarming and migratory nature which gives immense economic loss leading to national emergency of food and fodder. The students will be taught about their control, monitoring and management strategies.

Learning Outcomes:

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

- Understand about the locust as serious pests that cause damage to the agroecosystems affecting the economy.
- Understand the habit, habitat, behaviour, morphology and different phases.
- Know the different species and their comparison with grasshoppers.
- Study their biology, monitoring techniques, and various methods of control measures.
- Know the role of national and international organizations to manage locust.

Theory:

Unit 1: Lectures: 6

Introduction, historical background, locust plague and upsurges, Systematic position of locusts and grasshoppers; habitat, behaviour and morphology of locusts. Difference between locusts and grasshoppers.

Unit 2: Lectures: 9

Locusts in India, distribution, life cycle: *Schistocerca gregaria*, *Patanga succincta*, *Locusta migratoria;* damage caused by them.

Unit 3: Lectures: 7

Breeding seasons and breeding areas, swarming. biological phases: solitary, transients and gregarious and changes in their behavior, color and structure. Biotic theory of periodicity.

Unit 4: Lectures: 6

Locust management: National and international organizations - LWO, SALO, CALO, FAO, NLCC, IRLCO-CSA (International Red Locust Control Organization for Central and Southern Africa), swarm monitoring. Control methods- Mechanical and traditional, regulatory practices, Chemical methods: ULV Sprays, dusting, baits, IGRs; advantages and disadvantages of different chemical control methods, biological practices: biopesticides, predators, parasitoids; Integrated Pest Management; Plant quarantine.

Unit 5: Lectures: 2

Socio-Economic importance: Impact on the health of fauna and humans; on agriculture.

Practical:

1. Comparative study of different species of locusts through specimens /photographs.
2. Study of mouthparts, wings and legs of locust through specimens /photographs.
3. Study of sexual dimorphism in locust through specimens /photographs.
4. Study the life stages of the locust through specimens/slides/photographs.
5. Study of different tools used in the management of locust.
6. Study of different host plants of locust.
7. Visit to different institutes/stations/laboratories (submit a Report on visit/current status of locusts in India).

Suggested Readings:

1. Ritchie, J. M., & Dobson, H. (1995). *Desert Locust, control operations and their environmental impact*. NRI bulletin 67, Hopps the printers Ltd.
2. Atwal, A. S.; & Dhaliwal, G. S. (2015). *Agricultural pest South Asia and their management* (8th Ed.). Kalyani publishers.
3. Pradhan, S. (2016). *Agricultural Entomology and Pest Control*. ICAR publication.
4. Pandey, & Kumari R. (2021) *Locust in Indian Agriculture*. Notion press India.
5. Rachadi, Tahar (2010). *Locust control handbook*. CTA publication, AJ Wagningen-The Netherlands.
6. Krall, S; Peveling, R & Diallo, D. Ba. (1997). *New strategies in Locust Control*. Pirahauser

Basel springer.

E- contents:

1. https://link.springer.com/book/10.1007/978-3-0348-9202-5? No Access=true.
2. https://www.researchgate.net/publication/349553095_Locust_Introduction_biology_and_Management_in_Pakistan.
3. http://ppqs.gov.in/divisions/locust-control-research/organizations-locust-control-campaign.

Keywords:

Locust, grasshopper, swarm, locust outbreak, *Schistocerca*.

Teaching Learning Process through:

Specimen pictures/slides, related photographs, powerpoint presentations, maximizing interaction with students, Analysis of Scientific articles, Observation based on actual handling of insects and their body parts.

Assessment Methods:

Students will be assessed by the following ways:

- Continuous assessment during entire semester along with the Summative assessment by the semester-end evaluation.
- Blackboard or power point presentation on related topics by students thereby increasing presentation skills and knowledge of students.
- Assignments and projects on related topics for improving writing skills and academic performance of the students.
- Regular class tests for concept clarity.
- *Viva -voce* for ensuring the basic understanding and concept building.

Course Code: ALS ZOO GE 06
Course Title: Beneficial Insects and their products
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

The course will make the students aware about the significance of beneficial insects. It will help the students to understand the various products of insect origin and their uses. This course will also focus on how to maximize commercial production for economic benefits. It will also help the learner in developing entrepreneurial skills required for self-employment.

