SHRI GURU RAM RAI UNIVERSITY

PATELNAGAR, DEHRADUN-UTTARAKHAND-248001

[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)

National Education Policy-2020

School of Basic & Applied Sciences

(w.e.f. 2025-2026)

Master of Science (Botany)

Programme outcome (POs)

The student will be able to:

PO 1	In depth understanding of operational aspects, principles and objectives of botany and Allied Sciences.
PO2	Understand ethical issues, academic and research ethics, the need and value of lifelong learning, and the scientific misconduct of a scientist to serve society.
PO3	Understand the contribution of scientific knowledge in environmental contexts for sustainable development.
PO4	Demonstrate the professional botanical solutions in societal and environmental contexts, with the knowledge and need for sustainable development
PO5	Identify the situation-based problems, formulation, and action is taken based on analytical thinking and principles of science
PO6	Execute effective communication through interactive and presenting skills, technical report writings, and proper documentation of ideas.
PO7	Formulate, design, experimental techniques, scientific tools, analysis of scientific data, interpretation of data, and establish a hypothesis for various interdisciplinary research problems.
PO8	Enables individuals to function effectively in cross-cultural environments as an individual, and as a member or leaders.
PO9	Enhance and adopt employability skills through research, internship, and dissertation.
PO10	Implement strong theoretical and practical knowledge of botany to solve complex scientific problems
PO 11	Create a new conceptual, theoretical and operational approach to address various problems in interdisciplinary fields
PO12	Generate a culture of life-long learning in an inclined environment to achieve personal and enhance their employability for jobs in different sectors

Program Specific Outcome (PSOs)

PSO 1	Knowledge about the basics and advanced aspects of cryptogamic botany. 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.
PSO2	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.
PSO3	Identify various life forms of plants, design and execute experiments related to basic and applied studies.
PSO4	Evaluating the efficiency of various technologies and developing entrepreneurial and job-oriented skills needed in research, consultancy, forest service and industry

Eligibility for admission:

Any candidate who has passed the B. Sc. with Botany as one of the subjects 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 80 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 10 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	Course Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC101	Mycology and Microbiology	3	0	0	3	40	60	100
2	Core	MBOC102	Phycology and Bryology	3	0	0	3	40	60	100
3	Core	MBOC103	Pteridology, Gymnosperm and Paleobotany	3	0	0	3	40	60	100
4	Core	MBOC104	Taxonomy and Diversity of Flowering Plants	3	0	0	3	40	60	100
Practical										
1	Core	MBOL105	Laboratory Course I Based on C101&C102	0	0	4	4	40	60	100
2	Core	MBOL106	Laboratory Course II Based on C103&C104	0	0	4	4	40	60	100
			Total	12		8	20	240	360	600

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

Second Semester

S. N.	Course Category	Course 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	3	0	0	3	40	60	100
2	Core	MBOC202	Resource Utilization, IPR and Ethnobotany	3	0	0	3	40	60	100
3	Core	MBOC203	Cytogenetics and Molecular Biology	3	0	0	3	40	60	100
4	Core	MBOC204	Plant Breeding and Biostatistics	3	0	0	3	40	60	100
Practical										
1	Core	MBOL105	Laboratory Course I Based on C101&C102	0	0	4	4	40	60	100
2	Core	MBOL106	Laboratory Course II Based on C103&C104	0	0	4	4	40	60	100
			Total	12		8	20	240	360	600

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

Third Semester

S. No.	Course Category	Course Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC301	Plant Physiology and Biochemistry	3	0	0	3	40	60	100
2	Core	MBOC302	Ecology and Remote Sensing	3	0	0	3	40	60	100
3	Elective-I	MBOE304/ 305	Palynology and Pollination Biology/Fresh water algal flora of Himalaya	3	0	0	3	40	60	100
4	Elective-II	MBOE306/ 307	Plant Health Management/ Environment microbiology	3	0	0	3	40	60	100
Practical										
1	Core	MBOL 303	Laboratory Course – I Based on C301&C302	0	0	4	4	40	60	100
2	Elective	MBOL308	Laboratory course-II Based on E304/305/306/307	0	0	4	4	40	60	100
3	Self-study qualifying Not included while calculating Grade	MBOS309/ 310/311	Forest Ecology/Introduct-ion to medicinal and aromatic plants/ Pathogens and pests of crop Plants	3	0	0	3	40	60	100
			Total	12	0	8	20	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	Course Code	Course Name	Periods				Evaluation scheme		
				L	T	P	C	Sessional (Internal)		
Theory										
1	Core	MBOC401	Conservation Biology	3	0	0	3	40		
2	Core	MBOC402	Biotechnology and Genetic Engineering of Plants and Microbes	3	0	0	3	40		
3	Elective	MBOE404	Dissertation	0	0	10	10	60		
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		
5	Elective	MBOE406	Seed Technology	3	0	0	3	40		
Practical										
1	Core	MBOL403	Laboratory Course – I Based on C401&C402	0	0	4	4	40	60	100
2	Elective	MBOL407	Laboratory Course II Based on E405/406	0	0	4	4	40	60	100
3	Self-Study	MBOS 408/409	Analytical Techniques in Plant Sciences/ Nursery and Gardening	3	0	0	3	40		
			Total	6+6	0	10+8	20	180+240		

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

Total Credits = 80 (Core Credits 60 + Elective Credits 20) with additional 3 Credits of Self Study*

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 Semester				
	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

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

Course Objectives: The objectives of this course-

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 macro fungi and demonstrate a working knowledge of how fungi grow and reproduce, and where and how they can be isolated.

Course contents

Unit 1- History of Mycology; India and abroad, General characters of Fungi: Substrate relationship in fungi; Cell ultra-structure; unicellular and multi cellular organization, nutrition (saprobic, biotrophic, symbiotic); reproduction (vegetative, asexual, sexual); Recent trends in the classification. Phylogeny of Fungi; General account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina; Fungi in industry, medicine and as food. Mycorrhizal Fungi as biocontrol agents. **(No. of Hours: 12)**

Unit 2- Symptoms, causal organisms of plant pathogens belonging to various fungal sub-division *i.e.* Mastigomycotina, Zygomycotina, Acomycotina, Basidiomycotina and Deuteromycotina. **(No. of Hours: 10)**

Unit 3- A brief history of Microbiology, the diversity of micro-organisms, microbial growth. Archaebacteria and Eubacteria: General account; ultrastructure, nutrition and reproduction; biology and economic importance; Cyanobacteria- classification, salient features and economic importance. **(No. of Hours: 9)**

Unit 4- Viruses: Characteristics; isolation and purification of viruses; chemical nature, replication, Transmission of viruses; economic importance. Phytoplasma: General characteristics and role in causing plant diseases. (e.g. sandal spike disease, sesamum phyllody, little leaf of brinjal). **(No. of Hours: 8)**

Unit 5- Immunology: Structure of antigens and antibodies, antigen-antibody reaction, Mechanism of antigen-antibody reactions. Vaccines and toxoids, Hypersensitivity. **(No. of Hours: 6)**

Course outcomes (COs):

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

CO1	Describes the history, concept and scope of mycology & Microbiology.
CO2	Estimates the general characters and structural organization of Fungi and Microbes.
CO3	Explain about the symptoms and causal organisms of various fungal and Microbial diseases of plants.
CO4	Analyze the importance of the characteristics, mode of reproduction and economic importance of Microbes, update the knowledge of basic of immunology.
CO5	Summarized the basic concept of fungi and microbes.
CO6	Generalized the knowledge about the Mycology and Microbiology.

Suggested Books:

1. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (2010). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
3. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi, India.
4. Pandey, S.N and Trivedi, P.S. (2015). A text book of Botany Vol. I Vikas publishing House Pvt/ Ltd, New Delhi.
5. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
6. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
7. Mehrotra, R.S. and Aneja, R.S. An Introduction to Mycology. New Age Intermediate Press.
8. Dubey, R.C. & D.K. Maheshwari. A text book of Microbiology. S. Chand& Co. New Delhi.

Reference Books:

1. Pearson Benjamin Cummings, U.S.A. 13th edition.
2. Willey, Joanne, Sherwood, Linda, Woolverton, Christopher J.(2017). Prescott's Microbiology. McGraw Hill New York, 11th edition.
3. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition
4. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
5. Alexander, M.(1991). Microbial Ecology. John Wiley and Sons. New York.
6. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
7. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V.,

Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
8. Frazier, W.C. & D.C. Westhoff. (2008).Food Microbiology. Tata McGraw Hill
9. Tortora, G. J., Funke, B.R. and Case C.L. (2021). Microbiology: An Introduction Benjamin Cummings, U.S.A. 10th edition

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	3	0	2	2	0	0	1	2	1	0	3	3	3	0	2
CO2	3	0	2	3	3	2	2	1	3	2	2	3	1	1	2	2
CO3	2	2	2	2	2	0	3	2	2	3	1	2	1	1	2	3
CO4	1	3	2	2	2	0	0	1	3	2	2	2	2	3	0	1
CO5	2	3	2	0	2	0	3	1	3	2	0	1	2	3	0	3
CO6	3	2	1	2	3	2	2	2	3	2	2	1	3	2	2	3

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

Course code	**: MBOC 102**			
Course Name	**: Phycology and Bryology**			
Semester /Year	**: I Semester**			
	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 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

Unit 1- Algal habitats, Algal Classification, Criteria for classification of algae: pigments, reserve food and flagella, thallus organization, cell structure and reproduction (vegetative, asexual and sexual), Phylogeny and interrelationships of algae. **(No. of Hours: 12)**

Unit 2- Classification and salient features of Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta and Cyanophyta. **(No. of Hours: 12)**

Unit 3- Nitrogen fixating algae, parasitic algae, Economic importance of Algae, Algal blooms, algal Biofertilizers, algae as food, feed, as Fuel and uses in industry. **(No. of Hours: 3)**

Unit 4- Morphology, structure reproduction, life history and Classification of Bryophyta, Ecology of bryophytes, their association with other organisms, Economic importance of Bryophytes, Fossil bryophytes, Knowledge of the distribution of bryophytes in the Himalaya. **(No. of Hours: 10)**

Unit 5- General account of Marchantaials, Jungermanniales, Calobryales, Sphaerocarpales and Anthocerotales, Sphagnales, Andreales, Funariales and Polytrichales. **(No. of Hours: 12)**

Course outcomes (COs):

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

CO1	Knows about the habitats of algae and bryophyte, their general characters, classification, occurrence and reproduction.
CO2	Summarized the thallus organization, cell structure, classification and reproduction of algae and bryophyte.
CO3	Explain the phylogeny, morphology, reproduction, life history and economic importance of algae and Bryophytes.
CO4	Analyze the applications of algae and bryophytes with their uses.
CO5	Evaluate the skills related to laboratory as well as industries-based studies.
CO6	Elaborate the knowledge related to algae and Bryophytes.

