SHRI GURU RAM RAI UNIVERSITY

[Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017 & recognized by UGC u/s (2f) of UGC Act 1956]

SYLLABUS FOR

Master of Science (Botany)

School of Basic & Applied Sciences

(w.e.f 2021-2022)

SHRI GURU RAM RAI UNIVERSITY, PATELNAGAR, DEHRADUN-UTTARAKHAND-248001

Master of Science (Botany)

Programme outcome (POs)

The student will be able to:

PO 1	Implement strong theoretical and practical knowledge of botany to solve complex scientific problems
PO2	Identify the situation-based problems, formulation, and action is taken based on analytical thinking and principles of science
PO3	Execute effective communication through interactive and presenting skills, technical report writings, and proper documentation of ideas.
PO4	Formulate, design, experimental techniques, scientific tools, analysis of scientific data, interpretation of data, and establish a hypothesis for various interdisciplinary research problems.
PO5	Create a new conceptual, theoretical and operational approach to address various problems in interdisciplinary fields.
PO6	Enables individuals to function effectively in cross-cultural environments as an individual, and as a member or leaders.
PO7	Understand ethical issues, academic and research ethics, the need and value of lifelong learning, and the scientific misconduct of a scientist to serve society.
PO8	Understand the contribution of scientific knowledge in environmental contexts for sustainable development.
PO9	Enhance and adopt employability skills through research, internship, and dissertation.
PO10	Successfully compete in the state level, national level and international level exam or competition

Program Specific Outcome (PSOs)

PSO 1	Knowledge about the basics and advanced aspects of cryptogamic botany.
PSO 2	Understand different specializations of botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell & molecular biology of various life-forms.
PSO 3	Learn, think and apply suitable methods to solve a wide range of problems in various analytical techniques of plant biology, use of plants as industrial resources or as human livelihood support system, transgenic technologies for basic and applied research in plants.
PSO 4	Identify various life forms of plants, design and execute experiments related to basic and applied studies.
PSO 5	Develop job-oriented skills needed in research, consultancy, forest service, entrepreneurial pursuit and industry

Eligibility for admission:

Any candidate who has passed the B. Sc. with Botany as one of the subject with not less than 45%-marks in aggregate is eligible for admission, However, SC/ST, OBC and other eligible communities shall be given relaxation as per University rules.

Duration of the Programme: 2 Years (Four semesters)

Admission of the Master's Program in Botany shall be through entrance examination conducted by the University/ Merit of qualifying exam and the program shall be based on choice based credit system in which credit defines the quantum of content/ syllabus prescribed for a course system and determines the number of hours of instruction per week

The student shall be eligible for admission to a Master's Degree Program in Botany after he/she has successfully completed a three year undergraduate degree or earned prescribed number of credits (under CBCS) through the examinations conducted by University as equivalent to an undergraduate degree.

Core courses prescribed for every Semester shall be mandatory for all students registered for the Master's Program in Botany and shall carry minimum 66 credits. Besides this there shall be Elective courses offered in semester III and IV and shall carry a minimum of 20 credits. A self-study course would comprise of maximum 6 credits of which minimum 03 credits shall be mandatory which shall not be included while calculating grades. The student may choose self-study course semesters III. The self-study course shall be based on advanced topics.

Each candidate is expected to participate in the field surveys and excursions required for the Laboratory Courses as and when organized by the Department. Subsequent to that the student would have to present a detailed report of such visits at the time of Semester Practical examination

In order to qualify for a two year master's degree, a student must acquire a minimum of 86 credits including a minimum of 20 credits in electives choosing at least two elective (leading to a minimum 11 credits) offered by other departments and one qualifying self-study course of minimum 03 credits.

Dissertation is an elective one. The dissertation is to be allotted in the beginning of III Semester and would be submitted during the examination of the IV Semester. In lieu of dissertation any two of the given elective papers of 03 credits each and one lab course (of both elective papers) of 03 credits (total 09 credits) may be chosen by those students who secure less than 75% up to II semester level. The Dissertation may be allotted at the start of III semester to those students who secure 75% or more up to II semester level and the Dissertation would be submitted at the time of IV Semester practical examination.

STUDY & EVALUATION SCHEME
Choice Based Credit System
Master of Science (Botany)

First Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC101	Mycology and Microbiology	4	0	0	4	40	60	100
2	Core	MBOC102	Phycology and Bryology	4	0	0	4	40	60	100
3	Core	MBOC103	Pteridology, Gymnosperm and Palaeobotany	4	0	0	4	40	60	100
4	Core	MBOC104	Taxonomy and Diversity of Flowering Plants	4	0	0	4	40	60	100
Practical										
1	Core	MBOL105	Laboratory Course I Based on C101&C102	0	0	3	3	40	60	100
2	Core	MBOL106	Laboratory Course II Based on C103&C104	0	0	3	3	40	60	100
			Total	16		6	22	240	360	600

L – Lecture, T – Tutorial, P – Practical, C – Credit

Second Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC201	Plant Development and Reproductive Biology	4	0	0	4	40	60	100
2	Core	MBOC202	Resource Utilization, IPR and Ethnobotany	4	0	0	4	40	60	100
3	Core	MBOC203	Cytogenetics and Molecular Biology	4	0	0	4	40	60	100
4	Core	MBOC204	Plant Breeding and Biostatistics	4	0	0	4	40	60	100
Practical										
1	Core	MBOL105	Laboratory Course I Based on C101&C102	0	0	3	3	40	60	100
2	Core	MBOL106	Laboratory Course II Based on C103&C104	0	0	3	3	40	60	100
			Total	16		6	22	240	360	600

L – Lecture, T – Tutorial, P – Practical, C – Credit

Third Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC301	Plant Physiology and Biochemistry	4	0	0	4	40	60	100
2	Core	MBOC302	Ecology and Remote Sensing	4	0	0	4	40	60	100
3	Elective-I	MBOE304/ 305	Palynology and Pollination Biology/Fresh water algal flora of Himalaya	4	0	0	4	40	60	100
4	Elective-II	MBOE306/ 307	Plant Health Management/ Environment microbiology	4	0	0	4	40	60	100
Practical										
1	Core	MBOL 303	Laboratory Course – I Based on C301&C302	0	0	3	3	40	60	100
2	Elective	MBOL308	Laboratory course-II Based on E304/305/306/307	0	0	3	3	40	60	100
3	Self-study qualifying Not included while calculating grade	MBOS309/ 310/311	Forest Ecology/Introduction to medicinal and aromatic plants/ Pathogens and pests of crop plants	3	0	0	3	40	60	100
			Total	16	0	6	22	240	360	600

L – Lecture, T – Tutorial, P – Practical, C – Credit

Self-study marks not to be included while calculating grades.

Fourth Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC401	Conservation Biology	4	0	0	4	40	60	100
2	Core	MBOC402	Biotechnology and Genetic Engineering of Plants and Microbes	4	0	0	4	40	60	100
3	Elective	MBOE404	Dissertation	0	0	9	9	60	240	300
Note: In lieu of dissertation following elective papers and their practical may be chosen										
4	Elective	MBOE405	Environment Management with Reference to Western Himalaya/	3	0	0	3	40	60	100
6	Elective	MBOE406	Seed Pathology	3	0	0	3	40	60	100
Practical										
1	Core	MBOL403	Laboratory Course – I Based on C401&C402	0	0	3	3	40	60	100
2	Elective	MBOL407	Laboratory Course II Based on E405/406	0	0	3	3	40	60	100
3	Self-Study	MBOS 408/409	Analytical Techniques in Plant Sciences/ Nursery and Gardening	3	0	0	3	40	60	100
			Total	8+6	0	9+6	20	180+240	340+360	600

L – Lecture, T – Tutorial, P – Practical, C – Credit

Total Credits = 86 (Core Credits 11+ Elective Credits 11) with additional 3 Credits of Self Study*

Grand Total: Core Credits 66+ Elective Credits 20= 86

With a total of 6 Credits (3+3 Credits in III and IV semester) of Self Study (2 Seminars equivalent to 2 sessionals plus one end term written examination).

Maximum Marks for each paper is 100 (Sessional Tests- 40 + End Term Test- 60).

01 Credit= 01 hour of lecture/instructions per week; 01 Credit course= 15 hours of lectures per semester.

Examination Scheme:

Components	Ist internal Assignment/Presentation-I	IInd Internal Written/Attendance/Presentation-II	External (ESE)
Weightage (%) Theory/Practical	**20 Marks**	**20 Marks**	**60**

Weightage (%) Dissertation	**30 Marks**	**30 Marks**	**240**

Master of Science (Botany)

Course code : MBOC 101					
Course Name : Mycology and Microbiology					
Semester /Year : I					
	L	**T**	**P**	**C**	
	4	**0**	**0**	**4**	

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. The course aims to provide students with an understanding of general microbiology, contribution of microbiology to human life for various daily needs. The knowledge is used in health care for prevention of diseases, diagnosis, sterilization methods and drug production. Further, the knowledge is also extended into food production, production of alcohol, in agriculture, leather industry etc.

2. Discuss the importance of fungi in various ecological roles. Demonstrate an understanding of how fungi impact human affairs. Outline the higher taxonomy of the fungi and how the fungi relate to other organisms. Discuss the characteristics of the major classes and orders within the fungal kingdom. Identify the major families and certain species of mushrooms and other macrofungi and Demonstrate a working knowledge of how fungi grow and reproduce, and where and how they can be isolated.

Course contents

MYCOLOGY **(No. of Hours: 24)**

1. History of Mycology; India and abroad.
2. General characters of Fungi: Substrate relationship in fungi; Cell ultra structure; unicellular and multicellular organization, nutrition (saprobic, biotrophic, symbiotic); reproduction (vegetative, asexual, sexual); Recent trends in the classification.
3. Phylogeny of Fungi; General account of *Mastigomycotina*, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina; Fungi in industry, medicine and as food. Mycorrhizae; Fungi as biocontrol agents.

4. Symptoms, causal organisms of plant phogens belonging to various fungal classes i.e. *Mastigomycotina,*Zygomycotina, acomycotina, basidiomycotina and deuteromycotina.

MICROBIOLOGY **(No. of Hours: 24)**

1. A brief history of Microbiology, the diversity of micro-organisms, microbial growth.
2. Archaebacteria and Eubacteria: General account; ultrastructure, nutrition and reproduction; biology and economic importance; cyanobacteria- classification, salient features and economic importance.
3. Viruses: Characteristics; isolation and purification of viruses; chemical nature, replication, Transmission of viruses; economic importance.
4. Phytoplasma: General characteristics and role in causing plant diseases. (e.g. sandal spike disease, sesamum phyllody, little leaf of brinjal)
5. Immunology: Structure of antigens and antibodies, antigen- antibody reaction, Mechanism of antigen-antibody reactions. Vaccines and toxoids, Hypersensitivity

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Gain knowledge about the history and scope of mycology.
CO2	Understand the general characters and structural organization of Fungi.
CO3	**Learn** and think about the symptoms and causal organisms of various fungal diseases of plants.
CO4	Learn the characteristics, mode of reproduction and economic importance of Viruses and update the knowledge of basic of immunology

Text Books:

1. Ainsworth, G.C. 1971. Ainsworth and Bisby's Dictionary of Genera of Fungi. Central Myco. Inst. Kew, Surrey.UK.
2. Alexopoulus, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. John Willey & Sons Inc.
3. Bilgrami, K.S. 1982. Physiology of Fungi. Bishen Singh Mahendrapal Singh, Dehradun.
4. Clifton, A. 1958. Introduction to the Bacteria. McGraw-Hill book Co., New York.
5. Mandahar, C.L. 1978. Introduction to Plant Viruses. Chand & Co. Ltd., Delhi.
6. Mehrotra, R.S. and Aneja, R.S. 1998. An Introduction to Mycology. New Age Intermediate Press.
7. Webster, J. 1985. Introduction to Fungi. Cambridge University Press.
8. Doelle, H.W. and C.G, Heden 1986. Applied Microbiology, Kluwer Academic Press, London.

Reference Books:

1. Pelczar, M.J., Chan, ECS and Kreig, N.R. 1993. Microbiology, Concept and Applications. Mc Graw Hill, New York.
2. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merril. Publ. Co. Columbus, Ohio.

3. Alexander, M. 1991. Microbial Ecology. John Wiley and Sons. New York.
4. APHA. 1971. Standard Methods for the Examination of water and Waste Water. Washington DC
5. Atlas. R. M. Principle of Microbiology.
6. Board, R.G. and D.W., Lovelock 1975. Some Method for Microbiological Assay. Acadmic Press. New York
7. Casida, L.E. 1968. Industrial Microbiology. John Wiley and Sons, New York.
8. Clifford, H.T. and W. Stephenson 1975. An Introduction to Numerical Classification, Academic press, New York.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	…	2	…	2	2	2	…	…	2	3	2	2	1	2
CO2	2	…	2	2	2	…	2	2	2	1	2	2	3	1	2
CO3	2	3	3	2	2	2	2	2	2	3	2	…	2	2	2
CO4	3	1	3	1	2	…	2	…	…	2	3	2	3	2	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOC 102				
Course Name : Phycology and Bryology				
Semester /Year : I				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. To develop understanding about core concept of occurrence, distribution or diversity, evolution and life history of lower plants.
2. To increase the understanding of students about the identification, classification, structure and growth and economic importance algae and bryophytes.

Course contents

PHYCOLOGY (No. of Hours: 24)

1. Algal habitats.
2. Thallus organization, cell structure and reproduction (vegetative, asexual and sexual).
3. Algal Classification, Criteria for classification of algae: pigments, reserve food and flagella.
4. Phylogeny and interrelationships of algae.
5. Classification and salient features of Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta and Cyanophyta.
6. A knowledge of algal life cycles; alternation of generation in algae; cytology and sexuality; physiology and biochemistry of algae; nitrogen fixation; parasitic algae.
7. Economic importance of Algae, Algal blooms, algal biofertilizers, algae as food, feed and uses in industry.