Learning Outcomes:

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

- Attain knowledge of beneficial insects and their products.
- Develop an understanding of the biology of beneficial insects, their interactions with each other and with the environment.
- Enhance knowledge of sericulture, apiculture etc.

Theory:

Unit 1: **Lectures: 5**

An introduction to the beneficial insects and their applications in agriculture - (Pollination and dispersal; decomposition - dung, carrion and plant materials), in medicine, in veterinary and in forensic entomology. Bioagents: Insects as natural enemies of pests and as scavengers.

Unit 2: **Lectures: 7**

Honey and Wax: Introduction and history of bee-keeping; Honey bees: species type, morphology, biology, conservation, seasonal management, hives, diseases; Honey and wax production and their uses, Ripening of honey, Propolis.

Unit 3: Lectures: 7

Silk: History and development of silkworms in India, different species, voltinism and biology of silkworm, main and alternate host plants, method of harvesting and preservation of mulberry leaves, types of silk, silk production.

Unit 4: Lectures: 6

Lac: Species of lac insects, morphology, biology, host plants, Lac production and its uses, Types of lac; seed lac, button lac, shellac, and lac-products.

Unit 5: Lectures: 5

Dyes: Insect derived - Cochineal dye: *Dactylopius coccus*; Polish cochineal dye: *Porphyrophora polonica*; Carmine dye: *Kermes varmilo* and other insects.

Insect induced plant products: Tannic acid.

Other products: Honeydew.

Practical:

1. Study of different species of honeybees (mouthparts, legs of worker, stinging apparatus) through specimens/photographs/slides.
2. Study of adult lac insect through photographs and slides.
3. Study of different species of silk moth (mouthparts and legs)
4. Study of biocontrol agents/natural enemies of insect pests through photographs/slides. .
6. To study the adulterations/purity of honey/shellac/silk.
7. Visit to research and training Institutions/Unit of Beekeeping, Sericulture, Lac culture.

Suggested Readings:

1. David, V. Alford. (2019). *Beneficial insects*. CRC Press, taylor and francis, vocaraton, Florida.
2. Sathe, T. V., and Jadhav, A. (2002). *Sericulture and Pest Management.* Daya Publishing House.
3. Yonemura, M., and Rama Rao, N. (1951). *A Handbook of Sericulture. I. Rearing of silk-worms*. Government Branch Press, Mysore.

E-contents:

1. Silkworm crop protection (https://swayam.gov.in/courses/152-silkworm-crop-protection).
2. Sericulture (http://csb.gov.in/silk-sericulture/sericulture).

Keywords:

Pollination, Carrion, Propolis, Bee Conservation, Honeydew, Lac, Silk, Honey, Wax.

Teaching Learning Process through:

Specimen pictures/slides, related photographs, powerpoint presentations, maximizing interaction with students, Analysis of Scientific articles, Observation based on actual handling of insects and their body parts.

Assessment Methods:

Students will be assessed by the following ways:

- Continuous assessment during entire semester along with the Summative assessment by the semester-end evaluation.
- Blackboard or power point presentation on related topics by students thereby increasing presentation skills and knowledge of students.
- Assignments and projects on related topics for improving writing skills and academic performance of the students.
- Regular class tests for concept clarity.
- *Viva -voce* for ensuring the basic understanding and concept building.

Course Code: ALS ZOO GE 07
Course Title: Insect Ecology
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Objectives:

The course aims to give knowledge to the students about the basic ecology and role of different biotic and abiotic factors. It introduces the learner to concepts of ecosystem, energy flow, attributes of insect population and different factors affecting the distribution, abundance and prey- predator relationship of insects. Students will be taught about the insect population interactions and their role in different ecosystems.

Learning Outcomes:

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

- Understand the key concepts in ecology and role of insects in ecosystem.
- Learn about abiotic and biotic factors
- Comprehend the population characteristics, dynamics, growth models and interactions.
- Understand the community characteristics, ecosystem development and climax theories.
- Know about the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies.

Theory:

Unit 1: **Lectures: 3**

Fundamentals of Insect ecology, abiotic factors and biotic factors, Laws of limiting factors.

Unit 2: **Lectures: 5**

Ecosystem: Concept types, role of insects in ecosystems. Food chain, Food web and energy flow through the ecosystem, Productivity, Ecological pyramids and ecological efficiencies, interactions of insects and their environment.