Suggested Textbooks

1. B.N. Vashishta, B.R., A.K. Sinha and A. Kumar. 2010. Algae. S. Chand and Co. Ltd. Delhi.
2. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
3. Fritsch, F.E. (1979). The Structure and Reproduction of Algae. Reprint. Bishen Singh Mahendra pal Singh, Dehradun.
4. Kashyap, S.R. (2017). Liverworts of the Western Himalayas and Punjab Plains. The Chronica Botanic Co. Delhi.
5. Kumar, H.D. (2004). Introductory Phycology. Affiliated East-West Press Ltd., New Delhi.
6. Parihar, N.S. (1991). Bryophyta. Central Book Depot, Allahabad.

Reference Books

1. Presscott, G.W. Algae: A Review. Bishen Singh Mahendra pal Singh.
2. Puri, P. (2011). Bryophytes. Atma Ram Sons, Delhi.
3. Ram Udar. Fifty years of Bryology in India. Golden Jubilee Series. IBS, New Delhi.
4. Smith, G. M. (2020). Cryptogamic Botany. Vol. I and II. Tata McGraw Hill, New Delhi.
5. Vashishta, B.R. (2010). Botany for degree students. Bryophytes 8th ed. S. Chand and Co. Ltd. Delhi.
6. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
7. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.
8. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
9. Vander-Poorteri (2009). Introduction to Bryophytes. COP.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PSO 3	PSO4
CO1	1	2	0	0	1	0	0	1	3	2	0	2	1	2	1	3
CO2	0	1	0	0	2	1	1	2	2	1	2	3	0	3	2	0
CO3	0	1	0	0	2	0	2	0	2	1	2	3	2	2	3	1
CO4	0	3	0	2	1	0	0	0	2	3	2	2	3	3	2	2
CO5	2	2	0	2	3	2	0	2	3	3	1	2	3	2	3	2
CO6	2	3	0	2	2	2	2	3	1	3	2	2	2	1	1	3

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

Course code	**: MBOC 103**			
Course Name	**: Pteridology, Gymnosperm and Paleobotany**			
Semester /Year	**: I Semester**			
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. 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 Paleobotany

Course contents

Unit 1- History, origin, classification, present and past distribution, morphology and life history of Psilophyta: Psilophytales (*Psilophyton*) and Psilotales (*Psilotum*). Lycophyta: Lepidodendrales (*Lepidodendron*), Lycopodiales (*Phylloglossum*), Lepidospermales (*Lepidocarpon*) and Isoetales (*Isoetes*). Sphenophyta: Hyeniales, Sphenophyllales and Calamitales. Pterophyta: Ophioglossales, Osmundales, Filicales and Salviniales. **(No. of Hours: 18)**

Unit 2- Classification and distribution of Gymnosperms in India with special reference to Himalaya region. Morphology, structure and life-history of Pteridospermales: Palaeozoic andMesozoic groups with references to Lyginopteridaceae (*Lyginopteris*) and Medullosaceae (*Trigonocarpus*). **(No. of Hours: 8)**

Unit 3- A general account of Glossopteridaceae. Bennettitales: A general account of Cycadeoidaceae, William soniaceae and Wielandiellaceae. Cycadales: A detailed account including distribution of living Cycads. **(No. of Hours: 8)**

Unit 4- A general account of Pentoxylales, Cordaitales, Ginkgoales (*Ginkgo),* Ephedrales, Welwitschiales and Gnetales. A general account of fossil and living Coniferales and Taxales. Economic importance of Gymnosperms. **(No. of Hours: 6)**

Unit 5- Definition of fossil, different types of plant fossil as per their mode of preservation, concept of form genus. Indian Gondwana Sequence, Introductory idea of Continental Drift Hypothesis. **(No. of Hours: 5)**

Course outcomes (COs):

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

CO1	Describe about the history, origin, classification of Pteridophytes and Gymnosperms in India with special reference to Himalaya.
CO2	Generalizes the history origin, classification, distribution, morphology and life history of Pteridophyte and Gymnosperms.
CO3	Explain Illustrate and design the morphology, structure and life history of Pteridophytes and Gymnosperms with their economic importance.
CO4	Analyze the scope of Pteridophyte, Gymnosperms, Paleobotany, types of fossils, its role in global economy and geological time scale.
CO5	Summarized the history, origin, classification of Pteridophytes and Gymnosperms.
CO6	Express the knowledge related to Pteridophyte and Gymnosperms.

Suggested Textbooks

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India
3. Andrews, HN. 1961. Studies in Paleobotany. New York.
4. Baker, J.G. (2018). Hand book of the Fern Allies. Reprint. Bishen Singh Mahendra Pal Singh, Dehradun.
5. Bhavnagar, S.P. and Moitra, A. (2020). Gymnosperms. New Age International (P) Ltd. Publisher, P480.
6. O.P. Sharma. (2017). Pteridophyte. McGraw Hill Education.
7. Parihar, N.S. 1996. Biology & Morphology of Pteridophytes. Central Book Depot Allahabad.

Reference Books

1. Sahni, K.C. 1996. Gymnosperms of India and Adjacent Countries. Bishen Singh Mahendra pal Singh, Dehradun.
2. Seward, A.C. (2011). Fossil Plants for Students of Botany and Geology. 4Vols. Cambridge.
3. Chamberlain, C.J. (2017). Gymnosperms: Structure and Evolution. Chicago.
4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	0	2	0	2	1	1	0	2	3	2	1	2	3	2	0	0
CO2	2	0	1	0	3	2	2	0	3	2	1	2	3	0	3	3
CO3	1	0	0	2	3	0	2	2	2	3	2	2	3	0	3	2
CO4	0	3	1	3	2	2	0	0	2	3	2	2	2	3	2	0
CO5	3	2	2	3	2	2	2	3	2	2	1	2	2	0	2	3
CO6	3	2	3	2	2	2	2	3	2	2	1	2	2	1	2	3

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

Course code	**: MBOC 104**			
Course Name	**: Taxonomy and Diversity of Flowering Plants**			
Semester /Year	**: I Semester**			
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. This course aims to add the understanding about the diversity of plants, their Description, Identification, Nomenclature and their classification including recent advances in the field.

Course contents

Unit 1- Origin of intra-population variation: Population and the environment; ecads and ecotypes; evolution and differentiation of species- various models. 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: 8)**

Unit 2- Salient features of the International Code of Botanical Nomenclature. Taxonomic evidences and Taxonomic tools: anatomy, palynology, embryology, Photochemistry, histological, serological and molecular-techniques. Herbarium and Botanical gardens: General account. **(No. of Hours: 7)**

Unit 3- Systems of angiosperm classification: Phenetic versus phylogenetic systems; cladistics sin taxonomy; major systems of classification (Bentham and Hooker, Hutchinson, Cronquist) and their relative merits and demerits. **(No. of Hours: 8)**

Unit 4- A study of the following families and their relationships:

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 a real so expected to have a complete knowledge of families which they have studied at under graduate syllabus of this University.

(No. of Hours: 20)

Unit 5- Plant exploration in India with reference to North West and Uttarakhand Himalaya. Status of flowering plant diversity in Garhwal Himalaya region. **(No. of Hours: 2)**

Course outcomes (COs):

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

CO1	Recognized in-depth knowledge of the salient features, origin, and evolution of angiosperms.
CO2	Explain the various systems of plant classification and their distinguishing characteristics.
CO3	Apply the key principles of the International Code of Botanical Nomenclature (ICBN/ICN), species concepts, taxonomic hierarchy, and the processes involved in the delimitation and ranking of taxa.
CO4	Analyse the plants taxonomically, using standard diagnostic characters and terminology.
CO5	Summarized the skills in plant inventory, field exploration, species identification, and strategies for plant conservation.
CO6	Apply the foundational concepts of plant taxonomy, particularly in relation to flowering plants.

Suggested Textbooks

1. Singh S. K. and singh M.P. (2022). Taxonomy of Angiosperms, Publisher Pravalika publications Prayagraj.
2. Babu, C.R. (1976). Herbaceous Flora of Dehradun. CSIR, New Delhi.
3. Gaur, R.D. (1999). Flora of District Garhwal: NW Himalaya. Transmedia, Srinagar, Garhwal.
4. Jain, S.K. and Rao, R.R. (2016). A handbook of Field and Herbarium methods. Today and Tomorrow, 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 21 Century. Portlant Press Ltd., London.
3. Takhtajan, A.L. (1997). Diversity and Classification of Flowering Plants. Columbia University Press, New York.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	0	2	0	2	1	1	0	2	3	2	1	2	3	2	0	0
CO2	2	0	1	0	3	2	2	0	3	2	1	2	3	0	3	3
CO3	1	0	0	2	3	0	2	2	2	3	2	2	3	0	3	2
CO4	0	3	1	3	2	2	0	0	2	3	2	2	2	3	2	0
CO5	3	2	2	3	2	2	2	3	2	2	1	2	2	2	2	3
CO6	3	2	3	2	2	2	2	3	2	2	1	2	2	1	2	3

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

Course code : MBOL 105				
Course Name : Laboratory Course-I				
Semester /Year : I Semester				
	L	**T**	**P**	**C**
	0	**0**	**4**	**4**

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 airflow.
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, Enteromorpha, Drapernaldiopsis, Stigeoclonium, Fritschiella, Coleochaete,Bulbochaete, Cosmarium, Caulerpa, Nitella, Dictyota, Gelidium, Gracillaria, Batrachospermum* and *Polysiphonia.*
7. Study and identification with suitable preparations of *Ricciocarpus, Targionia, Cyathodium, Plagiochasma, Asterella (Fimbriaria), Dumortiera, Sewardiella, Pellia, Fossombronia, Porella, Reccia, Anthocerose, Marchentia, Calobryum, Notothylas, Sphagnum, Polytrichum* and *Funaria.*

Course outcomes (COs):

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

CO1	Recall the knowledge of different genera belong to different classes of fungi, Microbes, Algae and Bryophytes.
CO2	Explain about different instruments and lab safety rules.
CO3	Apply the methods of isolation and identification.
CO4	Analyze the agar plate technique for isolation, enumeration and identification of microbes.
CO5	Reframe the identification and Isolation of fungi, Algae and Bryophytes.
CO6	Create the knowledge of media preparation, isolation and identification fungi, Algae and Bryophytes.