BRYOLOGY (No. of Hours: 24)

1. Morphology, structure reproduction and life history.
2. Classification and Phylogeny of various groups.
3. General account of Marchantiales, Jungermanniales, Calobryales, Sphaerocarpales, and Anthocerotales.
4. Sphagnales, Andreales, Funariales, and Polytrichales.
5. Knowledge of the distribution of bryophytes in the Himalaya. Ecology of bryophytes, their association with other organisms.

6. Fossil bryophytes, general account.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Know about the habitats of algae.
CO2	Learn about the thallus organization, cell structure, classification and reproduction and economic importance of algae
CO3	Understand the classification, phylogeny, morphology, structure reproduction, life history and economic importance of Bryophytes
CO4	Aware and execute applications of different plants in various industries and highlight the potential of these studies to become an entrepreneur.
CO5	Develop skills related to laboratory as well as industries based studies

Suggested Textbooks

1. Cavers, F. 1979. The Interrelationships of the Bryophytes Reprint. Bishen Singh Mahendrapal Singh, Dehradun.
2. Fritsch, F.E. 1979. The Structure and Reproduction of Algae. Reprint. Bishen Singh Mahendrapal Singh, Dehradun.
3. Kashyap, S.R. 1968. Liverworts of the Western Himalayas and Punjab Plains. The Chronica Botanic Co. Delhi.
4. Kumar, H.D. 1988. Introductory Phycology. Affiliated East-West Press Ltd., New Delhl.
5. Morris, I. 1986. An Introduction to the Algae. Cambridge University Press, U.K.
6. Parihar, N.S.1991. Bryophyta. Central Book Depot, Allahabad.

Reference Books

1. Presscott, G.W. Algae: A Review. Bishen Singh Mahendrapal Singh.
2. Puri, P. 1980. Bryophytes. Atma Ram & Sons, Delhi.
3. Ram Udar. Fifty years of Bryology in India. Golden Jubilee Series. IBS, New Delhi
4. Round, F.E. 1986.The Biology of Algae. Cambridge University Press, Cambridge.
5. Smith, G.M. 1955. Cryptogamic Botany. Vol. I and II. Tata Mc Graw Hill, New Delhi.
6. Stewart, W.N. and Rathwell, G.W. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press.

Indian authors:

1. Vashishta, B.R. 1991. Botany for degree students. Bryophytes 8th ed. S. Chand and Co. Ltd. Delhi.
2. B.N. Vashishta, B.R., A.K. Sinha and A. Kumar. 2010. Algae. S. Chand and Co. Ltd. Delhi

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	…	2	2	…	1	…	2	2	2	…	1	…
CO2	3	2	…	2	…	2	3	2	2	2	2	2	3	2	3
CO3	2	2	2	2	…	2	2	3	2	2	3	3	2	2	2
CO4	3	2	2	3	2	3	2	…	2	2	2	…	3	3	3
CO5	…	1	3	2	2	2	3	1	2	…	3	…	2	2	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOC 103				
Course Name : Pteridology, Gymnosperm and Palaeobotany				
Semester /Year : I				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. The course focuses on morphology, anatomy, reproduction and evolution in Pteridophytes and Gymnosperms.
2. Develop the basic understanding of important characteristics, anatomy, reproduction and evolution along with economic importance of these two groups and Palaeobotany

Course contents

PTERIDOPHYTA (No. of Hours: 20)

1. History, origin, classification, present and past distribution, morphology and life history of the following types.
   a. Psilophyta: Psilophytales (*Psilophyton*) and Psilotales (*Psilotum*).
   b. Lycophyta: Lepidodendrales (*Lepidodendron*), Lycopodiales (*Phylloglossum*), Lepidospermales (*Lepidocarpon*) and Isoetales (*Isoetes*).
   c. Sphenophyta :Salient features of order Hyeniales, Sphenophyllales and Calamitales
   d. Pterophyta: A general account of Ophioglossales Osmundales Filicales,and Salviniales .

GYMNOSPERMS (No. of Hours: 22)

1. Classification and distribution of Gymnosperms in India with special reference to Himalaya. Study of their morphology, structure and life-history as illustrated by the following and indicated in the practical work.
   e. Pteridospermales: Palaeozoic and Mesozoic groups with references to Lyginopteridaceae (*Lyginopteris*) and Medullosaceae (*Trigonocarpus*), A general account of Glossopteridaceae.
   f. Bennettitales: A general account of Cycadeoidaceae, Williamsoniaceae and Wielandiellaceae.
   g. Cycadales: A detailed account including distribution of living Cycads.
   h. A general account of Pentoxylales and Cordaitales.
   i. Ginkgoales: *Ginkgo.*
   j. A general account of fossil and living Coniferales and Taxales.

k. Ephedrales, Welwitschiales and Gnetales: A general account.

2. Economic importance of Gymnosperms.

PALAEOBOTANY **(No. of Hours: 6)**

3. Definition of fossil, different types of plant fossil as per their mode of preservation, concept of form genus.
4. Indian Gondwana Sequence, a general account.
5. Introductory idea of Continental Drift Hypothesis.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the history origin, classification, present and past distribution, morphology and life history of Psilophyta, Lycophyta and Sphenophyta and Gymnosperms in India with special reference to Himalaya.
CO2	Explain the history origin, classification, distribution, morphology and life history of Pterophyta.
CO3	Illustrate and design the morphology, structure and life history of Fossil Pteridophytes and Gymnosperms and their economic importance.
CO4	Know the scope of Paleobotany, types of fossils, its role in global economy and geological time scale
CO5	Create awareness on the threats to biodiversity and sensitize towards the Biodiversity Conservation for sustainable development

Suggested Textbooks

1. Andrews, HN. 1961. Studies in Palaeobotany. New York.
2. Baker, J.G. 1995. Handbook of the Fern Allies. Reprint. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Bhatnagar, S.P. and Mitra, A. 1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.
4. Beddome, R.H. 1966. The Ferns of British India. 2 Vols. Oxford and IBH, New Delhi.
5. Chamberlain, C.J. 1955. Gymnosperms: Structure and Evolution. Chicago.
6. Eams, A.J. 1969. Morphology of Lower Vascular Plants.
7. Parihar, N.S. 1996. Biology & Morphology of Pteridophytes. Central Book Depot Allahabad.

Reference Books

1. Raizada, M.B and Sahni, K.C. 1958. Living Indian Gymnosperms.
2. Sahni, K.C. 1996. Gymnosperms of India and Adjacent Countries. Bishen Singh Mahendrapal Singh, Dehradun.
3. Seward, A.C. 1919. Fossil Plants for Students of Botany and Geology. 4 Vols. Cambridge.
4. Sporne, K.R. 1991. The Morphology of Pteridophytes. Hutchinson Library Series London.
5. Sporne, K.R. 1991. The Morphology of Gymnosperms. Hutchinson Library Series London

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	…	2	2	…	2	3	3	…	2	2	3	2	2	…
CO2	3	2	2	…	2	…	1	1	…	…	2	2	1	3	…
CO3	2	2	2	3	…	…	3	2	2	2	3	3	3	2	2
CO4	3	…	2	…	2	2	…	1	…	…	3	3	3	2	2
CO5	…	2	2	2	3	…	3	1	3	2	3	1	1	3	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOC 104				
Course Name : Taxonomy and Diversity of flowering Plants				
Semester /Year : I				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course is

This course aims to add to understanding of the students about the diversity of plants, their Description, Identification, Nomenclature and their classification including recent advances in the field.

Course contents

1. Origin of intra- population variation: Population and the environment; ecads and ecotypes; evolution and differentiation of species- various models. **(No. of Hours: 4)**
2. The species concepts; taxonomic hierarchy, species, genus, family and other categories; principles used in assessing relationship, delimitation of taxa and attribution of rank. **(No. of Hours: 3)**
3. Salient features of the International Code of Botanical Nomenclature.**(No. of Hours: 3)**
4. Taxonomic evidences and Taxonomic tools: anatomy, palynology, embryology, phytochemistry, histological, serological, and molecular-techniques. **(No. of Hours: 8)**
5. Systems of angiosperm classification: Phenetic versus phylogenetic systems; cladistics in taxonomy; major systems of classification (Bentham and Hooker, Hutchinson, Cronquist) and their relative merits and demerits. **(No. of Hours: 4)**
6. Herbarium and Botanical gardens: General account. **(No. of Hours: 1)**
7. Plant exploration in India with reference to North west and Uttarakhand Himalaya **(No. of Hours: 2)**
8. Status of flowering plant diversity in Garhwal Himalaya. **(No. of Hours: 1)**
9. A study of the following families and their relationships: **(No. of Hours: 22)**

a. Dicotyledons:, Magnoliaceae, Berberidaceae, Fumariaceae, Violaceae, Meliaceae, Apiaceae, Sterculiaceae, Tiliaceae, Geraniaceae, Asteraceae, Campanulaceae, Ericaceae, Primulaceae, Asclepiadaceae, Convolvulaceae, Verbenaceae, Scrophulariaceae, Oleaceae, Amaranthaceae, Loranthaceae, Urticaceae, Juglandaceae, Salicaceae and Fagaceae

b. Monocotyledons: Hydrocharitaceae, Orchidaceae, Amaryllidaceae, Araceae, Poaceae and

Cyperaceae

Besides these families, the students are also expected to have a complete knowledge of families which they have studied at under graduate syllabus of this University.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Gaining in-depth knowledge salient features of angiosperms, concept of origin and evolution of angiosperms.
CO2	Understanding various systems of classifications
CO3	Learn salient features of ICBN/ICN species concept, taxonomic hierarchy, delimitation of taxa and attribution of rank.
CO4	Think and analyse the plants and describe them taxonomically
CO5	Develop skills in Plant inventory and exploration and identification

Suggested Textbooks

1. Babu, C.R. 1976. Herbaceous Flora of Dehradun. CSIR, New Delhi.
2. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New york.
3. Gaur, R.D. 1999. Flora of District Garhwal: NW Himalaya. Transmedia, Srinagar, Garhwal.
4. Hutchinson, J. 1973. The Families of Flowering Plants. 2 Vols. Oxford University Press, Oxford.
5. Jain, S.K. and Rao, R.R. 1977. A handbook of Field and Herbarium methods. Today and Tomorrow, New Delhi.
6. Lawrence, H.W. 1951. Taxonomy of Vascular Plants. Reprint Oxford and IBH, New Delhi.

Reference Books

1. Naithani, B.D. 1985. Flora of Chamoli. 2 Vols, BSI, Calcutta.
2. Nordenstam, B., El Gazaly, G. and St Kassas, M. 2000. Plant Systematic for 21Century. Portlant Press Ltd., London.
3. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
4. Singh, H. 1978. Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder Bortraeger, Berlin.
5. Odum E.P. 2009. Fundamental of Ecology. McGraw Hill Pub.
6. Singh H.R. and Kumar. 2008. Ecology and Environmental Science. Vishal Publishing Co.
7. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2edition). Edward Arnold Ltd., London.
8. Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	…	2	2	2	…	1	…	2	3	2	1	…	1
CO2	1	…	2	2	2	…	1	3	…	2	…	3	…	2	…
CO3	…	1	2	2	2	1	2	…	1	…	2	1	2	…	1
CO4	1	2	…	2	…	…	2	…	2	2	2	2	2	1	…
CO5	1	1	2	2	…	2	…	2	2	3	1	…	…	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOL 105				
Course Name : Laboratory Course-I				
Semester /Year : I				
	L	**T**	**P**	**C**
	0	**0**	**3**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course contents

1. Study of representative genera of Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.
2. Symptomatology of at least one diseased specimen of plant pathogens belonging to various fungal sub-division i.e. *Mastigomycotina*, Zygomycotina, acomycotina, basidiomycotina and deuteromycotina, bacteria and viruses.
3. Aseptic methods and demonstration of instruments viz., autoclave, hot air oven, incubator, laminar air flow.
4. Direct examination of root nodule bacteria under microscope and isolation of *Rhizobium* in root nodules.
5. Isolation and enumeration of microbes from natural samples (soil and water) by agar plate technique.
6. Morphological study of representative members of algae: *Microcystis, Lyngbya, Cylindrospermum, Gloeotrichia, Scytonema, Pandorina, Eudorina, Scendesmus, Pediastrum, Hydrodictyon, Ulva,*
7. *Enteromorpha, Drapernaldiopsis, Stigeoclonium, Fritschiella, Coleochaete, Bulbochaete, Cosmarium, Caulerpa, Nitella, Dictyota, Gelidium, Gracillaria, Batrachospermum* and *Polysiphonia.*
8. Study and identification with suitable preparations of *Ricciocarpus, Targionia, Cyathodium, Plagiochasma, Asterella (Fimbriaria), Dumortiera, Sewardiella, Pellia, Fossombronia, Porella, Calobryum, Notothylas, Sphagnum, Polytrichum* and *Funaria*

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Gain knowledge about different genera belong to different classes of fungi, algae and bryophytes.
CO2	Gain Understanding about different instruments and lab safety rules
CO3	Learn and think about the methods of isolation and identification
CO4	Execute and apply the agar plate technique for isolation, enumeration and identification of microbes.

Suggested Textbooks

1. B.P. Pandey. (2019). Practical Botany-Revised ed. S. Chand Co. Ltd. Delhi
2. Yadav, S. (2022). Plant Systematics with Practical. Mahaveer Publication.

Reference Book

1. S. Sundara Rajan. (2003). Practical Manual of Plant Morphology (Algae, Fungi, Bryophytes and Angiosperms). Anmol Publications.

Course code : MBOL 106				
Course Name : Laboratory Course-II				
Semester /Year : I				
	L	**T**	**P**	**C**
	0	**0**	**3**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course contents

Study and identification with suitable preparations of the following:

A. PTERIDOPHYTES

Psilotum, Isoetes, Ophioglossum, Osmunda, Polypodium, Azolla, Salvinia and important fossil types.