Unit 3: Lectures: 12

Population: Attributes of Insect population: Density, Natality, Mmortality, Life tables, Survivorship curves, Dispersal and Dispersion, Exponential *vs* Logistic Growths, Carrying capacity. Population regulation, Basic concepts of Insect abundance: factors responsible for changes in the distribution and abundance of insects. Density dependent and independent factors.

Unit 4: Lectures: 5

Insect Population interactions: Basic factors governing the interspecific interactions, Classification of interspecific interactions, Understanding of Gause's principle with insects as examples, Prey-predator interactions, Lotka-Volterra Model. Functional and numerical response.

Unit 5: Lectures: 5

Community ecology: Characteristics, Abundance and diversity of insects, Species richness, Ecotone and edge effect. Food as a limiting factor for distribution. Insects as regulators of ecosystem processes. Ecological succession.

Practical:

1. Study of Life tables and plotting of survivorship curves of different types from the hypothetical data provided/real data of insect population obtained from the field.
2. Determination of insect population density in a natural or hypothetical community by quadrate method and calculation of the Shannon Wiener Index.
3. Study of abiotic factors in aquatic ecosystems: Temperature, turbidity, pH, dissolved oxygen content (by Winkler's method) and light intensity.
4. Biochemical estimation of nitrates and phosphates from the pond water samples.
5. Estimation of water quality using insects/other organisms as bio-indicators.
6. Estimation of primary productivity by light and dark bottle method.
7. Field visits to understand different ecosystems and to study insect diversity.

Suggested Readings:

1. Odum, E.P. (2008) Fundamentals of Ecology. Indian Edition. Brooks/Cole.
2. Smith, R. L. (2000) Ecology and field biology. Harper and Row publisher.
3. Krebs, C. J. (2001) Ecology. VI Edition. Benjamin Cummings.
4. Schowalter D.Timothy, (2006) Second edition, Insect Ecology an ecosystem approach, Academic Press.
5. Ricklefs, R.E. (2000) Ecology. V Edition. Chiron Press.

Keywords:

Ecosystem, Energy flow, Food chain, Food web, Energy pyramids, Population ecology, Abundance, Survivorship curves, Density, Natality, Mortality.

Teaching Learning Process:

Field study for terrestrial ecosystem/aquatic ecosystem, PowerPoint Presentations, Maximizing interaction/Group discussion with students, Analysis of Scientific Articles. Observation based on actual handling of insects and their body parts. Visit to observe insects in their natural environment. Inculcate quantitative and analytical skills.

Assessment Methods:

Students will be assessed by the following ways:

- Continuous assessment during entire semester along with the Summative assessment by the semester-end evaluation.
- Power point or blackboard presentation on related topics by students thereby increasing their knowledge and presentation skills.
- Assignments and projects on related topics for improving writing skills and academic performance of the students.
- Regular class tests for concept clarity.
- Problem based assignment to increase the analytical approach of the students.
- *Viva -voce* for ensuring the basic understanding and concept building.

List of Faculty members of Swami Shraddhanand College involved in the design of new curriculum of B.Sc. (H) ALS-ACPM.

S. No.	Name of the Faculty	Department
1.	Dr. Pradeep Kumar	Botany
2.	Dr. Bhawna Saxena	Botany
3.	Dr. Anil Kumar	Botany
4.	Dr. Shibaji Baghar	Botany
5.	Dr. Seema Gupta	Chemistry
6.	Dr. Mamta Kharkwal	Chemistry
7.	Dr. Chaggan Lal	Chemistry
8.	Dr. Amar Meena	Chemistry
9.	Dr. Surendra Kumar Sagar	Zoology
10.	Dr. Tanushri Saxena	Zoology
11.	Dr. Surendar Kumar	Zoology
12.	Dr. Gauri Mishra	Zoology
13.	Dr. Manas Kumar Dhal	Zoology
14.	Dr. Bipin Kumar Aggarwal	Zoology
15.	Ms. Akanksha Singh	Zoology
16.	Dr. Pushpa Singh	Zoology
17.	Mr. Preetam Kumar	Zoology
18.	Dr. Mukesh Kumar	Zoology
19.	Mr. Bhagat Singh	Zoology
20.	Dr. Smita Shukla	Zoology