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.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	0	2	0	2	1	1	0	2	3	2	1	2	3	2	0	0
CO2	2	0	1	0	3	2	2	0	3	2	1	2	3	0	3	3
CO3	1	0	0	2	3	0	2	2	2	3	2	2	3	0	3	2
CO4	0	3	1	3	2	2	0	0	2	3	2	2	2	3	2	0
CO5	3	2	2	3	2	2	2	3	2	2	1	2	2	0	2	3
CO6	3	2	3	2	2	2	2	3	2	2	1	2	2	1	2	3

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

Course code	**: MBOL 106**			
Course Name	**: Laboratory Course-II**			
Semester /Year	**: I Semester**			
	L	**T**	**P**	**C**
	0	**0**	**4**	**4**

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

Course contents

Study and identification with suitable preparations of the following:

1. Pteridophytes- *Psilotum, Isoetes, Ophioglossum, Osmunda, Polypodium, Azolla, Salvinia* and important fossil types.
2. Gymnosperms- *Cycas, Ginkgo, Abies, Cedrus, Cryptomeria, Cupressus, Podocarpus, Cephalotaxus, Araucaria, Taxus*, and *Gnetum*.
3. Paleo botany- Study of available fossil flora through specimens and slides, etc.
4. Taxonomy- 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.
5. Description of a species based on various specimens to study intra specific variation.
6. Studies of Indore the location of key characters and preparation of keys at generic level.
7. 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	Recall the knowledge of different genera belong to different classes and orders of Pteridophyte and Gymnosperms, Angiosperm and fossil plants.
CO2	Estimate the morphology of plants through live potted specimens.
CO3	Apply 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.
CO5	Justify the knowledge of Pteridophyte and Gymnosperms, Angiosperm and fossil plants.
CO6	Design report preparation of Field trips, compilation of field notes, the preparation of museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report.

Suggested Textbooks

1. Bhavnagar, S.P. and Moitra, A. (2020). Gymnosperms. New Age International (P) Ltd. Publisher, P480.
2. O.P. Sharma. (2017). Pteridophyte. McGraw Hill Education.

3. Rajan Sundara, S. (2021). Practical Manual of Angiosperm Taxonomy. Anmol Publication Pvt. Ltd.

Reference Book

1. Chitranjan Mohanty. (2018). Bryophytes, Pteridophyte, Gymnosperm and Palaeobotany, Kalyani Publisher.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	0	2	0	2	1	1	0	2	3	2	1	2	3	2	0	0
CO2	2	0	1	0	3	2	2	0	3	2	1	2	3	0	3	3
CO3	1	0	0	2	3	0	2	2	2	3	2	2	3	0	3	2
CO4	0	3	1	3	2	2	0	0	2	3	2	2	2	3	2	0
CO5	3	2	2	3	2	2	2	3	2	2	1	2	2	0	2	3
CO6	3	2	3	2	2	2	2	3	2	2	1	2	2	1	2	3

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

Course code	**: MBOC 201**			
Course Name	**: Plant Development and Reproductive Biology**			
Semester /Year	**: II Semester**			
	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. 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

Unit 1- Seed germination and seedling growth: Mobilization of food reserves; tropisms; hormonal control of seedling growth. Shoot development: Organization of the shoot apical meristem (SAM); cytological and molecular analysis of SAM; control of cell division and cell to cell communication. 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: 12)

Unit 2- Leaf growth and differentiation: Origin, development and Phyllotaxy. Cambium and its functions: formation of secondary xylem; general account of wood structure in relation to conduction of water and minerals. **(No. of Hours: 6)**

Unit 3- 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)

Unit 4- Malegametophyte: Structure of anthers; micro sporogenesis, role of tapetum; pollen development and gene expression. Female gametophyte: Ovule development; Megasporogenesis; organization of the embryo sac. 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: 12)

Unit 5- Seed development and Fruit growth: Endosperm development; embryogenesis, polyembryony; Apomixis, biochemistry and molecular biology of fruit maturation. Importance and types of seed dormancy, overcoming seed dormancy, bud dormancy. Basic concept and 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: 11)

Course outcomes (COs):

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

CO1	Describe the process of Plant Development and Reproductive Biology.
CO2	Generalized the organization and differentiation of shoot with reference to SAM and RAM, male and female gametophyte, ovule structure.
CO3	Explain the reproduction process, Seed development and Fruit growth.
CO4	Analyzed the differentiation and arrangement of leaf, shoot and root.
CO5	Summarized the growth and development of root, shoot, leaf, and seed.
CO6	Generalized the developmental process and organization of plant reproductive organs.

Suggested Textbooks

1. Bhojwani, S.S. and Bhatnagar, S.P. 2010. The Embryology of Angiosperms (5th 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. Johri, B.M. (2011). Embryology of Angiosperms. Springer-Verlag, Berlin
4. Maheshwari, P. (2008). An Introduction to Embryology of Angiosperms. McGraw Hill Book Co. London.
5. Raghavan, V. (1999). Developmental Biology of Flowering Plants. Springer-Verlag, NewYork.

Reference Books

1. Bewley, J.D. and Black, M. (1994). Seeds: Physiology of Development and Germination. Plenum Press, New York.
2. Burgess, J. (1989). An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
3. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi
4. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	3	0	3	2	0	0	2	3	2	0	0	3	0	3	2
CO2	2	0	2	2	3	2	1	2	3	0	3	3	2	2	2	3
CO3	3	2	2	3	2	0	2	3	3	0	3	2	2	0	2	2
CO4	0	3	2	2	3	0	0	2	2	3	2	0	3	2	1	3
CO5	2	2	2	0	2	0	3	2	2	0	2	3	2	2	2	2
CO6	3	2	0	3	2	2	2	3	2	1	2	3	2	3	3	2

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

Course code	**: MBOC 202**			
Course Name	**: Resource Utilization, IPR and Ethnobotany**			
Semester /Year	**: II Semester**			
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 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

Unit 1- Plant resources: Concept, status, utilization and concerns. World Centers of Primary Diversity of domesticated plants Origin, evolution, botany, cultivation, cyto-taxonomy and uses of (i) Cereals and millets (wheat, paddy, maize), (ii) Legumes (soybean, black gram and cow peas), (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)**

Unit 2- Important fire wood and timber yielding plants and non-wood forest products (NWFPs) such as bamboos, gums, tannins, dyes, resins, beverages. Plants used as ornamentals and avenue trees. **(No. of Hours: 06)**

Unit 3- Intellectual Property Rights, Concept, History, Protection of IPR; Patent-requirements, procedures and limitations; International convention on Biological Diversity. **(No. of Hours: 06)**

Unit 4- Ethnobotany: Concept, linkage with other sciences, tools of ethnobotanical studies world and Indian perspective with special reference to the Himalayas, Green revolution: Benefits and adverse consequences. **(No. of Hours: 04)**

Unit 5- Principles of conservation: Extinction; Status of plants based on International Union for Conservation of Nature (IUCN). 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	Recalls and define the concepts of Plant resources its economic value and conservation
CO2	Distinguished and classify the diversity and uses of plants in different aspects
CO3	Explain and develop a basic knowledge of important families of useful plants.
CO4	Analyze the concept of IPR, various legal issues related to IPR.
CO5	Summarized the concept of ethno-botany and folk medicines.
CO6	Generalized the basic concepts of Resource Utilization, Conservation and Ethnobotany

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. Kochar, S.L. (2012). Economic Botany in the Tropics. MacMillan India Ltd. Delhi
4. Kothari, A. (2018). Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.

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. 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.
3. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
4. Chrispeels, M.J. and Sadava, D.E. (2003). Plants, Genes and Agriculture. Jones & Bartlett Publishers.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	0	2	2	2	2	0	1	3	2	1	1	3	1	3	3
CO2	0	3	2	2	1	0	2	2	0	2	0	3	2	2	2	2
CO3	3	2	2	3	2	2	3	0	3	1	3	2	0	2	2	3
CO4	2	1	2	2	2	1	1	3	2	3	2	1	3	2	1	2
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	0
CO6	3	3	2	3	1	2	2	2	1	3	2	3	2	3	3	2

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

Course code	**: MBOC 203**			
Course Name	**: Cytogenetics and Molecular Biology**			
Semester /Year	**: II Semester**			
	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 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, epigenetic, 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

Unit 1-The dynamic cell: Structural organization of the plant cell, specialized plant cell, Structure and functions of Cell wall, Structure, models and functions of Plasma membrane, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. **(No. of Hours: 8)**

Unit-2- Structure, function and organization of Cell Organelles**;** Mitochondria, Chloroplast, Nucleus, Ribosome, Golgi Bodies, Endoplasmic Reticulum. **(No. of Hours: 12)**

Unit 3- Chromatin organization; Chromosome structure and packaging of DNA, Operon, trip Operon, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons, specialized types of chromosomes; Polytene, Lampbrush, B-chromosomes, DNA damage and repair mechanism. **(No. of Hours: 8)**

Unit 4- Principles of inheritance: Mendelian laws along with molecular explanations, Exceptions to Mendelian laws, lethal alleles and Gene Interactions. Structural and numerical alterations in chromosomes, Aneuploids, Euploids, Trisomics and Monosomics. Mutations: Spontaneous and induced mutations, physical and chemical mutation, molecular basis of gene mutation.

(No. of Hours: 7)

Unit 5- Genetic material (DNA: Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material); DNA replication (Prokaryotes); Transcription (Prokaryotes) Types of structures of RNA (mRNA, t RNA, r RNA); Translation (Prokaryotes), Regulation of gene expression (Prokaryotes: Lac operon and Tryptophan operon). **(No. of Hours: 11)**

Course outcomes (COs):

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

CO1	Knows the concept of cytogenetics and molecular biology and pattern of inheritance in various life forms.
CO2	Generalized the fundamental basics of cell structure, inheritance and genetics on molecular level.
CO3	Apply the knowledge about the plant cell structure, Cytogenetics and molecular biology.
CO4	Explain the principal mechanisms of genome replication, Genetic recombination, maintenance, function and regulation of expression.
CO5	Summarized the knowledge of Cytogenetics and molecular biology in designing experiment and statistical analysis.
CO6	Develop the concept of Cytogenetics and molecular biology

Suggested Textbooks

1. Buchanan, B.B., Gruissem, W, W, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryl and, USA.
2. Gupta, P.K.(2007). Cytogenetics. Rastogi Publications. Meerut.