B. GYMNOSPERMS

Cycas, Ginkgo, Abies, Cedrus, Cryptomeria, Cupressus, Podocarpus, Cephalotaxus, Araucaria, Taxus, and *Gnetum.*

C. PALAEOBOTANY

1. Study of available fossil flora through specimens and slides, etc.

D. TAXONOMY

1. Identification and description of locally available plants belonging to families included in the syllabus from fresh specimens, herbarium or preserved materials. After identification up to family level any suitable regional Flora may be provided for generic identification if required.
2. Description of a species based on various specimens to study intra specific variation.
3. Studies to find out the location of key characters and preparation of keys at generic level.
4. Field trips, compilation of field notes, the preparation of herbarium sheets and submission of herbarium and museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Gain knowledge about different genera belong to different classes and orders of Pteridophytes and Gymnosperms and fossil plants.
CO2	Gain Understanding about morphology of plants through live potted specimens
CO3	Learn and think about the methods of identification with the help of keys and flora
CO4	Execute and apply the herbarium preparation and to enhance their knowledge regarding conservation of plants through field trips.

Suggested Textbooks

1. Bhatnagar, S.P. and Moitra, A. (2020). Gymnosperms. New Age International (P) Ltd. Publisher, P480.
2. O.P. Sharma. (2017). Pteridophyta. McGraw Hill Education.
3. Rajan Sundara, S. (2021). Practical Manual of Angiosperm Taxonomy. Anmol Publication Pvt. Ltd.

Reference Book

1. Chitranjan Mohanty. (2018). Bryphytes, Pteridophytes, Gymnosperm and Palaeobotany. Kalyani Publisher.

Course code : MBOC 201				
Course Name : Plant Development and Reproductive Biology				
Semester /Year : II				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. This course aims at making the students acquainted with the fundamentals and present understanding of the mechanisms associated with development and differentiation of various plant organs.
2. To know the various structural and anatomical components of plant tissue and reproductive parts and its taxonomic significance.

Course contents

1. Seed germination and seedling growth: Mobilization of food reserves; tropisms; hormonal control of seedling growth. **(No. of Hours: 4)**
2. Shoot development: Organization of the shoot apical meristem (SAM); cytological and molecular analysis of SAM; control of cell division and cell to cell communication. **(No. of Hours: 6)**
3. Cambium and its functions: formation of secondary xylem; general account of wood structure in relation to conduction of water and minerals. **(No. of Hours: 3)**
4. Leaf growth and differentiation: Origin, development and phyllotaxy. **(No. of Hours: 2)**
5. Root development: Organization of root apical meristem (RAM); cell fates and lineages; vascular tissue differentiation; lateral roots; root hairs; root-microbe interactions. **(No. of Hours: 4)**
6. Reproduction: Vegetative options and sexual reproduction; flower- a modified shoot, structure, functions; structure of anther and pistil; Genetics of floral organ differentiation. **(No. of Hours: 4)**
7. Male gametophyte: Structure of anthers; microsporogenesis, role of tapetum; pollen development and gene expression. **(No. of Hours: 3)**
8. Female gametophyte: Ovule development; megasporogenesis; organization of the embryo sac. **(No. of Hours: 3)**
9. Pollination, pollen-pistil interaction and fertilization: Pollen-stigma interactions, sporophytic and gametophytes self-incompatibility (cytological, biochemical and molecular aspects); double fertilization; *in vitro* fertilization. **(No. of Hours: 6)**
10. Seed development and Fruit growth: Endosperm development; embryogenesis, polyembryony; apomixis; embryo culture; biochemistry and molecular biology of fruit maturation. **(No. of Hours: 4)**

11. Latent life–Dormancy: Importance and types of dormancy; seed dormancy; overcoming seed dormancy; bud dormancy. **(No. of Hours: 2)**
12. Senescence and programmed cell death (PCD): Basic concept, types of cell death, PCD in the life cycle of plant, metabolic change associated with senescence and its regulation; influence of hormones and environmental factors on senescence. **(No. of Hours: 7)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	State the process of seed germination and seedling growth.
CO2	Understand the organization and differentiation of shoot.
CO3	Mention the role of cambium in secondary growth of plants.
CO4	Infer the growth, differentiation and arrangement of leaf on the stem.
CO5	Learn and understand the growth and development of root.
CO6	Predict developmental process and organization of plant reproductive organs.

Suggested Textbooks

1. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th enlarged edition). Vikas Publishing House, New Delhi.
2. Eams, A.J. 1989. An Introduction to Plant Anatomy. Reprint. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Maheshwari, P. 1950. An Introduction to Embryology of Angiosperms. McGraw Hill, New York.
4. Raghavan, V. 1999.Developmental Biology of Flowering Plants. Springer- Verlag, New York.

Reference Books

1. Bewley, J.D. and Black, M. 1994. Seeds: Physiology of Development and Germination. Plenum Press, New York.
2. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
3. Fageri, K. and Van der Pijl, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.
4. Fahn, A. 1982. Plant Anatomy. (4th edition). Pergamon Press, Oxford.
5. Fosket, D.E. 1994. Plant Growth and Development. A Molecular Approach.Academic Press, San Diego.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	…	…	2	3	2	…	…	…	2	2	2	…	2	2
CO2	…	…	2	2	…	2	3	3	…	2	…	3	2	…	3
CO3	2	2	1	…	3	2	1	…	…	2	…	2	2	2	…
CO4	2	2	…	3	…	2	1	…	2	2	2	2	…	2	2
CO5	2	…	2	2	2	3	2	3	2	3	…	3	2	2	1
CO6	3	2	2	3	3	2	…	…	2	3	2	2	2	2	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOC 202				
Course Name : Resource Utilization, IPR and Ethnobotany				
Semester /Year : II				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. To apprises students of conventional and non-conventional plant resources being used by human, their effective and sustainable utilization and improvement.
2. Transforming the knowledge into skills for promotion of traditional medicine and conservation of plants.

.**Course contents**

1. Plant resources: Concept, status, utilization and concerns. **(No. of Hours: 01)**
2. World Centers of Primary Diversity of domesticated plants **(No. of Hours: 02)**
3. Origin, evolution, botany, cultivation, cytotaxonomy and uses of (i) Cereals and millets (wheat, paddy, maize), (ii) Legumes (soybean, black gram and cowpeas), (iii) Sugar cane and starches (sugarcane, beetroot, potato, sweat potato, cassava), (iv)Forage and fodder Crops. Fiber crops, medicinal and aromatic. **(No. of Hours: 12)**
4. Important firewood and timber yielding plants and non- wood forest products (NWFPs) such as bamboos, gums, tannins, dyes, resins, beverages. **(No. of Hours: 06)**
5. Intellectual Property Rights, Concept, History, Protection of IPR; Patent- requirements, procedures and limitations; International convention on Biological Diversity. **(No. of Hours: 05)**
6. Ethnobotany: Concept, linkage with other sciences, tools of ethnobotanical studies, world and Indian perspective with special reference to the Himalayas. **(No. of Hours: 04)**
7. Green revolution: Benefits and adverse consequences. **(No. of Hours: 02)**
8. Plants used as ornamentals and avenue trees. **(No. of Hours: 02)**
9. Principles of conservation: Extinction; Status of plants based on International Union for Conservation of Nature (IUCN). **(No. of Hours: 04)**
10. Strategies for conservation: *In situ* conservation; protected areas in India- sanctuaries, national parks and biosphere reserves. **(No. of Hours: 08)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand core concepts of Economic Botany and relate with environment, populations, communities, and ecosystems
CO2	Develop critical understanding on the evolution of concept of organization of apex new crops/varieties, importance of germplasm diversity, issues related to access and

	ownership.
CO3	Develop a basic knowledge of taxonomic diversity and important families of useful plants
CO4	Understand the concept of IPR, various legal issues related to IPR
CO5	Learn the concept of ethno-botany and folk medicines

Suggested Textbooks

1. P.C. Trivedi and Niranjan Sharma. (2017). Plant Resource Utilization and Conservation. Pointer Publication, Jaipur.
2. Chandel, K.P.S., Shukla, G. and Sharma, N.1996. Biodiversity in Medicinal and Aromatic Plants in India: Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
3. Hill, A.F. 1952. Economic Botany. McGraw Hill., New York.
4. Kochar, S.L. 1998. Economic Botany in the Tropics. Mac Millan India Ltd. Delhi
5. Kothari, A. 1997. Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.
6. Nair, M.N.B. *et al.* (Eds) 1998. Sustainable Management of Non-Wood forest Products. Faculty of Forestry, Universiti Putra Malaysia. 434004 PM Serdong, Selangor, Malaysia
7. Paroda, R.S. and Arora, R.K.1991. Plant Genetic resources conservation and Management. IPGRI (Publication) South Asia Office, C/o NBPGR, Pusa Campus, New Delhi.
8. Rodgers, N.A. and Panwar, H.S. 1988. Planning a Wildlife Protected Area Network in India. Vol. 1. The Report. Wildlife Institute of India, Dehradun.

Reference Books

1. Baenzinger, S.P., Kleese, R.A. and Barns, R.F. 1993. Intellectual Property Rights, Protection of plant materials; executive summary and work group reports. CSSA Publication No. 21. Crop Science Soc. of America, Wisconsin, Madison.
2. Council of Scientific & Industrial Research (1948-1976). The Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. New Delhi. Raw Materials I-XII, Revised Volume I-III (1985-1992) Supplement (2000).
3. Council of Scientific & Industrial Research 1986. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
4. Walter, K.S. and Gillet, H.J. 1998. IUCN Red List of Threatened Plants. IUCN The World Conservation Union. IUCN, Gland, Switzerland, and Cambridge, U.K.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	2	…	…	2	2	3	2	…	1	2	…	2	…
CO2	2	2	2	2	3	2	2	2	1	2	1	1	2	3	2
CO3	1	1	…	…	2	2	…	…	1	2	2	2	…	…	2

CO4	1	2	2	3	…	2	2	2	…	…	1	…	2	2	…
CO5	1	1	…	…	…	2	…	…	2	2	1	2	2	2	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code	**: MBOC 203**			
Course Name	**: Cytogenetics and Molecular Biology**			
Semester /Year	**: II**			
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. To understand the concept of Mendelian and non-mendelian inheritance, quantitative genetics, molecular markers and linkage mapping, prokaryotic and eukaryotic genome-structure, gene function and regulation, epigenetics, cytogenetics.
2. To provide a foundation and background in cellular and acellular entities of plants and animals, cell structure in relation to functions, eukaryotic genome structure (including nuclear and organellar), and regulatory mechanisms.

Course contents

1. The dynamic cell: Structural organization of the plant cell; specialized plant cell. **(No. of Hours: 1)**
2. Cell wall: structure and functions; biogenesis, growth. **(No. of Hours: 1)**
3. Plasma membrane: structure models and functions; sites for ATPases, ion carriers, channels and pumps, receptors. **(No. of Hours: 4)**
4. Mitochondria and chloroplast: Structure, genome organization, gene expression. **(No. of Hours: 3)**
5. Nucleus: structure, nuclear pores, nucleosome organization. **(No. of Hours: 2)**
6. Ribosomes: Structure, cytoprotein synthesis. **(No. of Hours: 1)**
7. Chromatin organization: Chromosome structure and packaging of DNA, molecular organization of centromere and telomere, euchromatin and heterochromatin, specialized types of chromosomes; polytene, lampbrush, B-chromosomes and sex chromosomes. **(No. of Hours: 6)**
8. Principles of inheritance: Mendelian laws along with molecular explanations, Exceptions to Mendelian laws, lethal alleles and Gene Interactions. **(No. of Hours: 6)**
9. Structural and numerical alterations in chromosomes: Origin, occurrence, production and meiosis of haploids, aneuploids and euploids, induction and characterization of trisomics and monosomics. **(No. of Hours: 8)**
10. Genetics of prokaryotes and eukaryotic organelles: genetic recombination of phage; genetic transportation, conjugation ant transduction in bacteria, cytoplasmic male sterility.

(No. of Hours: 6)

11. Gene structure and expression: Genetic fine structure, cis-trans test; fine structure analysis of eukaryotes, introns and their significance, regulation of gene expression in prokaryotes and eukaryotes. DNA damage and repair mechanism, defects in DNA repair; Initiation of cancer at cellular level, proto-oncogenes and oncogenes.

(No. of Hours: 6)

12. Genetic recombination and genetic mapping: Recombination; independent assortment and crossing over, linkage groups, genetic markers, construction of molecular maps.

(No. of Hours: 3)

13. Mutations: Spontaneous and induced mutations; physical and chemical mutation, molecular basis of gene mutation; mutations induced by transposons.

(No. of Hours: 3)

14. Nuclear DNA content; C-value paradox; Cot curves. **(No. of Hours: 1)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the pattern of inheritance in various life forms.
CO2	Develop a strong fundaments basics for further molecular studies
CO3	Gain knowledge about the plant cell structure and their turn over, starting from cell wall to chromatin, in relation to their functions.
CO4	Understand the principle mechanisms of genome replication, maintenance, function and regulation of expression
CO5	Apply the principles of cytogenetics and molecular biology in designing experiment, statistical analysis, and interpretation of results

Suggested Textbooks

1. Barry, J.M. and Barry, B.M. 1973. Molecular Biology, Prentice Hall Of India New Delhi.
2. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
3. De, D.N. 2000. Plant Cell Vacuoles: An Introduction. CSIRO Publication, Collingwood, Australia.
4. Gupta, P.K. 1998. Cytogenetics. Rastogi Publications. Meerut.

Reference Books

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1989. Molecular
2. Biology of the Cell (2nd edition). Garland Publishing Inc., New York.
3. Atherly, A.G., Girton, J.R. and McDonald, J.F. 1999. The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
4. Burnham, C.R. 1962. Discussions in Cytogenetics. Burgess Publishing Co., Minnesota.
5. Busch, H. and Rothblum, L. 1982. Volume X. The Cell Nucleus rDNA Part A. Academic Press.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	…	…	…	1	1	1	…	1	1	2	…	…	…	….