Reference Books

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D.(1989). Molecular Biology of the Cell (2edition). Garland Publishing Inc., New York.
2. Atherly, A.G., Girton, J.R. and McDonald, J.F.(1999). The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
3. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
4. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
5. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
6. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	0	0	2.	0	0	1	3	2	0	2	1	2	1	3
CO2	3	1	2	3	2	2	2	2	2	0	2	3	2	3	2	2
CO3	1	1	2	0	2	2	2	0	2	1	2	3	2	2	3	1
CO4	2	3	3	2	1	0	1	1	2	3	2	2	3	3	2	2
CO5	2	2	0	2	3	2	0	2	3	3	1	2	3	2	3	2
CO6	2	3	0	2	2	2	2	3	1	3	2	2	2	1	1	3

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

Course code	**: MBOC 204**			
Course Name	**: Plant Breeding and Biostatistics**			
Semester /Year	**: II Semester**			
	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 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 bio statistical tools.

Course contents

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

Unit 2- Self- incompatibility system, male sterility, Selection: Mass selection, Pure line selection, Hybridization: Interspecific and Inter generic, Bulk method, pedigree method, back-cross hybridization. **(No. of Hours: 8)**

Unit 3- Heterosis: Its genetic and physiological basis. Breeding for resistance to diseases, physiological races. Role of mutation in crop improving and evolution. **(No. of Hours: 6)**

Unit 4- Plant breeding work done in India with special reference to potato, paddy, wheat and sugarcane. Maintenance of collection, registration of varieties, seed production, testing, certification and distribution. **(No. of Hours: 9)**

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

(No. of Hours: 14)

Course outcomes (COs):

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

CO1	Describe the knowledge about the fundamental aspects of plant breeding and Biostatistics.
CO2	Estimates the experimental steps and methods involved in generating new varieties using classical and contemporary breeding practices
CO3	Explain the maintenance, registration, production, testing, certification and distribution of seeds. Illustrate the methods of plant breeding.
CO4	Analyze the application of plant breeding and statistical methods to conduct research
CO5	Summarized knowledge of plant breeding techniques and formulation of Biostatistics.
CO6	Generalized the all-concern area of plant breeding and Biostatistics.

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. 2Vols.
4. McDonald, M.B. 1997. Seed Production: Principles and Practices.
5. Bliss, C.I. 1967. Statistics in Biology. 2Vols. McGrawHill, NewYork.
6. Singh, R.K. 1994. Biometrical Techniques in breeding and Genetics. Bishen Singh Mahendra Pal Singh. Dehradun.
7. Watt, T. 1993. Introductory Statistics for Biology Students. Narosa, NewDelhi.

Reference Books

1. Sharma, J.R. 1994. Principles and Practice of Plant Breeding. Tata McGrawHill Publ. Co. Ltd. New Delhi.
2. Singh, B.D. 2002. Plant Breeding Principles and Methods. Kalyani Publ. New Delhi.
3. Winer, B.J. 1962. Statistical Principles in Experimental Design. McGrawHill, NY

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	0	2	2	2	2	0	1	3	2	1	1	3	1	3	3
CO2	0	3	2	2	1	0	2	2	0	2	0	3	2	2	2	2
CO3	3	2	2	3	2	2	3	0	3	1	3	2	0	2	2	3
CO4	2	1	2	2	2	1	1	3	2	3	2	1	3	2	1	2
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	0
CO6	3	3	2	3	1	2	2	2	1	3	2	3	2	3	3	2

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

Course code	**: MBOL 205**			
Course Name	**: Laboratory Course-I**			
Semester /Year	**: I Semester**			
L	**T**	**P**	**C**	
0	**0**	**4**	**4**	

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

Course contents

1. Effect of gravity, uni lateral light and plant growth regulators on the growth of young seedlings.
2. Role of dark and red light/far red light on the expansion of cotyledons and epicotyl hook opening in pea.
3. Study of cyto-histological 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.
4. 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.
5. 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.
6. 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.
7. 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.
8. Study of microsporogenesis and gametogenesis in sections of anthers.
9. Examination of modes of anther dehiscence and collection of pollen grains form microscopic
10. Examination (maize, grasses, *Cannabis sativa, Crotolaria, Tradescantia, Brassica, Petunia, Solanum melongena,* and locally available flowers).
11. Tests for pollen-viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures.
12. Pollen storage, pollen–pistil interaction, self-incompatibility, *in-vitro* pollination.
13. Study of ovules in cleared preparations. Study of monosporic, bi-sporic and tetra-sporic types of embryo sac development through permanent slides.
14. Field study of types of flowers with different pollination mechanisms (wind pollination, insect pollination, etc.).
15. Study of seed dormancy and methods to break dormancy.
16. Food crops: wheat, rice, maize, chickpea, potato, tapioca, sweet potato, sugarcane; morphology, anatomy and micro chemical tests for stored food materials.
17. Forage/fodder plants: Study of ten important fodder crops of the locality.
18. 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.
19. Medicinal and aromatic plants including narcotics and antibiotics.

20. Vegetable oils: Mustard, groundnut, soybean, coconut, sunflower and castor. Morphology, microscopic structure of oil yielding tissues, test for oil and iodine number.
21. 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	Define the topic related to plant anatomy, embryology and resource utilization.
CO2	Explain the entire topic related to plant anatomy, embryology and resource utilization.
CO3	Apply the Knowledge related to plant anatomy, embryology and resource utilization
CO4	Analyze the topic related to plant anatomy, embryology and resource utilization.
CO5	Evaluate the entire topic related to plant anatomy, embryology and resource utilization.
CO6	Generalized the Preparation of report related to plant anatomy, embryology and resource utilization.

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 Authors press.

Reference Books

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

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	0	0	2.	0	0	1	3	2	0	2	1	2	1	3
CO2	3	1	2	3	2	2	2	2	2	0	2	3	2	3	2	2
CO3	1	1	2	0	2	2	2	0	2	1	2	3	2	2	3	1
CO4	2	3	3	2	1	0	1	1	2	3	2	2	3	3	2	2
CO5	2	2	0	2	3	2	0	2	3	3	1	2	3	2	3	2
CO6	2	3	0	2	2	2	2	3	1	3	2	2	2	1	1	3

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

Course code	**: MBOL 206**			
Course Name	**: Laboratory Course-II**			
Semester /Year	**: I semester**			
	L	**T**	**P**	**C**
	0	**0**	**4**	**4**

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

Course contents

1. To study the different cell organelles of plant cell.
2. To Study of mitotic chromosomes in root tips and leaf buds and meiotic chromosomes in floral buds.
3. Estimation of amount of chlorophyll present in the leaf tissue.
4. Isolation of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.
5. Isolation of RNA and quantitation by spectro photometric method.
6. To Study of the different type of chromosomal aberration.
7. Genetical problems on Mendelian and post- Mendelian ratios, gene interactions, sex- linked inheritance.
8. To study the common plant breeding techniques.
9. To work out the mode of pollination in a given crop and extent of natural out-crossing.
10. Emasculation, bagging and hand pollination techniques to study pollen germination.
11. Identification of Indian varieties of important crops.
12. Floral biology of local food, pulse, vegetable and horti-cultural crops.
13. Collection of germplasm of different crops being grown in the area.
14. Study of techniques of bio metrical studies.
15. 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	Knows about the cytogenetics, molecular biology and Plant breeding.
CO2	Explain and perform experiment related to cytogenetics, molecular biology and Plant breeding.
CO3	Generalized the knowledge of cytogenetics, molecular biology and Plant breeding.
CO4	Illustrate the principal and application of cytogenetics, molecular biology and Plant breeding.
CO5	Analyze and the problems related cytogenetics, molecular biology and Plant breeding.
CO6	Develop the knowledge of the normal practices of cytogenetics, molecular biology and 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.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	0	2	3	1	2	1	2	3	3	1	2	2	1	2	0
CO2	2	1	1	2	0	1	2	2	3	1	3	3	2	2	3	2
CO3	2	2	1	3	2	2	1	2	3	0	3	2	1	0	2	3
CO4	3	3	2	1	2	2	1	2	2	3	2	1	3	2	2	3
CO5	2	0	3	1	2	3	2	2	2	0	2	3	2	3	0	2
CO6	2	1	3	2	3	2	2	2	2	2	3	3	2	3	2	3

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

Course code	**: MBOC 301**			
Course Name	**: Plant Physiology and Biochemistry**			
Semester /Year	**: III Semester**			
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. This course aims to educate student about the mechanism and physiology life processes in plants. It focuses 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

Unit 1. Concept of water potential, diffusion, osmosis and Imbibition. Principles of thermodynamics, redox reactions, structure and functions of ATP. Membrane transport and translocation of water and solutes, Plant-water relations, mechanism of water transport through xylem and transport in cells. **(No. of Hours:8)**

Unit 2. Biologically important molecules: Carbohydrates, Amino acids, Proteins and Lipids. Fundamentals of enzymology: General aspects of enzymes, allosteric mechanism, regulatory and active sites, isozymes, kinetic analysis. **(No. of Hours: 12)**

Unit 3. Photo physiology and photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, factors of photosynthesis. photo oxidation of water, Z scheme and photo phosphorylation, mechanism of electron transport, carbon assimilation – the Calvin cycle, photorespiration, C4 cycle, CAM pathway, **(No. of Hours: 10)**

Unit 4. 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)**

Unit 5. Nitrogen fixation, nitrogen and Sulphur metabolism: Overview, biological nitrogen fixation, nodule formation, mechanism of nitrate uptake and assimilation. Phytohormones and Sensory photobiology: History of discovery of phytochromes and cryptochromes, and their photochemical and biochemical properties. **(No. of Hours: 7)**

Course outcomes (COs):

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

CO1	Describe the concept of Plant Physiology and Biochemistry.
CO2	Explain the knowledge of Plant Physiology and Biochemistry.
CO3	Illustrate the experiments based on Plant Physiology and Biochemistry.
CO4	Analyze and classify the knowledge about Plant Physiology and Biochemistry.
CO5	Summarized the fundamentals and advanced aspects of Plant Physiology and Biochemistry.
CO6	Create and develop the knowledge of plant physiology and biochemistry.