CO2	2	1	2	2	2	1	…	2	…	1	1	1	…	…	3
CO3	2	…	2	1	…	1	1	…	1	2	1	1	1	…	…
CO4	2	2	1	…	1	1	2	…	1	1	2	2	1	2	…
CO5	2	2	…	2	2	1	2	1	…	…	…	2	2	2	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code	**: MBOC 204**			
Course Name	**: Plant Breeding and Biostatistics**			
Semester /Year	**: II**			
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. To integrate molecular methods with conventional improvement strategies to accelerate plant breeding.
2. To gain knowledge on commercially important plants, their breeding systems and strategies employed for crop improvement.
3. To have knowledge of analysis of scientific data with the help of biostatistical tools.

Course contents

PLANT BREEDING (No. of Hours: 26)

1. The role of plant breeding – historical aspects and genetic basis: mode of reproduction in relation to breeding methods, breeding techniques; method of plant breeding in relation to self-pollinated and cross pollinated plants.
2. Hybridization: Interspecific and inter generic; pure line; back cross hybridization; self-incompatibility system.
3. Heterosis: Its genetic and physiological basis.
4. Breeding for resistance to diseases, physiological races.
5. Role of mutation in crop improving and evolution.
6. Plant breeding work done in India with special reference to potato, paddy, wheat and sugarcane.
7. Maintenance of collection, registration of varieties, seed production, testing, certification and distribution.

BIOSTATISTICS (No. of Hours: 22)

1. Bio-statistics and its application in life sciences.
2. Methods of representation of statistical data and measurements of central tendencies.
3. Correlation, regression, curve fitting and ratio of variation.
4. Probability and use of binomial trials.
5. Test of significance, X , ‘t’ and ‘f’ tests.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Learn and know about fundamental aspects of plant breeding and its achievements
CO2	Understand the experimental steps and methods involved in generating new varieties using classical and contemporary breeding practices
CO3	Create the maintenance, registration, production, testing, certification and distribution of seeds
CO4	Analyse the application of statistical methods to conduct research

Suggested Textbooks

1. Harihar, Ram, 1997. Vegetable Breeding; Principles and Practices. Jagminder Book Agency. New Delhi
2. Hill, J. 1997. Quantitative and Ecological Aspects of Plant Breeding, Jagminder Book Agency. New Delhi.
3. Kapoor, R.L. 1997. Plant Breeding and Crop Improvement. 2 Vols
4. Mc Donald, M.B. 1997. Seed Production: Principles and Practices.
5. Bliss, C.I. 1967. Statistics in Biology. 2 Vols. Mc Graw Hill, New York.
6. Downey, N.M and Heath, R.W. 1960. Basic Statistical Methods, Harper International.
7. Rayner, A.A. 1969. A first Course in Biometry for Agriculture Students. Peitermaritzburg. University of Natal Press.
8. Singh, R.K. 1994. Biometrical Techniques in Breeding and Genetics. Bishen Singh Mahendra Pal Singh. Dehradun.
9. Watt, T. 1993. Introductory Statistics for Biology Students. Narosa, New Delhi.

Reference Books

1. Poelhman, J.M and Sleeper, D.R. 1995. Breeding Field Crops. Panima Publ. House, New Delhi.
2. Sharma, J.R. 1994. Principles and Practice of Plant Breeding. Tata McGraw Hill Publ. Co. Ltd. New Delhi.
3. Singh, B.D. 2002. Plant Breeding Principles and Methods. Kalyani Publ. New Delhi.
4. Winer, B.J. 1962. Statistical Principles in Experimental Design. Mc Graw Hill, NY

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	…	1	1	…	1	…	1	2	1	3	…	…
CO2	2	3	…	1	1	1	2	3	2	1	2	2	2	1	…
CO3	3	2	…	2	3	…	…	1	2	1	2	…	1	2	2
CO4	3	3	1	3	1	…	2	3	3	1	3	1	3	1	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOL 205				
Course Name : Laboratory Course-I				
Semester /Year : I				
	L	**T**	**P**	**C**
	0	**0**	**3**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course contents

a. Effect of gravity, unilateral light and plant growth regulators on the growth of young seedlings.
b. Role of dark and red light / far red light on the expansion of cotyledons and epicotylar hook opening in pea.
c. Study of cytohistological zones in the shoot apical meristem (SAM) in sectioned and double stained slides of suitable plants such as *Coleus, Kalanchoe, Nicotiana.* Examination in shoot apices in a monocot both in T. S. and L. S. to show the origin of leaf primordia.
d. Study of alternate and distichous, alternate and superposed, opposite and superposed opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea, Mollugo, Raphanus, Hyoscyamus*, etc.) and induction of bolting under natural conditions as well as GA treatment.
e. Microscopical examination of vertical section of leaves, such as that of *Cannabis, Nicotiana, Zea mays* and *Triticum* to understand the internal structure of the tissue and trichomes, glands, etc. Also to study the anatomy of C3 and C4 plants.
f. Study of epidermal peels of leaves to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effect of ABA on stomatal closure.
g. Study the whole roots of dicots and monocots. Examination of root apical meristem and its derivatives (using maize, aerial roots of banyan, etc.). Study of lateral roots. Study of lateral roots with different types of nodules.
h. Study of microsporogenesis and gametogenesis in sections of anthers.
i. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa, Crotolaria, Tradescantia, Brassica, Petunia, Solanum melongena,* and locally available flowers).
j. Tests for pollen viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures.
k. Pollen storage, pollen–pistil interaction, self-incompatibility, *in vitro* pollination.
l. Study of ovules in cleared preparations. Study of monosporic, bisporic and tetrasporic types of embryosac development through permanent slides.
m. Field study of types of flowers with different pollination mechanisms (wind pollination, insect

pollination, etc.).

n. Emasculation, bagging and hand pollination techniques to study pollen germination. Study of seed dormancy and methods to break dormancy.

i. The practical course of this section is divided into three units: (1) Laboratory work, (2) Field survey and (3) Scientific visits

i. Food crops: wheat, rice, maize, chickpea, potato, tapioca, sweet potato, sugarcane; morphology, anatomy and micro chemical tests for stored food materials.

ii. Forage/fodder plants: Study of ten important fodder crops of the locality.

iii. Plant fibers: Textiles fibers (cotton, jute, sun hemp, cannabis, *Grewia*, etc.), Cordage fibers (coir), Stuffing fibers (silk cotton). Morphology, anatomy, microscopic study of whole fibers using appropriate, staining procedures.

iv. Medicinal and aromatic plants including narcotics and antibiotics.

v. Vegetable oils: Mustard, groundnut, soybean, coconut, sunflower and castor. Morphology, microscopic structure of oil yielding tissues, test for oil and iodine number.

vi. To prepare a water extract of vegetable tannins (*Acacia, Terminalia, Camellia, Cassia*) and dyes (*Curcuma longa, Bixa orellana, Indigofera, Butea monosperma, Lawsonia inermis, etc.).*

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Learn the effect of gravity, unilateral light and plant growth regulators on the growth of young seedlings.
CO2	Understand the role of dark and red-farred light on the expansion of cotyledons and epicotylar hook opening in pea.
CO3	Develop the cytohistological zones in the shoot apical meristem through preparing sectioned and double stained slides of various suitable plant species, such as *Coleus*, *Kalanchoe* and *Nicotiana*.
CO4	Analyze the leaf arrangement through studying fresh specimens of various types.
CO5	Verify the differences in the anatomy of C3 and C4 plants by making suitable preparation of leaves of various plants such as *Cannabis*, *Nicotiana*, *Zea mays* and *Triticum*.

Suggested Textbooks

1. Singh, Pande and Jain. (2017). Anatomy and Embryology of Angiosperm. Rastogi Publication.
2. Bijan Bihari Dutta. (2015). A Handbook of Plant Resource Utilization and Conservation. Publ. by Authorspress.

Reference Books

1. Hussain, A. (2016). Reproductive Biology of Plants. MedTech.
2. Singh, Pande and Jain (2008). Economic Botany. Rastogi Publication

Course code : MBOL 206				
Course Name : Laboratory Course-II				
Semester /Year : I				
	L	**T**	**P**	**C**
	0	**0**	**3**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course contents

1. Study of mitotic chromosomes in root tips and leaf buds and meiotic chromosomes in floral buds.
2. Isolation of chloroplasts and SDS-PAGE profile of proteins to demarcate the two subunits of Rubisco.
3. Isolation of DNA and preparation of *'cot'* curves.
4. Restrictioin digestion of plant DNA, its seperation by agarose gel electrophoresis and visualization by ethidium bromide staining.
5. Isolation of RNA and quantitation by spectrophotometric method.
6. Southern blot analysis using a gene specific probe.
7. Northern blot analysis using a gene specific probe.
8. Western blotting and ELISA.
9. Genetical problems on Mendelian and post-Mendelian ratios, gene interactions, sex-linked inheritance, chromosomal mapping, etc.
10. Application of common plant breeding techniques
11. Identification of Indian varieties of important crops.
12. Floral biology of local food, pulse, vegetable and horticultural crops.
13. Collection of germplasm of different crops being grown in the area.
13. Study of techniques of biometrical studies.
14. To test the goodness of fit and independent assortment using Chi-square method.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the various stages of mitotic and meiotic cell divisions.
CO2	Performing SDS-PAGE of chlorplastic proteins.
CO3	Perform restriction digestion of plant DNA and its separation using AGE and visualization by staining with EtBr.
CO4	Execute southern, northern, western blotting and ELISA.
CO5	Solve problems related to the Mendelian, post-Mendelian ratios, gene interactions, sex

	linked inheritance and chromosomal mapping.
CO6	Apply the normal practices of plant breeding.

Suggested Textbooks

1. Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
2. Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1988. An Introduction to Recombinant DNA Techniques: Basic Experiments in Gene Manipulation. The Benjamin/Cummings Publishing Co., Inc Menlo Park, California.

Reference Books

1. Shaw, C.H. (Ed.), 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.
2. Snustad. D.P. and Simmons, M.J. 2000. Principles of Genetics (2nd edition). John Willey & Sons Inc., USA

Course code : MBOC 301				
Course Name : Plant Physiology and Biochemistry				
Semester /Year : III				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. This course aims to educate student about the mechanism and physiology life processes in plants. It focus on the plant nutrient uptake and translocation, photosynthesis, respiration and nitrogen metabolism.
2. To educate student about the various metabolic pathways lead it to the formation of significant molecules and their catabolism. It focuses upon the vital role of each of these molecules in plants

Course contents

1. Concept of water potential, diffusion, osmosis and imbibition. **(No. of Hours: 6)**
2. Energy flow: Principles of thermodynamics, free energy and chemical potential, redox reactions, structure and functions of ATP. **(No. of Hours: 2)**
3. Biologically important molecules: Carbohydrates, Amino acids, Proteins and Lipids. Fundamentals of enzymology: General aspects of enzymes, allosteric mechanism, regulatory and active sites, isozymes, kinetic catalysis. **(No. of Hours: 6)**
4. Membrane transport and translocation of water and solutes: Plant-water relations, mechanism of water transport through xylem and transport in cells. Absorption and transpiration of water. **(No. of Hours: 6)**
5. Photophysiology and photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, photo oxidation of water, light reaction, Z scheme and photophosphorylation, mechanism of electron transport, carbon assimilation – the Calvin cycle, photorespiration and its

significance, the C_4 cycle, the CAM pathway, factors of photosynthesis.
(No. of Hours: 10)

6. Respiration and lipid metabolism: Overview of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, pentose phosphate pathway, glyoxylate cycle, alternative oxidation system, photorespiration

(No. of Hours: 8)

7. Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and assimilation.

(No. of Hours: 4)

8. Phytohormones and Sensory photobiology: History of discovery of phytochromes and cryptochromes, and their photochemical and biochemical properties,

(No. of Hours: 6)

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the concept of diffusion, osmosis and water potential.
CO2	Explain the concepts of energy flow, chemical potential and structure and function of ATP.
CO3	Learn the structure, composition and functional mechanisms of various biologically important molecules like carbohydrates, amino acids, proteins and lipids.
CO4	Enhance the knowledge about membrane transport and translocation of water and solutes.
CO5	Analyze the fundamentals and advanced aspects of photosynthesis, respiration and lipid metabolism

Suggested Textbooks

1. Nobel, P.S. 1999. Physiochemical and Environmental Plant Physiology (Second edition). Academic Press, San Diego, USA.
2. Noggle, G.R and Fritz, G.F. 1977. Introductory Plant Physiology. Prentice Hall. New Delhi.
3. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4^{th} edition). Wadsworth Publishing Co., California, USA.
4. Singhal, G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee 1999. Concepts in Photobiology: Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.
5. Taiz, L. and Zeiger, E. 1998. Plant Physiology (2^{nd} edition). Sinauer Associates, Inc., Publishers, Massachusetts, USA.
6. Thomas, B. and Vince-Prue, D. (1997) Photoperiodism in Plants (Second edition). Academic Press, San Diego, USA.

Reference Books

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. (eds) 1997. Plant Metabolism (second

edition). Longman, Essex, England.
3. Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.
4. V.K. Jain. (2017). Plant Physiology. S. Chand Co Pvt Ltd.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	…	1	…	…	…	…	2	…	1	1	2	…	…	…
CO2	1	…	1	…	1	…	…	…	…	1	…	1	1	…	…
CO3	…	2	1	1	…	2	2	1	…	1	1	1	3	…	…
CO4	1	2	…	1	1	…	…	1	3	1	2	1	…	1	…
CO5	1	2	2	…	1	2	2	1	2	1	1	1	2	1	1

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOC 302				
Course Name : Ecology and Remote Sensing				
Semester /Year : III				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. To provide exposure to students in gaining knowledge on concepts and applications leading to modeling of earth resources management using Remote Sensing.
2. This course aims to introduce the concepts and principles of ecology, biological diversity, conservation, sustainable development, population, community and ecosystem structure and function, application of these concepts to solve environmental problems.