Suggested Textbooks

1. Nobel, P.S. 1999. Physiochemical and Environmental Plant Physiology (Second edition). Academic Press, San Diego, USA.
2. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing Co., California, USA.
3. Taiz, L. and Zeiger, E. 1998. Plant Physiology (2nd edition). Sinauer Associates, Inc., Publishers, Massachusetts, USA.
4. 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. Hopkins, W.G. (2019). Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.
3. V.K. Jain. (2017). Plant Physiology. S. Chand Co. Pvt. Ltd.
4. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
5. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
6. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
7. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
8. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	0	0	2	0	0	1	3	2	0	2	1	2	1	3
CO2	3	1	1	3	2	1	2	0	2	0	2	3	2	3	2	2
CO3	1	1	2	0	2	0	2	2	2	1	2	3	2	2	3	1
CO4	2	3	0	2	1	3	0	0	2	3	2	2	3	3	2	2
CO5	2	2	2	1	3	2	0	2	3	3	1	2	3	2	3	2
CO6	2	3	3	2	2	2	2	3	1	3	2	2	2	1	1	3

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

Course code	**: MBOC 302**			
Course Name	**: Ecology and Remote Sensing**			
Semester /Year	**: III Semester**			
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 provide exposure to students in gaining knowledge on concepts and applications leading to modelling 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

Unit 1. Vegetation organization: Concepts of community and continuum; concept of ecological niche. 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: 8)**

Unit 2. Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies). Global bio geochemical cycles of C, N, P and S; mineral cycle (pathways, processes, budgets) in terrestrial ecosystems. **(No. of Hours: 8)**

Unit 3. 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. Biological diversity: Concepts and levels; role of biodiversity in ecosystem functions and stability, IUCN categories of threat; distribution in global patterns; terrestrial biodiversity hot spots; inventory. **(No. of Hours: 9)**

Unit 4. Soil: Definition, formation, profile and components and soil types of the world. 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). Fire as an ecological factor: Types, role of fire, extent and causes of fire in forest, grassland sand in tropical savanna, fuel load, controlled burning, fire in different forest types in Uttarakhand; fire as management tool. **(No. of Hours: 12)**

Unit 5. Remote Sensing: Concepts and stages in the acquisition of remote sensing data; Spectral signature, Photographic and non-photographic sensors, Space Platforms. Basics of Global Positioning System, GPS Satellites and GPS utility. Application of remote sensing in ecological and forestry research. **(No. of Hours: 8)**

Course outcomes (COs):

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

CO1	Knows the concept of ecology, ecological dynamics and Application of remote sensing.
CO2	Explain the knowledge of ecology with reference to ecosystem, succession and biogeochemical cycles with the Application of remote sensing.
CO3	Analyze ecosystem services, ecological resilience, ecological economics, and landscape ecology, soil profiling climate change and Remote Sensing.
CO4	Explain the concepts of Ecology and Remote Sensing.
CO5	Summarize the knowledge about Ecology and Remote Sensing.
CO6	Generalized the fundamentals, and applications of remote sensing and ecology.

Suggested Textbooks

1. Odum, E.P. (2005). Fundamentals of Ecology. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition.
2. Sharma, P.D. (2010). Ecology and Environment. Meerut, India: Rastogi Publications. 8th edition
3. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. New Delhi, India: S. Chand.
4. 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. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology, Environment and Resource Conservation. New Delhi, India: Anamaya Publications.

CO-PO Mapping

Course	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	0	1	2	0	1	1	1	2	1	1	3	3	3	1	2
CO2	3	1	2	3	3	2	2	1	3	2	2	0	0	1	2	2
CO3	2	2	2	2	2	0	0	2	2	3	0	2	1	0	2	0
CO4	1	0	2	0	2	1	1	1	0	2	2	2	2	3	1	1
CO5	2	3	2	1	2	2	3	0	3	2	1	0	2	3	0	3
CO6	3	2	1	2	0	2	2	2	3	0	2	1	3	2	2	0

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

Course code	**: MBOL 303**			
Course Name	**: Laboratory Course-I**			
Semester /Year	**: III Semester**			
	L	**T**	**P**	**C**
	0	**0**	**4**	**4**

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

Course contents

1. To study the effect of temperature upon the permeability of the cytoplasmic membrane.
2. To determine the osmotic pressure (potential) of cells of living cells 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 on the rate of photosynthesis, Varying CO2 concentration and different wavelengths of light.
5. To separate the four pigments i.e. chlorophyll a & b, carotene and xanthophylls from the green leaves by paper chromatography.
6. To perform the aerobic and anaerobic respiration.
7. To measure the R.Q. by Ganonge's respirometer.
8. To measure the growth in plants.
9. To demonstrate the effect of phyto-hormones.
10. To separate the amino acids by paper chromatography.
11. Principles of colorimetry, spectro-photometry and flourimetry.
12. To determine the minimum size of the quadrate by species are a curve method and minimum number of quadrats to be laid down in the field understudy.
13. To determine the frequency, density and abundance of each species present in community.
14. To calculate relative frequency and relative density of each species in a given area.
15. To calculate mean basal cover and total basal cover of each species in a given area.
16. To calculate the Alpha diversity, Beta diversity and total diversity of given community.
17. To calculate water holding capacity of three samples of various soil types and to find the percolation percentage of water in the given soil.
18. To test the pH and the buffering properties of soils.
19. 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	Knows the knowledge experimental values of Plant physiology, Biochemistry, Ecology and Remote Sensing.
CO2	Generalized the Principles of Plant physiology, Biochemistry, Ecology and Remote Sensing.
CO3	Illustrate the experiments related to Plant physiology, Biochemistry, Ecology and Remote Sensing.
CO4	Contrast and execute the experiment based on Plant physiology, Biochemistry, Ecology and Remote Sensing.
CO5	Perform the experiments related to Plant physiology, Biochemistry and Ecology.
CO6	Solve the problem related to plant physiology, biochemistry and ecology.

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. (2014). Ecological Methodology. Harper and Row, New York, USA.

Reference Books

1. Plummer, D.T. (2019). 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.(2021). Methods in Plant Ecology. Black well Scientific Publications.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	0	0	2	0	0	1	3	2	0	2	1	2	1	3
CO2	3	1	1	3	2	1	2	0	2	0	2	3	2	3	2	2
CO3	1	1	2	0	2	0	2	2	2	1	2	3	2	2	3	1
CO4	2	3	0	2	1	3	0	0	2	3	2	2	3	3	2	2
CO5	2	2	2	1	3	2	0	2	3	3	1	2	3	2	3	2
CO6	2	3	3	2	2	2	2	3	1	3	2	2	2	1	1	3

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

Course code	**: MBOE 304**			
Course Name	**: Palynology and Pollination Biology**			
Semester /Year	**:III Semester**			
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 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

Unit 1. General Introduction, microsporogenesis, micro spore tetrads and polarity of spores and pollen grains. Pollen wall development and pollen chemistry, Chemical nature of sporopollenin, development of pollen wall, Ubisch body, pollen wall proteins, origin and formation exine less pollen grains. Spore-pollen morphology: Symmetry, shape, size, aperture patterns, NPC System for numerical expression of apertural details, exine stratification, surface structures and sculptures of sporoderm. **(No. of Hours: 9)**

Unit 2. A. Palyno-taxonomy: Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works. **(No. of Hours: 9)**

Unit 3. 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. **(No. of Hours: 9)**

Unit 4. Melisso-palynology: Indian species of honeybees, 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 melisso-palynological studies, and important bee plants of North-West Himalaya. **(No. of Hours: 9)**

Unit 5. Palaeo-palynology: Introductory idea about palaeo-palynological remains, significance of palaeopalynology. Forensic-palynology: Definition and significance, a few well-known case studies. Pollination-Biology: Pollen dispersal units; pollination types, contrivances for cross-and self- pollination; pollen vectors, pollination modes and flora organization, Pollen viability and storage. **(No. of Hours: 9)**

Course outcomes (COs):

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

CO1	Describe the general concepts of palynology and pollination biology.
CO2	Explain the structure and development of pollen.
CO3	Examine the morphological features of pollen.
CO4	Analyze and identify the various aspects of Palyno-taxonomy and pollination biology.
CO5	Summarized the importance of palynology and pollination biology.
CO6	Generalized the concepts Palynology and Pollination Biology.

Suggested Textbooks

1. Erdtman, G. (1986). 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 Agency.

Reference Book

1. Nair, P.K.K. (2019). Essentails of Palynology; Asia Publication House Lucknow.
2. Woodhouse, R.P. (1959). Pollen Grains: Hafner Publication Co.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	1	0	2	1	1	0	2	1	0	3	3	3	1	0
CO2	3	1	2	3	3	2	0	1	3	2	2	0	1	0	0	2
CO3	0	2	2	2	2	2	3	2	2	3	0	2	1	0	2	0
CO4	1	3	0	0	2	1	1	1	3	0	2	2	0	3	2	1
CO5	2	3	2	1	2	0	3	1	0	2	1	1	2	3	0	3
CO6	3	2	1	2	3	2	2	2	3	2	2	0	3	2	2	3

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

Course code	**: MBOE 305**			
Course Name	**: Fresh water algal flora of Himalaya**			
Semester /Year	**: III Semester**			
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 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 1- Characters & Keys: Green and Blue-Green Algae: Taxonomy terminology, flora in Himalaya Macrophytic vegetation. Centrale and Pennale diatoms, diatom taxonomy terminology.

(No. of Hours: 8)

Unit 2- Centrale diatom Families and Genera Melosira, Cyclotella in Himalaya. Araphid Fam& genera Fragilaria, Diatoma, Meridion, Hannae in Uttarakhand Himalaya**.** **(No. of Hours: 10)**

Unit 3- Characters of raphidiod and monoraphidiod families Raphidiod: Eunotia Monoraphids, Achnanthaceae – Achnanthidium, Cocconeis. **(No. of Hours: 9)**

Unit 4- Characters of naviculoid biraphid families Naviculoid diatom flora Naviculaceae: Navicula& Cymbella sensulato & sensustricto, Gomphonema Other naviculoid diatom flora: Diploneis, Pinnularia, Caloneis. **(No. of Hours: 8)**

Unit 5- 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).