Course contents

1. Vegetation organization: Concepts of community and continuum; concept of ecological niche. **(No. of Hours: 4)**
2. Vegetation development: Temporal changes (cyclic and non-cyclic); mechanism of ecological succession (relay floristics and initial floristic composition; Facilitation, tolerance and inhibition models); changes in ecosystem properties during succession. **(No. of Hours: 4)**
3. Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies). **(No. of Hours: 6)**
4. Global biogeochemical cycles of C, N, P and S; mineral cycle (pathways, processes, budgets) in terrestrial ecosystems. **(No. of Hours: 2)**
5. Ecosystem stability: Concept (resistance and resilience); ecological perturbation (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion; environmental

impact assessment; ecosystem restoration. **(No. of Hours: 6)**

6. Biological diversity: Concepts and levels; role of biodiversity in ecosystem functions and stability; speciation and extinction; IUCN categories of threat; distribution in global patterns; terrestrial biodiversity hot spots; inventory. **(No. of Hours: 4)**
7. Soil: Definition, formation, profile and components and soil types of the world. **(No. of Hours: 2)**
8. Climate change: Greenhouse gases (CO_2, CH_4, N_2O, CFCs; sources, trends and role); Ozone layer and ozone hole; consequences of climate changes (CO_2 fertilization, global warming, sea level rise, UV radiation). **(No. of Hours: 4)**
9. Fire as an ecological factor: Types, role of fire, extent and causes of fire in forest, grasslands and in tropical savanna, fuel load, controlled burning, fire in different forest types in Uttarakhand; fire as management tool. **(No. of Hours: 4)**
10. Remote Sensing: Concepts and stages in the acquisition of remote sensing data; Spectral signature, Photographic and non-photographic sensors, Space Plat forms. **(No. of Hours: 4)**
11. Basics of Global Positioning System, GPS Satellites and GPS utility **(No. of Hours: 2)**
12. Application of remote sensing in ecological and forestry research **(No. of Hours: 2)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Gain Knowledge on ecology, and ecological dynamics
CO2	Correlate ecological dynamics and regulation of vital processes on earth as biogeochemical cycles
CO3	Interpret ecosystem services, ecological resilience, ecological economics, and landscape ecology
CO4	Set up experiments to appreciate concepts of Ecology
CO5	Critically examine the forces impacting ecosystems viz., climate change, stress, population, consumerism, globalization, land use change
CO6	Summarize the fundamentals, and applications of remote sensing in ecological and forestry research.

Suggested Textbooks

1. Odum, E.P. (2005). Fundamentals of Ecology. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition.
2. Kormondy, E.J. (1996). Concepts of Ecology. New Delhi, India: PHI Learning Pvt. Ltd. 4th edition.
3. Sharma, P.D. (2010). Ecology and Environment. Meerut, India: Rastogi Publications. 8th edition
4. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. New Delhi, India: S. Chand.
5. Panda, B.C. (2008). Remote Sensing: Principles and Applications. Viva Books.

Reference Books

1. Ambasht, R.S. and Ambasht, N.K. (2008). A text book of Plant Ecology, CBS Publishers & Distributors PVT. LTD.
2. Majumdar, R and Kashyap, R (2019). Practical Manual of Ecology and Environmental Science, New Delhi, India: Prestige Publishers
3. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology, Environment and Resource Conservation. New Delhi, India: Anamaya Publications.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	…	…	…	1	1	…	…	…	…	3	1	…	…	…
CO2	1	1	1	2	2	1	1	1	…	1	…	1	1	1	…
CO3	1	2	…	2	2	…	2	1	2	1	1	1	2	1	2
CO4	2	2	1	2	2	1	…	…	…	…	2	1	1	2	…
CO5	…	2	…	1	2	…	1	1	2	1	1	1	2	2	2
CO6	1	…	…	…	1	…	1	1	2	1	1	1	…	1	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code	**: MBOL 303**			
Course Name	**: Laboratory Course-I**			
Semester /Year	**: III**			
	L	**T**	**P**	**C**
	0	**0**	**3**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course contents

Practical Exercises based on MBOC301

1. To study the effect of temperature upon the permeability of the cytoplasmic membrane.
2. To determine the osmotic pressure (potential) of cell saps of living cells by plasmolytic method
3. To calculate stomatal frequency and stomatal index of green leaves.
4. To set up a Wilmott's bubbler and to study the effect of the following on the rate of photosynthesis (a) varying CO_2 concentration and (b) different wavelengths of light.
5. To extract the four pigments i.e. chlorophyll a & b, carotene and xanthophylls from the green leaves and preparation of their absorption spectrum.
6. To separate the four pigments i.e. chlorophyll a & b, carotene and xanthophylls from the green leaves by paper chromatography.
7. To separate the amino acids by paper chromatography.
8. Principles of colorimetry, spectro-photometry and flourimetry.

Practical Exercises based on MBOC302

1. To determine the minimum size of the quadrat by species area curve method and minimum number of quadrats to be laid down in the field under study.
2. To determine the frequency, density and abundance of each species present in community.
3. To calculate relative frequency and relative density of each species in a given area.
4. To calculate mean basal cover and total basal cover of each species in a given area.
5. To calculate the Alpha diversity, Beta diversity and total diversity of given community.
6. To calculate water holding capacity of three samples of various soil types and to find the percolation percentage of water in the given soil.
7. To test the pH and the buffering properties of soils.
8. Study of types of aerial photos and satellite data products.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Gain knowledge of effect of temperature upon the permeability of the cytoplasmic membrane,
CO2	Learn Principles of colorimetry, spectro-photometry and flourimetry
CO3	Perform separation of chloroplast pigment and amino acids by paper and column chromatography
CO4	Determine and execute the minimum size and number of quadrats to be laid down in the field for the calculating the diversity indices.

Suggested Textbooks

1. Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.
2. Kapoor /Govil. 2000. Experimental Plant Ecology.
3. Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York, USA.

Reference Books

1. Plummer, D.T. 1988. An Introduction to Practical Biochemistry. Tata McGraw- Hill Publishing co. Ltd., New Delhi
2. Misra, R. 1968. Ecology Work Book. Oxford & IBH New Delhi.
3. Moore, P.W. and Chapman, S.B. 1986. Methods in Plant Ecology. Blackwell Scientific Publications

Course code : MBOE 304				
Course Name : Palynology and Pollination Biology				
Semester /Year : III				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course is

1. To prepare the students with a good and up-to-date knowledge of the morphology, structure and function of the pollen and spores and the applications of the Pollen Analysis in Taxonomy, Ecology, Geology, Aerobiology, Medicine, etc.

Course contents **(Total No. of Hours: 48)**

1. General Introduction, microsporogenesis, microspore tetrads and polarity of spores and pollen grains.
2. Pollen wall development and pollen chemistry, Chemical nature of sporopollenin, development of pollen wall, Ubisch body, pollen wall proteins, origin and formation exineless pollen grains.
3. **Spore-pollen morphology:** Symmetry, shape, size, aperture patterns, NPC System for numerical expression of apertural details, exine stratification, surface structures and sculptures of sporoderm.
4. **Palynotaxonomy:** Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works.
5. **Aeropalynology with reference to allergy:** AeroalIergens, introductory idea of Immune System with special reference to IgE. Study of airspora, chemical nature of exine-borne

allergens, allergic taxa of North-West Himalaya.

6. **Melissopalynology:** Indian species of honey bees, importance of pollen grains as constituent of bee-bread, pollen-collecting mechanism of honey bees, analysis of pollen load and honey sample in understanding bee forage, objectives of melissopalynological studies, and important bee plants of North-West Himalaya.
7. **Palaeopalynology:** Introductory idea about palaeo-palynological remains, significance of palaeopalynology.
8. **Forensic palynology:** Definition and significance, a few well-known case studies.
9. **Pollination Biology:** Pollen dispersal units; pollination types, contrivances for cross- and self- pollination; pollen vectors, pollination modes and flora organization, Pollen viability and storage.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the general concepts of palynology
CO2	Learn and Understand the structure and development of pollen wall development.
CO3	Examine the morphological features of Spore-pollen.
CO4	Relate and identify the various aspects of Paynotaxonomy.
CO5	Analyse the importance of aeropalynology with reference to allergy.
CO6	Determine the concepts, scope and future perspectives of Melissopalynology.

Suggested Textbooks

1. Erdtman, G. 1952. Pollen morphology and Plant Taxonomy, Angiosperm: Almquist and Wiksell, Stockholm.
2. Bhattacharya, K. and Majumdar, M.R. 2011. A text book of Palynology. p364. New Central Book Agengcy.

Reference Book

1. Nair, P.K.K. 1966. Essentails of Palynology; Asia Publication House Lucknow.
2. Woodhouse, R.P. 1935. Pollen Grains: Hafner Publication Co.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	1	…	1	…	…	1	…	2	…	…	1	2	…	…	…
CO2	1	…	1	…	1	…	…	2	…	1	1	2	2	…	…
CO3	1	2	…	2	…	…	…	…	…	…	1	…	1	…	…
CO4	1	2	1	1	2	…	…	1	1	1	1	1	1	1	1
CO5	1	2	…	3	…	1	…	…	…	…	1	1	2	1	…
CO6	1	…	…	…	…	1	2	1	1	1	1	1	…	…	1

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOE 305				
Course Name : Fresh water algal flora of Himalaya				
Semester /Year : III				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course is

To introduce students regarding biological diversity of fresh water algal species representing various groups and distributed in diverse fresh water habitats of Himalaya with special emphasis on Uttarakhand Himalaya, their role, documentation and conservation.

Course contents

UNIT-I **(No. of Hours: 12)**

Characters & Keys: Green and Blue-Green Algae: Taxonomy terminology, flora in Himalaya Macrophytic vegetation. Centrale and Pennale diatoms, diatom taxonomy terminology. Centrale diatom Families and Genera Melosira, Cyclotella in Himalaya. Araphid Fam & genera Fragilaria, Diatoma, Meridion, Hannae in Uttarakhand HImalaya**.**

UNIT-II **(No. of Hours: 12)**

Characters of raphidiod and monoraphidiod families Raphidiod: Eunotia Monoraphids, Achnanthaceae – Achnanthidium, Cocconeis

UNIT-III **(No. of Hours: 12)**

Characters of naviculoid biraphid families Naviculoid diatom flora Naviculaceae: Navicula & Cymbella sensu lato & sensu stricto, Gomphonema Other naviculoid diatom flora: Diploneis, Pinnularia, Caloneis

UNIT-IV **(No. of Hours: 12)**

Characters of non-naviculoid biraphid families Bacillariaceae Nitzschia, Denticula Epithemiaceae: Epithemia Surirellaceae: Surirella Algal communities in Himalayan lotic, lentic systems, wetlands Ecological preferences of abundant forms of Himalaya (OMNIDIA)

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Learn and understand taxonomic keys for identifying different floral diversity in the Himalayan region.
CO2	Understand freshwater diatoms and their taxonomic terminology will be useful and will have a brief insight.
CO3	Compare characters of Green, blue-green algae and their taxonomic terminology.
CO4	Examine floral diversity, which plays many important and beneficial roles in freshwater ecosystems of the Himalayan regions.

Suggested Textbooks

1. Fresh water Diatoms of Central Gujarat (with a review and some others). H P Gandhi, Bishen Pal Singh, Mahendra Pal Singh, Dehradun
2. Algal flora of Andaman & Nicobar Prasad & Srivastava
3. Ganga: A water marvel, A.C. Shukla and A. Vandana, Ashish Publishing House, New Delhi

Reference Books

1. Bellinger, E.G., Sigee, D.C. (2010) *Freshwater Algae (Identification and Use as Bioindicators)*. Wiley-Blackwell, pp1–243.
2. Vuuren, V.J.S., Taylor, J., Gerber, A., Van Ginkei, C. (2006). *Easy identification of the most common Fresh water Algae. A guide for the identification of microscopic algae in South African Fresh waters*, Publ. by North West University, Potchefstroom, p212.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	…	1	…	…	1	2	2	…	…	…	2	2	1	…
CO2	1	…	1	2	1	1	2	2	2	1	1	2	…	…	1
CO3	1	…	…	1	…	1	…	1	…	1	1	2	2	1	…
CO4	1	…	1	2	1	1	…	…	2	…	1	2	1	…	1

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOE 306				
Course Name : Plant Health Management				
Semester /Year : III				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. To introduce students and develops their skills in biology, ecology and management of a variety of pests in agricultural, horticultural and viticultural ecosystems, especially arthropods, plant pathogens and weeds.

2. The key concepts of the course are integrated, and students enhance their ability to apply them to novel situations in problem-solving sessions.

Course contents

1. Basic procedure in diagnosis of plant diseases: Significance of plant diseases. **(No. of Hours: 4)**
2. Seed Pathology: Seed borne fungi. Disease transmitted through seeds. Biodeterioration of seed in storage. Control of seed borne fungi. **(No. of Hours: 6)**
3. Nursery disease: Important disease of nursery plants. **(No. of Hours: 4)**
4. Plantation disease: Plantation disease of Chir pine, *Eucalyptus*, Sal, Teak, Shisam, *Populus*, *Acacia* (Catechu). **(No. of Hours: 8)**
5. Important disease of cash crops: Sugarcane, Potato and Ginger. How plants defend themselves against pathogen. Control of crop and forest disease. Treatment of wounds. Introduction and various forms of Mycorrhiza. Role of Mycorrhiza in Forestry. **(No. of Hours: 16)**
6. Diseases of cereals, millets, vegetables and fruit trees. **(No. of Hours: 8)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the basic procedure of diagnosis of plant diseases.
CO2	Learn the concepts of seed pathology.
CO3	Explain the important diseases of Nursery.
CO4	Identify the important diseases of plantation.
CO5	Learn, understand and address the various types of mycorrhizal associations and their role in forestry.

Suggested Textbooks

1. Bilgrami, K.S. 1985. Text Book of Modern Plant Pathology. Bishen Singh Mahendra Pal Singh Dehradun.
2. Butler, E.J. 1973. Fungi and Disease in Plants, Intern, Book Distributers. Dehradun.
3. Singh, R.S.1983. Plants Diseases. Oxford and IBH Publ. Co. New Delhi.
4. Singh, R.S. Principle of Plants Pathology. Oxford and IBH Publ. Co. New Delhi

Reference Books

1. Strobel, G.A. and D.E., Mathre 1970. Outlines of Plant Pathology. Van Nostrand Reinhold Co. New York.
2. Tarr, S.A.J. 1972. The Principle of Plants Pathology. Winchester Press, New York.
3. Western, J.H. 1971. Diseases of Crop Plants. Mc Millan Press London

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	1	2	1	…	…	1	2	2	…	…	2	2	2	1	…
CO2	1	1	2	1	1	1	2	2	2	1	…	2	…	…	1
CO3	1	1	…	1	…	1	…	1	…	1	2	2	2	1	…
CO4	1	…	1	1	1	1	…	…	2	…	3	..	1	…	1

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOE 307				
Course Name : Environment Microbiology				
Semester /Year : III				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course is

1. Understand the role of microorganisms as agents of environmental change.
2. Recognize microorganisms as indicators of alteration of an ecosystem.

3. Understand microbial processes aimed to solve environmental problems.

Course contents

Unit I: Fundamentals of Microbial Ecology (No. of Hours: 8)

Ecosystem; Biotic and abiotic components; Habitat and Niche; Population and guilds; Concept of community; Stability hypothesis; Intermediate-disturbance hypothesis; Concept of ecological niche; Ecosystem organization: Structure and functions, Primary production, Energy dynamics (Trophic organization and energy flow pathways); Microbial community dynamics: r and k strategies of population selection within communities.

Unit II: Air and Aquatic Microbiology (No. of Hours: 8)

Aerobiology: Droplet nuclei, Aerosol, Assessment of air quality, Solid and liquid impingement methods, Brief account of air born transmission of microbes; Aquatic microbiology: Zonation and microbiota of fresh water (Ponds, lake and rivers) and marine habitats (Estuaries and deep sea), Upwelling and downwelling, Eutrophication, Food chain, Mechanism of dissolved organic matter production, Microbial assessment of water quality, Water purification.

Unit III: Microbial Interactions (No. of Hours: 8)

Positive and negative interactions amongst microbial populations: Cooperation, Neutralism, Commensalism, Synergism, Mutualism, Competition, Amensalism, Parasitism, Predation; Interactions between microorganisms and plants: Rhizobacteria, Mycorrhiza, Epiphytic and endophytic microorganisms; Interactions between microorganisms and animals: Predation on microorganisms by animals, Cultivation of microorganisms by animals for food and food processing.

Unit IV: Pollution and its Control (No. of Hours: 14)

Air pollution and its control: Sources, Major pollutants, Adverse effect on living organisms (Acid rain and its impact on ecosystem, greenhouse effect, global warming, ozone layer depletion and its effect, smog), Control through biotechnology (Deodorization, reduction in CO2 emission, bioscrubbers, biobeds and biofilters); Water pollution and its control: Sources, Ground water contamination, Wastes: Characterization of solid and liquid wastes, Solid waste treatment (Landfills, incineration, composting, anaerobic digestion and pyrolysis), Waste water treatment (Pretreatment, primary, secondary and tertiary treatment, Application of biofilm in waste water treatment); Environment impact assessment.

Unit V: Impact of Microbes on Environment (No. of Hours: 10)

Biodegradation of recalcitrant compounds: Pesticides and Petroleum; Bioremediation: *In situ* and *Ex situ* remediation, Bioremediation of oil spills; Bioaugmentation; Biomagnification; Biomineralization; Metal corrosion: Mode of deterioration, Microorganisms involved, Mode of prevention; Bioleaching of ore; Microbial plastics; Biodiesel.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Apply knowledge of the biology and distribution of certain species of microorganisms, principally bacteria, in order to use them as bioindicators of contamination and other environmental impacts.
CO2	Apply the metabolic processes of microorganisms, principally bacteria, to industrial processes related to the environment.

CO3	Develop analysis and synthesis skills.
CO4	Obtain information, design experiments and interpret results.
CO5	Recognise and use the properties of microorganisms, principally bacteria, to remedy problems of contamination and other environmental impacts.

Suggested Textbook

1. Alexander, M. Microbial ecology. John Wiley and Sons, New York.
2. Eldowney, S., and Waites, S. Pollution: Ecology and biotreatment. Longman, Harlow.

Reference Book

1. Baker, K.H. and Herson, D.S. Bioremediation. McGraw- Hill, New York.
2. Marshal, K.C. Advances of microbial ecology. Plenum Press, New York.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	2	…	1	1	1	1	…	3	1	…	1	1
CO2	1	1	1	2	…	1	…	…	1	1	…	1	1	1	1
CO3	1	3	1	2	1	…	1	1	2	…	2	2	2	1	1
CO4	1	1	1	2	2	…	…	1	…	…	…	1	2	2	1
CO5	1	2	1	…	2	…	…	…	1	1	1	1	..	…	1

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOL 308				
Course Name : Laboratory Course-II				
Semester /Year : III				
	L	**T**	**P**	**C**
	0	**0**	**3**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course contents

1. Pollen morphological studies of some pterodophytes, gymnosperms, and angiosperms representing different morphological types using acetolysis / alkali maceration method.
2. Study of in vivo and in vitro germination of pollen grains.
3. Morpho-anatomical study of stigma and style.
4. Study of allergy producing pollen morpho-types

5. Collection and identification of different floral diversity in the Himalayan region.
6. Cultivation of algae of commercial importance.
7. Study of representative genera of different families viz., Melosira, Cyclotella, Fragilaria, Diatoma, Meridion, Achnanthidium, Cocconeis, Navicula & Cymbella, Gomphonema, Diploneis, Pinnularia, Caloneis, Nitzschia, Denticula, Green and Blue-Green Algae.

8. Study of seed borne pathogen. Description of pathogen, symptoms and section cutting.
9. Isolation of some important pathogens.
10. Procedure of equipments uses.
11. To establish a plant disease clinic in the department for advise to local people.
12. Sampling and enumeration techniques for microbes.
13. Determination of total microbial count in a water sample.
14. Determination of total count (MPN) of coliform in a water sample.
15. To prepare the Nutrient Agar/CDA/MEA medium for culturing bacteria and Fungi present in our surroundings.
16. Isolation of Fungi/bacteria by the Pour- plate method, Spread-pate and Streak Plate method.
17. To prepare the differential medium (MacConky) so as to grow the enteric bacteria.
18. Isolation of fungi from the given sample of water and soil.
19. Isolation of the *Lactobacillus* bacteria from the given sample of curd.
20. Working principle molecular technique–PCR

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Identify pollen grains from honey samples and to study the frequency of different morpho-types.
CO2	Relate vivo and in vitro germination of pollen grains.
CO3	Cultivation of algae of commercial importance
CO4	Isolate some important plant pathogen.
CO5	Isolation of Fungi/bacteria by the Pour- plate method, Spread-pate and Streak Plate method.

Suggested Textbooks

1. Hurst, Crawford, Garland, Lipson, Mills & Stetzenbach. 2007. Manual of environmental microbiology. 3th Edition. ASM Press.
2. Husain Hadi Khan et al. 2019. Practical Lab manual for microbiology and plant pathology, Akinik Publication, Delhi.
3. James, B. Riding. 2021. A guide to preparation protocols in palynology. Taylor and Francis.

Course code : MBOS 309				
Course Name : Forest Ecology				
Semester /Year : III				
	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives: The objectives of this course are

1. This course will provide students and land managers with basic forest ecology and management knowledge and skills in order to better apply them in various decision making situations, including habitat conservation, forest planning, and Service guidance.
2. The skill set gained by students will help them improve communications with professional foresters, private landowners, federal agency partners, and forest researchers.
3. The course will provide a greater understanding of how silviculture can be used to achieve a range of conservation objectives, including habitat management and ecosystem restoration.

Course contents

1. Forests, forestry and man: Definition, forests in geological ages, forests in prehistoric era, shifting cultivation, forests in historical time, scientific forestry, forest policy, natural forest policy, private forest policy, panned forest development, forestry education in India. **(No. of Hours: 8)**
2. Essential elements of forest ecology: Extent and boundaries, physical features, geology, river system, soil, land-use pattern, role in country's economy, forests and wild lands. **(No. of Hours: 4)**
3. Forests and trees: Locality factors of the forests, forest influences, forest composition, stand structure, dynamics and growth, classification, forest types and their distribution, species diversity. **(No. of Hours: 6)**
4. Wild Life: Species and distribution, Sanctuaries, Biosphere reserves, wild life and recreation. **(No. of Hours: 4)**
5. Forest conservancy and Potential Productivity: Soil, Water relation and nutrition, soil erosion and conservation, potential productivity of forests, site quality evaluation. **(No. of Hours: 4)**
6. Forest Conservation and Management: **(No. of Hours: 16)**
   i) Impact of deforestation on soil and water, Role of fire: type, extent and cause of fire, fuel load, fire and different forest types of Himalaya.
   ii) Forest resource management and forest resource information system.
   iii) Forest cover in India-State of Art, Ground inventory. Application of Remote Sensing and Geographic Information System (GIS) in Land cover mapping. Vegetation and forest type maps.
7. Environmental Impact Assessment: Maintenance and conservational policies such as Joint Forest Management (JFM) and Agroforestry in the region. **(No. of Hours: 6)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand relationship of forests, forestry and man.
CO2	Describe the essential elements of forest ecology.
CO3	Comprehend the composition, structure, dynamics, growth and classification of forests and also about the factors affecting forests.
CO4	Knowledge about the various aspects of Wild Life in relation to Sanctuaries and Biosphere reserves.
CO5	Examine the essential components of forest conservancy and its potential productivity.

Suggested Textbooks

1. Bir, S.S. and Chatha, G.S. 1988. Forest Vegetation Characteristics of Indian Hills. Today and Tomorrow's Printers & Publ., New Delhi.
2. Dwivedi, A.P. Forestry in India. Jugal Kishor and Company, Dehradun.
3. Misra, R. Ecology Work Book. Oxford & IBH Publishing Co. New Delhi.
4. Mishra, R. and Gopal, B. Recent Advances in Tropical Ecology: Part I & II. International Society for Tropical ecology, Varanasi.
5. Negi, S.S. 1983. Forest Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
6. Puri, G.S., Gupta, R.K., Meher-Homji, V.M. and Puri, S. 1989. Forest Ecology: PlantForm, Diversity, Communities and Succession. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
7. Puri, G.S., Meher-Homji, V.M., Gupta, R.K. and Puri, S. Forest Ecology: Vol I & II. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
8. Singh, G. 1987. Forest Ecology of India. Rawat Publications, Jaipur

Reference Books

1. Singh, J.S. and Singh, S.P. 1992. Forests of Himalaya. Consul Book Depot. Gyanodaya Prakashan, Nainital. India.
2. Singh, J.S. Singh, S.P. and Gupta, S.R. 2005. Ecology, Environment and Resource Conservation. Anamaya Publ., F-154/2 Ladosarai, New Delhi- 110 030
3. Singh, M.P. and Vishwakarma, V. 1997. Forest Environment and Biodiversity. Daya Publ. House, Delhi.
4. Wareing, R.H. and Schlesinger, W.H. 1985. Forest Ecosystems: Concepts and Management. Academic Press, New York.

Course code : MBOS 310				
Course Name : Introduction to Medicinal and Aromatic Plants				
Semester /Year : III				
	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives: The objectives of this course is

This Course provides introductory information in the production, processing, and marketing of medicinal and aromatic plants on the prairies. It also provides foundational information in the development of an herb enterprise.

Course contents

Unit - I **(No. of Hours: 12)**

MAPs: definition, history, importance and future prospects. Medicinal Plants – past and present status in world and India. MAPs as industrial crops - constraints and remedial measures. Medicinal plant diversity & local healthcare. Medicinal plant conservation – issues and approaches. Medicinal plant conservation areas (MPCA), Non-timber forest products (NTFP), Good Agriculture Practices (GAP). Indian Himalayan region (IHR).

Unit - II **(No. of Hours: 10)**

Promotion of medicinal plant sector at national level: National Medicinal Plant Board and State Medicinal Plant Boards - objectives and functions. Other organizational initiatives for promotion of MAPs at National and International levels. Demand and supply of medicinal plants. Herbal industries.

Unit-III **(No. of Hours: 8)**

Important medicinal plants of India with their systematics, geographical distribution and uses. Acorus calamus, Adhatoda vasica, Abrus precatorius Aloe vera, Phyllanthus amarus, Stevia rebaudiana, Belladona and Cinchona.

Unit –IV **(No. of Hours: 18)**

Important aromatic plants of India with their systematics, geographical distribution and uses. Introduction and historical background of aromatic plants. Aromatic and cosmetic products. Raw material for perfumes etc. Cosmetic Industries. Major, minor and less known aromatic plants of India. Taxonomic descriptions and uses of important aromatic plants – citronella, davana, damask rose, geranium, khus grass, large cardamom, lavender, lemon grass, mentha, holy basil, patchouli, rosemary Palmarosa, vetiver, artemisia, eucalyptus, thyme, marjoram and oreganum. Aromatic spices - clove, cinnamon, nutmeg, ajwain, dill, celery, tamarind, garcinia, curryleaf and saffron.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Knowledge of medicinal and aromatic plants, their importance, status and future prospects.
CO2	Understand the Good Agriculture Practices and Good Manufacturing Practices
CO3	Practice and conserve the medicinally important herbs
CO4	Enlist aromatic plants used in different industries particularly Perfume industry.