(No. of Hours: 12)

Course outcomes (COs):

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

CO1	Describe the taxonomic keys for identifying different floral diversity in the Himalayan region.
CO2	Explain the freshwater algae and their taxonomic terminology will be useful and will have a brief insight.
CO3	Examine floral diversity, which plays many important and beneficial roles in Fresh water ecosystems of the Himalayan regions.
CO4	Compare and analyze characters of Green, blue-green algae and their taxonomic Terminology
CO5	Summarized the Fresh water algal flora of Himalayan region.
CO6	Develop the concept of Fresh water algal flora of Himalaya

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	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	0	1	2	2	1	0	0	3	0	1	0	0	0	3	1	0
CO2	3	2	0	0	0	1	1	2	1	2	1	3	3	0	0	2
CO3	2	0	0	2	2	0	2	0	3	0	2	1	0	2	2	0
CO4	0	1	3	2	1	3	1	1	0	2	1	0	2	2	3	1
CO5	2	0	0	0	3	1	2	2	2	3	2	2	2	1	2	3
CO6	3	2	2	2	1	3	1	1	0	2	0	1	2	3	2	2

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

Course code : MBOE 306				
Course Name : Plant Health Management				
Semester /Year : III Semester				
	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 introduce students and develops their skills in biology, ecology and management of a variety of pests in agricultural, horticultural and viticulture 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

Unit 1. Basic procedure in diagnosis of plant diseases: Significance of plant diseases. **(No. of Hours: 9)**

Unit 2. Seed Pathology: Seed borne fungi. Disease transmitted through seeds. Bio deterioration of seed storage. Control of seed borne fungi. **(No. of Hours: 9)**

Unit 3. Nursery disease: Important disease of nursery plants. Plantation disease: Plantation disease of Chir pine, Eucalyptus, Sal, Teak, Shisam, Populus, Acacia (Catechu). **(No. of Hours: 9)**

Unit 4. 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: 12)**

Unit 5. Diseases of cereals, millets, vegetables and fruit trees. **(No. of Hours: 6)**

Course outcomes (COs):

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

CO1	Knows the terms associated with plant health management and basic procedure of diagnosis and significance of plant diseases.
CO2	Explain and learn the concepts of seed pathology and defense mechanism in plants
CO3	Illustrate the important of plant diseases.
CO4	Explain the important plant diseases in Plant Health Management.
CO5	Summarized the various management related to Plant Health.
CO6	Generalize and develop the management of diseases related cereals, millets, vegetables, fruit trees & forestry.

Suggested Textbooks

1. Bilgrami, K.S. (1990). Text Book of Modern Plant Pathology. Bishen Singh Mahendra Pal Singh Dehradun.
2. Singh, R.S. (2005). Plants Diseases. Oxford and IBH Publ. Co. New Delhi.
3. Singh, R.S. (2017) Principle of Plants Pathology. Oxford and IBH Publ. Co. New Delhi

Reference Books

1. Agrios, G.N. 1997 Plant Pathology, 4th edition, Academic Press, U.K.
2. Tarr, S.A.J.1981.The Principle of Plants Pathology. Winchester Press, New York.
3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
4. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
5. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO11	PSO2	PSO3	PSO4
CO1	0	0	2	2	2	2	0	1	0	2	0	0	3	2	3	2
CO2	1	3	2	2	1	2	2	0	3	2	3	3	0	2	0	0
CO3	3	2	0	3	0	2	3	2	0	1	3	2	2	0	2	2
CO4	2	1	2	2	2	0	1	0	2	3	2	0	3	2	1	3
CO5	1	3	0	1	1	3	2	3	2	1	2	3	2	0	2	0
CO6	0	3	2	3	0	2	2	2	0	3	2	3	0	3	3	2

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

Course code	**: MBOE 307**			
Course Name	**: Environment Microbiology**			
Semester /Year	**: III Semester**			
	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. 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 1: Fundamentals of Microbial Ecology Ecosystem; Biotic and abiotic components; Habitat and Niche, Concept of community; Concept of ecological niche; Ecosystem organization: Structure and functions, Primary production, Energy dynamics (Trophic organization and energy flow pathways). **(No. of Hours: 9)**

Unit 2: Air and Aquatic Microbiology: 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), Eutrophication, Microbial assessment of water quality, Water purification.

(No. of Hours: 9)

Unit 3: Microbial Interactions, 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. **(No. of Hours: 9)**

Unit 4: Air pollution and its control; Sources, Major pollutants, Acid rain and its impact on ecosystem, greenhouse effect, global warming, ozone layer depletion and its effect, smog, 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 (Pre-treatment, primary, secondary and tertiary treatment, Application of biofilm in waste water treatment); Environment impact assessment.

(No. of Hours: 9)

Unit 5: Impact of Microbes on Environment; Biodegradation of recalcitrant compounds: Pesticides and Petroleum; Bioremediation: In situ and Ex situ remediation, Bioaugmentation; Biomagnifications; Biomineralization; Metal corrosion: Mode of deterioration, Microorganisms involved, Mode of prevention, Microbial plastics; Biodiesel. **(No. of Hours: 9)**

Course outcomes (COs):

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

CO1	Describe the knowledge of Fundamentals of Microbial Ecology and impact of microbes on environment.
CO2	Generalized the metabolic processes of microorganisms related to the environment.
CO3	Explain the Microbial Ecology and its impact on environment.
CO4	Analyze design experiments related to Microbial Ecology.
CO5	Summarized the properties of microorganisms in concern with environment
CO6	Generalized the knowledge of Microbial Ecology.

Suggested Textbook

1. Alexander, M. Microbial ecology. John Wiley and Sons, New York.
2. Eldowney, S., and Waites, S. Pollution: Ecology and bio treatment. 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	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	3	3	2	1	2	0	2	3	2	1	1	3	2	1
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	3	2
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2	0	3
CO4	0	3	0	2	2	0	1	3	2	3	2	0	3	3	2	2
CO5	1	2	2	1	1	3	2	3	2	1	1	2	2	2	3	1
CO6	2	2	2	3	1	2	2	2	0	3	1	3	2	3	1	2

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

Course code	**: MBOL 308**			
Course Name	**: Laboratory Course-II**			
Semester /Year	**: III Semester**			
	L	**T**	**P**	**C**
	0	**0**	**4**	**4**

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

Course contents

1. Pollen morphological studies of some Pteridophyte, gymnosperms, and angiosperms representing different morphological types using acetolysis/ alkalimaceration 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. To study the Procedure of equipment's uses in Plant pathology and environment Microbiology.
11. To establish a plant disease clinic in the department for advice 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.

Course outcomes (COs):

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

CO1	Distinguished the pollen grains from different morpho-types, fresh water algae, plant pathogens and microbes.
CO2	Explain the pollen grains morpho types, types of fresh water algae, plant pathogens and microbes.
CO3	Apply the knowledge of in vivo and in vitro germination of pollen grains. Study different plant pathogens, diseases and microbes.
CO4	Analyze and isolate some important pollen grains, plant pathogen, fresh water algae and microbes.
CO5	Evaluate and isolation of Fungi/bacteria by the Pour- plate method, spread-plate and streak plate method.
CO6	Develop the knowledge the problem related pollen morphology and ecology, algae, microbes and plant pathogens.

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.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	3	3	2	1	2	0	2	3	2	1	1	3	2	1
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	3	2
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2	0	3
CO4	0	3	0	2	2	0	1	3	2	3	2	0	3	3	2	2
CO5	1	2	2	1	1	3	2	3	2	1	1	2	2	2	3	1
CO6	2	2	2	3	1	2	2	2	0	3	1	3	2	3	1	2

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

Course code	**: MBOS 309**			
Course Name	**: Forest Ecology**			
Semester /Year	**: III Semester**			
	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. 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

Unit 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. 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: 12)

Unit 2: 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: 7)**

Unit 3: Wild Life: Species and distribution, Sanctuaries, Biosphere reserves, wildlife and recreation. Forest conservancy and Potential Productivity: Soil, Water relation and nutrition, soil erosion and conservation, potential productivity of forests, site quality evaluation.

(No. of Hours: 9)

Unit 4: Forest Conservation and Management: 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. **(No. of Hours: 9)**

Unit 5: Application of Remote Sensing and Geographic Information System (GIS) in Land cover mapping. Vegetation and forest type maps. Environmental Impact Assessment:

Maintenance and conservational policies such as Joint Forest Management (JFM) and Agro forestry in the region. **(No. of Hours: 8)**

Course outcomes (COs):

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

CO1	Describe the relationship of forests, forestry and Human being.
CO2	Explain the essential elements of forest ecology.
CO3	Apply the knowledge about the forest ecology and factors affecting forests.
CO4	Illustrate about the forest ecology with reference to conservation and Remote sensing.
CO5	Examine the essential components of forest conservancy and its potential productivity.
CO6	Develop the concept of forestry and remote sensing in concern with environment conservation.

Suggested Textbooks

1. Bir, S.S. and Chatha, G.S. 1988. Forest Vegetation Characteristics of Indian Hills. Today and Tomorrows Printers & Publ., New Delhi.
2. Negi, S.S. (2012). Forest Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Puri, G.S., Meherom ji, V.M., Gupta, R.K. and Puri, S. Forest Ecology: Vol I & II. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
4. Singh, G. (2021). 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, M.P. and Vishwakarma, V. 1997. Forest Environment and Biodiversity. Daya Publ. House, Delhi.
3. Wareing, R.H. and Schlesinger, W.H. 1985. Forest Ecosystems: Concepts and Management. Academic Press, New York.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	0	2	2	2	2	0	1	3	2	0	0	3	2	3	2
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	2	0
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	0	2	2
CO4	0	1	2	2	2	0	1	3	2	3	2	0	3	2	1	3
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	2
CO6	3	3	2	3	1	2	2	2	0	3	2	3	2	3	3	2

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

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

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

Course Objectives: The objectives of this course are

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 1: 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).