CO5	Describe the role of agencies constituted for promotion of medicinal plant sector at national level.

Suggested Textbooks

1. Medicinal Plants of Uttarakhand by C.P. Kala (2010).
2. Indian Medicinal Plants by P.C. Trivedi (2009).
3. Medicinal Plants of Indian Himalaya by S.S. Samant and U. Dhar

Reference Books

1. Hand Book of Aromatic Plants by S.K. Bhattacharjee (2004).
2. Handbook of MAPs by S.K. Bhattacharjee (2009).

Course code : MBOS 311				
Course Name : Pathogens and Pests of Crop Plants				
Semester /Year : III				
	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives: The objectives of this course are

This course aims to enhance understanding of students in basic concepts of mycology and importance of fungi, as well as develop skills for handling fungi.

The course deals with basic concepts in plant pathology and interaction of plants with herbivores. Introduction to agricultural pathogens and pests of national importance will be accompanied by basic concepts in integrated disease/pest management, and breeding plants for durable resistance against insect pests and pathogens

Course contents

Unit I: (No. of Hours: 16)

Overview of Fungi and fungus-like organisms (Myxomycetes, Acrasiomyctes, and Oomyctes), A higher-level phylogenetic classification of the Fungi. True fungi: Characteristics and important Genera of Phyla – Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota, and Basidiomycota. Physiology of fungal growth, reproduction (asexual and sexual), and mating compatibility, Importance and ecological role of fungi.

Unit II: (No. of Hours: 12)

Plant Pathology: General concepts, General characteristics of plant pathogenic organisms and pests. Molecular approaches for the investigation of plant diseases. Control mechanisms based on chemical treatments, biological control and genetic engineering.

Unit III: (No. of Hours: 16)

Plant interactions with pathogens and pests: Plant-virus interactions with emphasis on potyviruses and horticultural crops; Plant-bacterial interactions with emphasis on Erwinia sp. and potatoes; Plant-fungus interactions with emphasis on Magnaporthe sp. and rice; Plant-nematode interactions with emphasis on Meloidogyne sp. and tomato; Plant-Insect interactions with emphasis on Pieris sp. and crucifers.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand basic fungal biology, taxonomy of the fungi and major fungal lineages
CO2	Gain skills necessary to isolate and handle fungi from nature, and to discern important microscopic characteristics of fungi.
CO3	Develop functional knowledge on differentiating disease caused by virus, fungi, and bacteria
CO4	Learn about the biology of major, and emerging pathogens and pests of crop plants
CO5	Examine advantages and disadvantages of current control practices based on chemical ecology, genetics of plant resistance and breeding including transgenic approaches

CO6	Combine theoretical and practical knowledge of plant disease and pest management

Suggested Textbooks

1. Alexopoulos, C.J., Mims, C.W. and Blaclwell, M. (2007). Introductory Mycology. Fourth Edition Wiley India Pvt. Limited
2. Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge University Press. Cambridge and New York
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi & Their Allies, Second Edition. MacMillan Publishers Pvt. Ltd., Delhi, India
4. Dickinson, M. (2003). Molecular Plant Pathology, Bios Scientific Publishers, London.
5. Sharma, P.D. (2017). Mycology and Phytopathology. Rastogi Publishers, Meerut, India

Reference Books

1. Burchett, S. and Burchett, S. (2018). Plant Pathology, Garland Science, US.
2. Koul, O., Dhaliwal, G.S. and Cuperus, G.W. (2004). Integrated Pest Management: Potential, constraints and challenges , CABI Press, UK
3. Dhaliwal, G.S. and Arora, R. (1996). Principles of insect pest management, National Agricultural Technological Information Center, Ludhiana, India

Course code : MBOC 401				
Course Name : Conservation Biology				
Semester /Year : IV				
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. Systematically understand biodiversity and its vital role in ecosystem function.
2. Identify the importance of biodiversity in natural environments. Critically examine biodiversity and human linkages, and help policy formulating for conservation. Application of knowledge in general communication for public extension.
3. Developing critical thinking for the conservation of biodiversity and stratigies used for the conservation of plant diversity, for shaping strategies viz. scientific, social, economic and legal issues; for environmental protection and conservation of biodiversity, social equity and sustainable development.

Course contents

1. Conservation: The basic concept, History of conservation biology. **(No. of Hours: 2)**
2. Patterns of biodiversity: Global and regional patterns of biodiversity, Distribution, Gradients, Magnitude of biodiversity, Hotspots, keystone species. **(No. of Hours: 4)**
3. Uses of biodiversity: food, fodder, timber, fibre, medicine, etc.; biodiversity based products and industries; wild relatives of cultivated plants; scientific role of biodiversity. **(No. of Hours: 2)**
4. Threats to biodiversity: Habitat loss and fragmentation, Genetic drift, Inbreeding, Disturbance, Pollution, Climate Change, Overexploitation, Invasive Species, Disease. **(No. of Hours: 4)**
5. Global environmental problems: Global warming, ozone depletion, desertification. **(No. of Hours: 2)**
6. Extinction to species: Susceptibility to extinction causes of species extinction, endangered species, Red and Green Data Books. **(No. of Hours: 2)**
7. Environmental Impact Assessment (EIA) origin and development, development in India, Purpose and aims of EIA, Core values and principles, EIA process, components of EIA, Participants in EIA process, Impact identification methods. **(No. of Hours: 5)**
8. Conservation of Biological diversity: Genetic principles in conservation, biodiversity assessment and inventory. **(No. of Hours: 4)**
9. Survey and monitoring of biological resources: sampling population for biological conservation; Collection and analysis of inventory data, criteria on choice of species for conservation. People participation, biodiversity registers and their maintenance. **(No. of Hours: 5)**
10. Conservation of energy resources; conservation and maintenance of non-renewable fossil fuel resources; Conservation of biodiversity based renewable energy resources.

(No. of Hours: 2)

11. Conservation of biological resources: In situ and Ex Situ Conservation Strategies, Designing Networks of Protected Areas; Restoration of endangered species. **(No. of Hours: 5)**
12. Protected Area Network, PAN with special reference to Uttarakhand and India. Indian biodiversity and its conservation: International efforts for conserving biodiversity viz., CITES, CBD, IUCN, MAB, UNEP, UPOV (Union for the Protection of New Plant Varieties), WTO etc.). International treaty on Plant Genetic Resources, Wetland conservation, **(No. of Hours: 4)**
13. National Forest Policy 1929, Wildlife (Protection) act 1975, Forest (Conservation) Act 1980, Environment (Protection) Act 1986, Fisheries Act 1987, Wildlife (Protection) Amendment Act 1991, Biodiversity Act 2003, etc. **(No. of Hours: 3)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Knowledge of basic concepts and history of conservation biology.
CO2	Learn origin and evolution of organism; genetic plasticity and the invasion of unoccupied ecological niches.
CO3	Correlate global and regional patterns of biodiversity.
CO4	Explain about the Global environmental problems: Global warming, ozone depletion, desertification.
CO5	Compare concept of species extinction, endangered species, Red and Green Data Books.
CO6	Execute Plan of Environmental Impact Assessment (EIA).

Suggested Textbooks

1. Cain, M.L., Bowman, W.D. & Hacker, S.D. 2008. Ecology. Sinauer Associates, Inc.
2. Dhar, U. 1993 (Ed.). Himalayan Biodiversity: Conservation Straegies, Gyanodaya Prakashan, Nainital.
3. Groombridge, B. and Jenkins, M.D. 2000. Global Biodiversity. Earth's living resources in the 21th century, UK. World conservation Monitoring Center. Pp 246.
4. Hunter, M.L.J. 1990. Wildlife, forest and forestry: Principals of Managing forests for biological diversity. Prentice Hall. Englewood. Cliffs. New Jersey. 370 pp.
5. Hunter, Jr, M.L. & Gibbs, J.P. 2006. Fundamentals of Conservation Biology. Wiley Blackwell.

Reference Books

1. Pullin, A Conservation Biology. Cambridge University Press, The Edinberg Building, Cambridge CB2ZRU, UK.
2. Primack, R.B. 2006. Essentials of Conservation Biology. Sinauer Associates, Inc.

3. Primack, R.B. 2008. A Primer of Conservation Biology. Sinauer Associates, Inc.
4. Singh, J.S., Singh, S.P. & Gupta, S.R. 2007. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi.
5. Western, D. and Pearl, M.C. 1989. Conservation for twenty-first century. Oxford University Press, Oxford UK. Pp 109-120.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	…	1	…	…	1	…	2	…	…	1	2	…	…	…
CO2	1	…	1	…	1	…	…	2	…	1	1	2	2	…	…
CO3	1	2	…	2	…	…	…	…	…	…	1	…	1	…	…
CO4	1	2	1	1	2	…	…	1	1	1	1	2	1	1	1
CO5	1	2	…	3	…	1	…	…	…	…	1	1	2	1	…
CO6	1	…	…	…	…	1	2	1	1	1	1	1	…	…	1

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code	**: MBOC 402**			
Course Name	**: Biotechnology and Genetic Engineering of Plants and Microbes**			
Semester /Year	**: IV**			
	L	**T**	**P**	**C**
	4	**0**	**0**	**4**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

This course would provide students with an understanding of principles and techniques of plant tissue culture, concepts and methods associated with development and analysis of transgenic plants, and their applications in basic and applied research

Course contents

1. Biotechnology: Basic concepts, principles and scope. **(No. of Hours: 2)**
2. Plant cell and tissue culture: General introduction, history, scope, concept of cellular differentiation, totipotency. **(No. of Hours: 2)**
3. Organogenesis and adventive embryogenisis: Fundamental aspects of morphogenesis, somatic embryogenesis and androgenesis, mechanisms, techniques and utility. **(No. of Hours: 4)**
4. Somatic hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitations of protoplast research. **(No. of Hours: 4)**
5. Applications of plant tissue culture: clonal propagation, artificial seed, production of hybrids and somaclones, production of secondary metabolites/natural products, cryopreservation and germplasm preservation. **(No. of Hours: 8)**
6. Recombinant DNA technology: Gene cloning principles and techniques, construction of genomic and cDNA libraries, choice of vectors, DNA synthesis and sequencing, polymerase chain reaction, DNA finger printing. **(No. of Hours: 8)**
7. Genetic engineering of plants: Aims, strategies for development of transgenics (with suitable examples), *Agrobacterium*- the natural genetic engineer, T-DNA and transposon mediated gene- tagging. **(No. of Hours: 8)**
8. Microbial genetic manipulation: Bacterial transformation, selection of recombinants

and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology. (**No. of Hours: 6)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Learn concepts, principles and scope of Biotechnology.
CO2	Explain the general introduction, history, scope and concept of plant cell and tissue culture.
CO3	Understand the fundamental aspects of organogenesis and adventive embryogenesis
CO4	Knowledge about concepts, key features and limitations of somatic hybridization technique.
CO5	Explain applications of plant tissue culture.
CO6	Understand fundamentals of Recombinant DNA technology.

Suggested Textbooks

1. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.
2. Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
3. Shantharam, S. and Montgomery, J.F. 1999. Biotechnology, Biosafety & Biodiversity. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Reference Books

1. Vasil, I.K. and Thorpe, T.A. 1994, Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.
2. Dubey, R.C. 2018. Biotechnology. S.Chand Publ. Co. Pvt. Ltd., New Delhi.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	…	1	2	1	…	…	1	1	…	1	1	3	…	…
CO2	1	1	…	1	2	…	…	…	…	1	1	1	2	1	2
CO3	2	1	1	1	…	1	1	2	1	…	1	2	…	1	…
CO4	2	2	…	1	…	…	…	…	…	1	2	1	…	…	…
CO5	1	…	1	1	2	…	…	…	…	2	1	…	2	1	2
CO6	2	…	1	1	…	1	1	2	1	2	1	2	…	2	…

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOL 403				
Course Name : Laboratory Course-I				
Semester /Year : IV				
	L	**T**	**P**	**C**
	0	**0**	**3**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course contents

A. Laboratory/Field Exercises in Conservation Biology.

1. To study the pattern of regional biodiversity.
2. To study the Hotspots and key-stone species.
3. Survey of biological resources.
4. Study of habitat loss with respect to plant species. To observe factors expediting habitat loss viz., floods, forest fires, landslides, natural and anthropological activities.
5. Visits to national parks, sanctuaries and biosphere reserves of Uttarakhand.

B. Laboratory/Field Exercises in Biotechnology and Genetic Engineering

1. Growth characteristics of *E. coli* using plating and turbidimetric methods.
2. Isolation of plasmid of *E. coli* by alkaline lysis method and its quantitation spectrophotometrically.
3. Restriction digestion of plasmid and estimation of the size of different DNA fragments.
4. Cloning of a DNA fragment in a plasmid vector, transformation of the given bacterial population and selection of recombinants.
5. Demonstration of DNA sequencing by Sanger's dideoxy method.
6. Demonstration of protoplast fusion employing PEG.
7. Organogenesis and somatic embryogenesis using appropriate explants and preparation of artificial seed.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Learn and identify pattern of regional biodiversity
CO2	Execute survey of biological resources
CO3	Collect and enhance information regarding visiting national parks, sanctuaries and biosphere reserves of Uttarakhand
CO4	Demonstration of protoplast fusion employing PEG
CO5	Demonstration of DNA sequencing by Sanger's dideoxy method

Suggested Textbook

1. George, E.F. 1993. Plant Propagation by Tissue Culture. Part 2.In Practice, 2nd edition Exegetics Ltd., Edington, UK.
2. Shaw, C.H. (Ed.) 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.

Reference Book

1. Smith, R.H. 2000. Plant Tissue Culture: Techniques and Experiments. Academic Press, New York.

Course code : MBOE 404				
Course Name : Dissertation				
Semester /Year : IV				
	L	**T**	**P**	**C**
	0	**0**	**9**	**9**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. The objective of this advanced course is to provide students with hands-on training in specialized areas of plant sciences.
2. To train students in basics of research, literature recession, analysis and expression of their understanding of the topic in their own words.
3. To create research oriented thought process and basic training.

Course contents

The student will be reading and analyzing published literature in the chosen area of plant science under direct mentoring of a faculty member and will participate in research activity

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Create awareness and interest towards research.
CO2	Develop scientific temperament.
CO3	Understand the fundamentals of research methodology.
CO4	Enhance skills for the writing of thesis and scientific papers.

Course code	**: MBOE 405**			
Course Name	**: Environment Management with reference to Western Himalaya**			
Semester /Year	**: IV**			
	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

1. To develop skills and knowledge for translating the theory and concepts of resource and environmental management into practice relevant to communities and workplaces.
2. To apply monitoring and environmental management tools used by resource and environmental practitioners.
3. To consider the impacts of flows (energy, water, resources/waste) within the built, urban, agricultural and natural environments.

Course contents

1. Introduction to the Environmental Management, Major Environmental Problems, Environmental ethics; Resource and conflicts, Environmental Laws; Stockholm Conference, The Earth summit, The Copenhagen Conference, Environmental Protection and Fundamental rights, Environmental Governance in India, Man and Environment, Trade and Environment; the WTO and GATS, Environment Concerns and WTO. **(No. of Hours: 8)**
2. Introduction to the Environmental Impact Assessment; Planning and Significance, EIA practices and future trends in India; Legal frame work for EIA. Impact of forest fires, Forest Fire Assessment and Risk Zonation. Thermal power stations, Power line and roads, River valley projects, Urbanization and Industrialization, Mining activities, GHGs, CFCs, fossil fuels etc., Flood monitoring, Snow melt and Glaciers, Ozone Layer Depletion. Principles of Environmental Analysis, Role of remote sensing in EIA. **(No. of Hours: 8)**
3. Environmental Management and Natural Resources, Air Pollution , Water Pollution and its Management, Environmental Pollution Act; Waste disposal and management, Integrated solid waste management, Recycling, Incineration, Sanitary landfill, Sewage disposal and sewage treatment; Hazardous wastes. **(No. of Hours: 4)**
4. Environmental policy and environmental management system, Audit items and audit procedures, ISO Certification. **(No. of Hours: 2)**
5. Watershed management: Definition and basic concepts, Aims and Principles, Importance of integrated watershed management, Principal watershed problems of India. **(No. of Hours: 2)**
6. Basic concept of ecosystem and community, Biological populations and communities, Ecological niches, interaction among species, Key stone species, Species diversity and edge effects, Major terrestrial and aquatic biomes, Energy Flow, Food webs and trophic levels, Ecosystem diversity, Climate shifts, Species movements. **(No. of Hours: 4)**
7. Biodiversity and conservation, *In-situ* and *ex-situ* conservation, Indigenous knowledge and biodiversity conservation, Loss of biodiversity- causes and its impact; Convention on biodiversity, Major Biodiversity resources. Global trends of invasive species, threats and managing invasive plants. **(No.**

of Hours: 6)

8. Protected areas concept and purpose, type of protected areas and threats, In situ conservation and protected areas; Role of local communities in protected area management. **(No. of Hours: 3)**
9. Renewable Energy Production and Management: Energy concepts, present global energy use, future energy needs, renewable needs, energy conservation. **(No. of Hours: 4)**
10. Biofuel plants- *Jatropha*, sugarcane and oil crops, Biofuel plantation, energy criteria for species selection, achievement of sustainable Biofuel production; Bioconversion, utilization of biomass sources, Incineration of organic wastes for energy. Alien invasive species and bioenergy production; Bioenergy and food production controversies. Carbon sequestration and carbon pools. **(No. of Hours: 6)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the environmental, social and economic framework in which environmental management decisions are made
CO2	Anticipate, recognize, evaluate, and control environmental issues
CO3	Recognize, evaluate, and control factors in the workplace and the environment that cause health and environmental hazards and utilize quantitative knowledge and skills and modern tools and technologies to assess, analyze, plan, and implement environmental management systems
CO4	Prepare, review, and update environmental monitoring and assessment Reports and Monitor progress of environmental improvement programs
CO5	Identify, formulate, analyze, and develop management systems and formulate solutions that are technically sound, economically feasible, and socially acceptable. Assess the potential environmental impact of development projects and design mitigation measures
CO6	Audit, analyse and report environmental performance to internal and external clients and regulatory bodies and find professional level employment or pursue higher studies and pursue research for contributing to the betterment of humanity and in shaping a sustainable society

Suggested Textbooks

1. Heywood, H.V. 1995. Global Biodiversity Assessment.
2. Ramakrishnan, P.S., Saxena, K.G. and Chandrashekara, U.M. 1998. Conserving the sacred for Biodiversity Management. Oxford and IBH Publ. Co. New Delhi
3. Sulphey, M.M. 2015. Introdution to Environment Management.pp428. Prentice Hall India Learning Pvt. Ltd.

Reference Book

1. Ajith Sankar. 2015. Environmental Management. Oxford Univ. Press.
2. Agarwal, S.K. 2005. Environmental Management. APH Publishing Corporation.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	1	2	1	…	…	1	1	2	…	1	1	1	1	…	…
CO2	2	1	…	1	2	…	…	…	1	1	1	1	2	1	1
CO3	1	3	1	2	2	2	1	1	1	1	1	1	2	2	1
CO4	1	2	…	1	…	…	1	…	1	1	1	1	…	…	1
CO5	1	3	…	3	2	…	2	…	1	1	1	1	2	3	1
CO6	1	2	1	2	…	…	1	1	3	1	1	1	2	…	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOE 406				
Course Name : Seed Pathology				
Semester /Year : IV				
	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course Objectives: The objectives of this course are

To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/loses and management.

Course content

1. Introduction, terminology and historical development, seed health and its importance. **(No. of Hour: 2)**
2. Kinds of seed borne pathogens: fungi, bacteria, viruses, viroides and nematodes. **(No. of Hour: 2)**
3. Types of damage caused by the seed borne fungi to seeds and crops. **(No. of Hours: 2)**
4. Nature of seed infection. Systemic infection through flower, fruit and seed stock. Penetration through seed coat, natural openings and inflicted openings. **(No. of Hours: 6)**
5. Longevity of seed borne pathogens. Factors influencing longevity. **(No. of Hours: 4)**
6. Epiphytology of seed borne diseases, monocyclic and polycyclic diseases **(No. of Hours: 4)**
7. Detection of seed borne pathogens, objectives of seed health testing. Testing methods for seed borne fungi, seed borne bacteria, seed borne viruses and seed borne nematodes. **(No. of Hours: 10)**
8. Study of seed borne diseases of certain specific crops, cereals, millets, pulses, oil crops, fibre crops, and vegetable and timber crops. **(No. of Hours: 10)**
9. Control of seed borne pathogens: selection of seed production areas, crop management, seed treatment, certification, plant quarantine and disease resistance. **(No. of Hours: 8)**

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the basics of seed pathology.
CO2	Know about the kinds of seed borne pathogens.
CO3	Infer the types of damage caused by the seed borne fungi to seeds and crops.
CO4	Learn the nature of seed infection, longevity of seed borne pathogens, epiphytology of seed borne diseases, monocyclic and polycyclic diseases.
CO5	Apply methodology of detection of seed borne pathogens.

Suggested Textbook

1. Neegard P. 1977. Seed Pathology Vol I and II. MacMillan Press, London
2. Suryanarayan, D. 1978. Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
3. Jha, D.K. 1995. A Text Book of Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
4. Agarwal, V.K. 1978. Principles of Seed Pathology. In (ed.) James B.S. Sindair.CRC Press. II Edition.

Reference Book

1. Singh, Gurnam, Seed Pathology. Pointer Publisher, Jaipur.
2. Sing, T. Seed Technology and Seed Pathology. Pointer Publisher, Jaipur.
3. Nene, Y.L. and Agarwal, V.K. 1978. Some seed borne diseases and their control. ICAR, New Delhi

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	…	…	1	2	2	…	…	2	2	2	1	…
CO2	1	1	2	1	1	1	2	2	2	1	1	2	…	…	1
CO3	1	1	…	1	…	1	…	1	…	1	2	2	2	1	…
CO4	1	…	1	1	1	1	…	…	2	…	3	..	1	…	1
CO5	1	1	1	…	…	1	1	…	1	2	1	.1	…		

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOL 407				
Course Name : Laboratory Course-II				
Semester /Year : IV				
	L	**T**	**P**	**C**
	0	**0**	**3**	**3**

L - Lecture T – Tutorial P – Practical C – Credit

Course contents

A. Practical Based on MBOE405

1. Identification of Key stone species.
2. To study phytoplankton and benthos in aquatic bodies.
3. Analysis of water for dissolved oxygen.
4. Estimation of biological oxygen demand and chemical oxygen demand.
5. Case study of any hydroelectric power project in Uttarakhand with EIA prospective using remote sensing and GIS.

B. Practical Based on MBOE406

1. Field inspection of seed crops and visual examination of seeds for infections.
2. Seed soaking for the detection of certain seed borne pathogens (fungi) and nematodes.
3. Seed washing tests and incubation methods.
4. Seedlings symptomatology tests.
7. Detection of bacteria by Agar Plate methods.
8. Viruses : Physical examination, Grow out tests, Enzyme linked immunoabsorbent assay (ELISA) and Polymerase Chain Reaction (PCR).
9. Visit to seed processing plants and seed testing laboratory.
10. Reduction of seed inoculum by chemical seed treatments.
11. Testing amount of pesticides in treated seeds

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Gain understanding of seed soaking method for the detection of seed borne pathogens
CO2	Learn identification of key stone species
CO3	Enumerate phytoplankton and benthos from aquatic bodies

CO4	Apply agar plate method for the detection of bacteria
CO5	Execute and estimate and analyse BOD, COD and DO of water.

Suggested Textbook

1. Frank, B. Friedman. 2011. A Practical guide to Environmental Management. 11th ed. Environment Law Institute.
2. Ram Prakash, Archana Sharma, O.P. Chaubey. Seed Technology and Seed Pathology. Pointer Publisher, Jaipur.

Reference Book

1. Khullar and Rao. 2021. Environment and Disaster Management. McGraw Hill Education India Pvt. Ltd.

Course code : MBOS 408				
Course Name : Analytical Techniques in Plant Sciences				
Semester /Year : IV				
	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives: The objectives of this course are

1. To gain the knowledge on various techniques and instruments used for the study of plant biology.
2. Understanding of principles and use of light, confocal transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques.

Course contents

Unit 1: (No. of Hours: 15)

Imaging and related techniques

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: (No. of Hours: 8)

Cell fractionation

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl2 gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: (No. of Hours: 8)

Radioisotopes

Use in biological research, auto-radiography, pulse chase experiment.

Spectrophotometry

Principle and its application in biological research.

Unit4: (No. of Hours: 14)

Chromatography

Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ionexchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Characterization of proteins and nucleic acids. Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Unit 5: **(No. of Hours: 15)**

Biostatistics

Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO 1	Learn about principles of different types of microscopy; types of centrifugation, spectrophotometry, chromatography; techniques of characterization of proteins and nucleic acids; use of radioisotopes in biological research; preliminary biostatistics.
CO 2	Able to use electrophoresis and Blotting techniques for DNA, RNA, and, protein characterization, paper chromatography for nitrogenous bases separation by, layer chromatography for sugar separation, prepare slides for microscopic studies
CO 3	Understand principles and technicality of Mass spectroscopy, X-ray diffraction, X-ray crystallography and various types of electrophoresis techniques.
CO4	Execute the applications of paper chromatography, column chromatography, TLC, GLC, HPLC

Suggested Textbooks:

1. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A
2. S.D. Ramteke and J.H. Meshram. (2019). Plant Analytical Techniques, p236, Daya Publication House, New Delhi

Reference Books:

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw- Hill Publishing Co. Ltd. New Delhi. 3rd edition.
2. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rd edition.
3. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

Course code : MBOS 409				
Course Name : Nursery and Gardening				
Semester /Year : IV				
	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives: The objectives of this course are

1. To gain knowledge of gardening, cultivation, multiplication, raising of seedlings of ornamental plants.
2. Students would have an understanding of:

a. How nursery of the plants is prepared?
b. How rooting is promoted in the stem cuttings?
c. How seeds are stored and what are the soil conditions for seed sowing and seedling growth?
d. How landscaping is designed?

Course content

Unit 1: **(No. of Hours: 4)**

Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.

Unit 2: **(No. of Hours: 6)**

Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion – Seed production technology - seed testing and certification.

Unit 3: **(No. of Hours: 6)**

Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants – green house - mist chamber, shed root, shade house and glass house.

Unit 4: **(No. of Hours: 8)**

Gardening: definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering,

management of pests and diseases and harvesting.

Unit 5: **(No. of Hours: 6)**

Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO 1	Understand the definition, objectives and scope of Nursery and Gardening
CO 2	Knowledge about the structure and types of seed,
CO 3	Learn the methods of vegetative propagation.
CO4	Learn the definition, objectives and scope of different types of gardening
CO5	Observe, think and measure sowing and raising of seeds and seedlings, transplanting and cultivation of seedlings and marketing procedures of the following vegetables:

Suggested Textbooks

1. Bose T.K. & Mukherjee, D., 1972, Gardening in India, Oxford & IBH Publishing Co., New Delhi.
2. Sandhu, M.K., 1989, Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.
3. Kumar, N., 1997, Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.

Reference Book

1. Edmond Musser & Andres, Fundamentals of Horticulture, McGraw Hill Book Co., New Delhi.
2. Agrawal, P.K. 1993, Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National _Seed Corporation Ltd., New Delhi.