(No. of Hours: 12)

Unit 2: 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. **(No. of Hours: 8)**

Unit 3: 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. **(No. of Hours: 8)**

Unit 4: Important aromatic plants of India with their systematics, geographical distribution and uses. Introduction and historical background of aromatic plants. Aromatic and cosmetic products. **(No. of Hours: 5)**

Unit 5: 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, curry leaf and saffron. **(No. of Hours: 12)**

Course outcomes (COs):

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

CO1	Describe the Knowledge about of medicinal and aromatic plants, their importance, and status and future prospects.
CO2	Explain the Good Agriculture Practices and Good Manufacturing Practices of Medicinal and Aromatic Plants.
CO3	Practice and conserve the medicinally important plants.
CO4	Explain aromatic plants used in different industries.
CO5	Justify the role of Medicinal and Aromatic Plants in life.
CO6	Develop the formulation and adapt the benefits of Medicinal and Aromatic Plants.

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).

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	1	2	3	0	2	1	0	1	0	3	2	1	1	0	2	1
CO2	0	3	2	2	0	2	2	2	3	0	0	3	2	2	3	2
CO3	3	0	2	3	2	0	3	0	0	1	3	2	0	2	3	3
CO4	3	3	2	2	2	1	1	3	2	3	2	1	3	3	0	0
CO5	1	2	2	1	1	3	2	3	2	0	1	2	2	2	3	1
CO6	2	2	0	3	1	2	2	2	1	3	1	3	2	3	1	2

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

Course code	**: MBOS 311**			
Course Name	**: Pathogens and Pests of Crop Plants**			
Semester /Year	**: III Semester**			
	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. 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.
2. 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 1: Overview of Fungi and fungus-like organisms (Myxomycetes, Acrasiomyctes, and Oomyctes), A higher-level phylogenetic classification of the Fungi. **(No. of Hours: 6)**

Unit 2: True fungi: Characteristics and important Genera of Phyla – Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota, and Basidiomycota. **(No. of Hours: 6)**

Unit 3: Physiology of fungal growth, reproduction (asexual and sexual), and mating compatibility, Importance and ecological role of fungi. **(No. of Hours: 9)**

Unit 4: 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. **(No. of Hours: 9)**

Unit 5: Plant interactions with pathogens and pests: Plant-virus interactions with emphasis on poty viruses and horticultural crops; Plant-bacterial interactions with emphasis on Erwinia sp. and potatoes; Plant-fungus interactions with emphasis on Magnapor the sp. andrice; Plant-nematode interactions with emphasis on Meloidogyne sp. and tomato; Plant- Insect interactions with emphasis on Pieris sp. and crucifers **(No. of Hours: 15)**

Course outcomes (COs):

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

CO1	Knows the basic fungal biology, Pathogens and Pests of Crop Plants.
CO2	Demonstrate the skills necessary to isolate and identified the plant pathogens.
CO3	Develop functional knowledge on Pathogens and Pests of Crop Plants.
CO4	Analyze the biology of emerges Pathogens and Pests of Crop Plants.
CO5	Evaluate the advantages and disadvantages of current control practices of Pathogens and Pests of Crop Plants.
CO6	Integrate the theoretical Knowledge and practical skill 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. (2017). Principles of insect pest management, National Agricultural Technological Information Center, Ludhiana, India

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	1	2	3	0	2	1	0	1	0	3	2	1	1	0	2	1
CO2	0	3	2	2	0	2	2	2	3	0	0	3	2	2	3	2
CO3	3	0	2	3	2	0	3	0	0	1	3	2	0	2	3	3
CO4	3	3	2	2	2	1	1	3	2	3	2	1	3	3	0	0
CO5	1	2	2	1	1	3	2	3	2	0	1	2	2	2	3	1
CO6	2	2	0	3	1	2	2	2	1	3	1	3	2	3	1	2

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

Course code	**: MBOC 401**			
Course Name	**: Conservation Biology**			
Semester /Year	**: IV Semester**			
	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. 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 strategies 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

Unit 1: Conservation: The basic concept, History of conservation biology. Patterns of biodiversity: Global and regional patterns of biodiversity, Distribution, Gradients, Magnitude of biodiversity, Hotspots, keystone species. Uses of biodiversity: food, fodder, timber, fibre, medicine, etc.; biodiversity based products and industries; wild relatives of cultivated plants; scientific role of biodiversity. Threats to biodiversity: Habitat loss and fragmentation, Genetic drift, Inbreeding, Disturbance, Pollution, Climate Change, Overexploitation, Invasive Species, Disease. **(No. of Hours: 12)**

Unit 2: Global environmental problems: Global warming, ozone depletion, desertification. Extinction to species: Susceptibility to extinction causes of species extinction, endangered species, Red and Green Data Books. 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: 8)

Unit 3: Conservation of Biological diversity: Genetic principles in conservation, biodiversity assessment and inventory. 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: 8)

Unit 4: Conservation of energy resources; conservation and maintenance of non-renewable fossil fuel resources; Conservation of biodiversity based renewable energy resources. Conservation of biological resources: In situ and Ex Situ Conservation Strategies, Designing Networks of Protected Areas; Restoration of endangered species. Protected Area Network, PAN with special reference to Uttarakhand and India. **(No. of Hours: 8)**

Unit 5: 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, 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: 9)**

Course outcomes (COs):

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

CO1	Describe the Knowledge of basic concepts and history of conservation biology.
CO2	Explain the knowledge about conservation strategies for biological resources and habitat management.
CO3	Apply and correlate global and regional patterns of biodiversity.
CO4	Analyze about the Global environmental problems in concern with conservation biology.
CO5	Summarized the concept conservation biology.
CO6	Design and implementation of the skills for conservation biology.

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 Strategies, Gyanodaya Prakashan, Nainital.
3. Hunter, M.L.J. (2022). Wildlife, forest and forestry: Principals of Managing forests for biological diversity. Prentice Hall. Englewood. Cliffs. New Jersey. 370pp.
4. 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. 2008. A Primer of Conservation Biology. Sinauer Associates, Inc.
3. Singh, J.S., Singh, S.P. & Gupta, S.R. 2007. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi.
4. Western, D. and Pearl, M.C. 1989. Conservation for twenty-first century. Oxford University Press, Oxford UK. Pp109-120.

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PS O3	PS O4
CO1	0	1	0	1	0	2	0	0	2	0	2	1	2	3	0	3
CO2	1	2	2	1	2	1	1	3	3	2	0	3	0	2	2	1
CO3	2	0	1	0	1	3	0	2	0	1	3	2	1	3	3	0
CO4	0	1	2	1	2	1	2	3	2	3	2	0	3	0	1	3
CO5	2	1	2	1	1	3	2	1	2	0	1	2	2	1	0	2
CO6	3	2	3	0	2	3	0	2	1	3	1	3	2	2	3	2

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 Semester**			
L	**T**	**P**	**C**	
3	**0**	**0**	**3**	

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

Unit 1: Biotechnology: Basic concepts, principles and scope. Plant cell and tissue culture: General introduction, history, scope, concept of cellular differentiation, totipotency. **(No. of Hours: 6)**

Unit 2: Organogenesis and adventives embryogenesis: Fundamental aspects of morphogenesis, somatic embryogenesis and Androgenesis, mechanisms, techniques and utility. Somatic hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitations of protoplast research. **(No. of Hours: 10)**

Unit 3: Applications of plant tissue culture: clonal propagation, artificial seed, production of hybrids and soma clones, production of secondary metabolites/natural products, cryopreservation and germplasm preservation. **(No. of Hours: 8)**

Unit 4: 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 fingerprinting. **(No. of Hours: 10)**

Unit 5: Genetic engineering of plants: Aims, strategies for development of transgenic (with suitable examples), Agrobacterium- the natural genetic engineer, T-DNA and transposons mediated gene- tagging. Microbial genetic manipulation: Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology. **(No. of Hours: 11)**

Course outcomes (COs):

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

CO1	Recognized the basic concepts & principles of Biotechnology.
CO2	Generalized the knowledge of plant tissue culture with Recombinant DNA technology.
CO3	Explain the fundamental aspects of Biotechnology and Genetic Engineering of Plants and Microbes

CO4	Analyze the concepts, key features and limitations of plant tissue culture technique and Recombinant DNA techniques.
CO5	Summarized the applications of Recombinant DNA technology and plant tissue culture.
CO6	Create the fundamentals of Biotechnology with reference to microbes and plants.

Suggested Textbooks

1. Bhojwani, S.S. and Razdan, M.K. (2019). 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., NewDelhi.
4. H. S. Chawla, Text book of Biotechnology. Oxford & IBH Publ., House

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	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	0	2	0	0	0	1	2	1	0	3	3	3	0	2
CO2	3	0	2	3	3	2	2	0	3	2	2	3	1	0	2	0
CO3	0	2	2	2	2	0	3	2	2	3	1	2	0	0	2	3
CO4	1	3	0	2	0	0	0	1	0	0	2	2	2	3	0	1
CO5	2	3	2	0	2	0	3	1	3	2	0	1	2	3	0	3
CO6	3	2	1	2	3	2	2	2	3	2	2	1	3	2	2	3

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

Course code	**: MBOL 403**			
Course Name	**: Laboratory Course-I**			
Semester /Year	**: IV Semester**			
L	**T**	**P**	**C**	
0	**0**	**4**	**4**	

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

Course contents

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.
6. To study the Instruments used in plant tissue culture and RDT.
7. To study the sterilization techniques.
8. Growth characteristics of *E. coli* using plating and turbid metric methods.
9. Isolation of plasmid from *E. coli.*
10. Isolation of DNA/ RNA isolation by plant material.
11. Demonstration of protoplast fusion employing PEG.
12. To demonstrate the process of Micropropagation.
13. To study the process of somatic embryogenesis using appropriate explants.
14. To study the procedure for preparation of artificial seed.

Course outcomes (COs):

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

CO1	Recall and identify pattern of regional biodiversity, tissue culture and RDT.
CO2	Summarized and survey of biological resources for biotechnology and conservation biology
CO3	Explain and collect the enhance information regarding biotechnology and conservation biology
CO4	Analyze the experimental values related to biotechnology and conservation biology.
CO5	Evaluation of the biotechnology process and conservation biology problems.
CO6	Develop the scientific approach toward nature for human welfare.

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.
3. H. S. Chawla, Text book of Biotechnology. Oxford & IBH Publ., House

Reference Book

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

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	0	2	0	0	0	1	2	1	0	3	3	3	0	2
CO2	3	0	2	3	3	2	2	0	3	2	2	3	1	0	2	0
CO3	0	2	2	2	2	0	3	2	2	3	1	2	0	0	2	3
CO4	1	3	0	2	0	0	0	1	0	0	2	2	2	3	0	1
CO5	2	3	2	0	2	0	3	1	3	2	0	1	2	3	0	3
CO6	3	2	1	2	3	2	2	2	3	2	2	1	3	2	2	3

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

Course code	**: MBOE 404**			
Course Name	**: Dissertation**			
Semester /Year	**: IV Semester**			
	L	**T**	**P**	**C**
	0	**0**	**10**	**10**

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	Recognized the subject knowledge.
CO2	Explain the scientific temperament.
CO3	Apply the fundamentals of research methodology.
CO4	Focus on the skills for the writing of thesis and scientific papers.
CO5	Justify the knowledge of course work.
CO6	Create awareness and interest towards research.

Course code	**: MBOE 405**			
Course Name	**: Environment Management with reference to Western Himalaya**			
Semester /Year	**: IV Semester**			
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

Unit 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: 9)**

Unit 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: 6)**

Unit 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. Environmental policy and environmental management system, Audit items and audit procedures, ISO Certification. Watershed management: Definition and basic concepts, Aims and Principles, Importance of integrated watershed management, Principal watershed problems of India. **(No. of Hours: 9)**

Unit 4: 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, 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. 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: 12)**

Unit 5: Renewable Energy Production and Management: Energy concepts, present global energy use, future energy needs, renewable needs, energy conservation. Bio fuel plants- Jatropha, sugarcane and oil crops, Bio fuel plantation, energy criteria for species selection, achievement of sustainable Bio fuel production; Bioconversion, utilization of biomass sources, Incineration of organic wastes for energy. Alien invasive species and bio energy production; Bio energy and food production controversies. Carbon sequestration and carbon pools. **(No. of Hours: 9)**

Course outcomes (COs):

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

CO1	Recall and describe the Environment Management with reference to Western Himalaya.
CO2	Explain, anticipate and control the environmental issues and Environment Management with reference to Western Himalaya.
CO3	Apply the knowledge of Environment Management with reference to Western Himalaya.
CO4	Analyze, Prepare and evaluate the environmental monitoring and assessment on Environment Management with reference to Western Himalaya
CO5	Conclude and propose the management systems for conservation of Western Himalaya.
CO6	Adapt and develop the environmental performance to Environment Management with reference to Western Himalaya.

Suggested Textbooks

1. Heywood, H.V. (1995). Global Biodiversity Assessment.
2. Ramakrishnan, P.S., Saxena, K.G. and Chandra shekara, U.M. (1998). Conserving the sacred for Biodiversity Management. Oxford and IBH Publ. Co. New Delhi
3. Sulphey, M.M. (2015). Introduction to Environment Management. Pp 428. Prentice Hall India Learning Pvt. Ltd.

Reference Book

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

CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PSO4
CO1	1	0	1	2	1	1	0	2	3	2	0	2	0	2	1	0
CO2	2	1	0	1	3	2	2	0	3	2	1	2	3	1	3	0
CO3	0	1	0	2	3	1	2	2	2	3	2	0	1	0	0	3
CO4	1	3	1	3	2	0	1	1	0	3	2	0	2	3	2	0
CO5	3	2	2	3	2	2	2	3	2	2	1	2	2	1	2	3
CO6	3	2	3	2	2	2	2	3	2	2	0	2	2	1	2	3

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

Course code	**: MBOE 406**			
Course Name	**: Seed Technology**			
Semester /Year	**: IV Semester**			
	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 types, seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/loses and management.

Course content

Unit 1: Introduction, terminology and historical development, seed health and its Importance. Structure and types of Dicot and monocot seeds. Kinds of seed borne pathogens: fungi, bacteria, viruses, viroides andNematodes. Types of damage caused by the seed borne fungi to seeds and crops.

(No. of Hours: 9)

Unit 2: Types of damage caused by the seed borne fungi to seeds and crops. Nature of seed infection. Systemic infection through flower, fruit and seed stock. Penetration through seed coat, natural openings and inflicted openings. **(No. of Hours: 9)**

Unit3: Longevity of seed borne pathogens. Factors influencing longevity. Epi phytology of seed borne diseases, monocyclic and polycyclic diseases. Detection of seed borne pathogens, objectives of seed health testing. **(No. of Hours: 9)**

Unit 4: Testing methods for seed borne fungi, seed borne bacteria, seed borne viruses and seed borne nematodes. Study of seed borne diseases of certain specific crops, cereals, millets, pulses, oil crops, fiber crops, and vegetable and timber crops. **(No. of Hours: 9)**

Unit 5: Control of seed borne pathogens: selection of seed production areas, crop management, seed treatment, certification, and plant quarantine and disease resistance.

(No. of Hours: 9)

Course outcomes (COs):

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

CO1	Define the term associated with seed pathology, history, concept and importance.
CO2	Comprehend the importance of seed health and various types of seed-borne pathogens, various ways of transmitting disease through seeds in other ways and the importance of transmitting diseases though seeds.
CO3	Demonstration about the penetration of pathogens into seeds and factors that cause pathogens to live in seeds.
CO4	Differentiate the spread of seed-borne pathogens.
CO5	Describe to detect pathogens carried by seeds and seed health.
CO6	Write comprehensively about pathogens carried by fungi and bacteria.

Suggested Textbook

1. Neegard P. (2009). Seed Pathology Vol I and II. MacMillan Press, London
2. Suryanarayan, D. (1995). 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. Anurag Shukla, CL. Maurya, GS. Parihar. (2022). Basics of Seed Pathology, International Books and Periodicals Supply Service, Delhi.

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. (2012). Some seed borne diseases and their control. ICAR, New Delhi

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PS O4
CO1	0	2	0	0	2	1	0	1	2	3	2	1	1	3	2	1
CO2	1	3	2	2	1	2	2	0	0	2	3	0	2	2	0	3
CO3	3	0	2	3	0	2	3	2	3	1	0	2	0	2	3	2
CO4	3	3	0	2	2	0	1	3	2	0	2	1	3	3	2	0
CO5	1	2	2	1	1	3	2	3	2	1	1	2	2	0	3	3
CO6	2	2	2	3	1	2	2	2	1	3	1	3	2	3	1	3

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

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

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

Course contents

1. Identification of Key stones 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.
6. Field inspection of seed crops and visual examination of seeds for infections.
7. Seed soaking for the detection of certain seed borne pathogens (fungi) and nematodes.
8. Seed washing tests and incubation methods.
9. Seedlings symptomatology tests.
10. Detection of bacteria by Agar Plate methods.
11. Viruses: Physical examination, grow out tests, Enzyme linked immune absorbent assay (ELISA) and Polymerase Chain Reaction (PCR).
12. Visit to seed processing plants and seed testing laboratory.
13. Reduction of seed inoculum by chemical seed treatments.
14. Testing the number of pesticides in treated seeds

Course outcomes (COs):

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

CO1	Recall and recite the experimental knowledge of seed pathology and environmental microbiology.
CO2	Explain the practical approach toward seed pathogens and environmental issues.
CO3	Apply and Enumerate seed pathology and environmental microbiology.
CO4	Illustrate the perform the experiment related to seed pathology and environmental microbiology.
CO5	Evaluate and estimate the problems related to seed pathology and environmental microbiology.
CO6	Create an idea to develop problems solving approach.

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.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	0	2	2	2	2	0	1	3	2	0	0	3	2	3	2
CO2	0	3	2	2	1	2	2	2	3	2	3	3	2	2	2	0
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	0	2	2
CO4	2	1	0	2	2	0	1	3	2	3	2	0	3	2	1	3
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	0
CO6	3	3	2	3	1	2	2	2	0	3	2	3	2	3	3	2

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

Course code	**: MBOS 408**			
Course Name	**: Analytical Techniques in Plant Sciences**			
Semester /Year	**: IV Semester**			
	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 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: 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, freezeetching. **(No. of Hours: 14)**

Unit 2: Cell fractionation Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CsCl_2$ gradient, analytical centrifugation, ultracentrifugation, marker enzymes. **(No. of Hours: 6)**

Unit 3: Radioisotopes Use in biological research, auto-radiography, pulse chase experiment. Spectrophotometry Principle and its application in biological research. **(No. of Hours: 4)**

Unit4: Chromatography Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion exchange 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. **(No. of Hours: 14)**

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

Course outcomes (COs):

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

CO 1	List the Imaging the Analytical Techniques in Plant Sciences.
CO 2	Explain the use of instrument and Analytical Techniques in Plant Sciences.
CO 3	Apply and Understand principles of Analytical Techniques in Plant Sciences.
CO4	Analyze the applications of Analytical Techniques in Plant Sciences.
CO5	Summarized the principles of different Analytical Techniques in Plant Sciences.
CO6	Develop the knowledge about Analytical Techniques in Plant Sciences.

Suggested Textbooks:

1. Ruzin, S.E. (1999). Plant Micro technique 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
3. Mishra BK and Dash Nirupama. 2022. Fundamental of Analytical Techniques in Plant Science, Kalyani Publisher, New Delhi, p296.

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. 4thedition.

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	0	2	2	2	2	0	1	3	2	0	0	3	2	3	2
CO2	0	3	2	2	1	2	2	2	3	2	3	3	2	2	2	0
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	0	2	2
CO4	2	1	0	2	2	0	1	3	2	3	2	0	3	2	1	3
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	0
CO6	3	3	2	3	1	2	2	2	0	3	2	3	2	3	3	2

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

Course code	**: MBOS 409**			
Course Name	**: Nursery and Gardening**			
Semester /Year	**: IV Semester**			
	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 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 can we design landscaping.

Course content

Unit 1: Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants. **(No. of Hours: 8)**

Unit 2: 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. **(No. of Hours: 9)**

Unit 3: 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. **(No. of Hours: 9)**

Unit 4: 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. **(No. of Hours: 10)**

Unit 5: 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. **(No. of Hours: 9)**

Course outcomes (COs):

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

CO 1	Describe the objectives and scope of Nursery, Gardening and cultivation of various vegetables.
CO 2	Explain about the structure of Nursery, Gardening and cultivation of various vegetables.
CO 3	Illustrate the methods of Nursery, Gardening and vegetative propagation.
CO4	Analyze the definition, objectives and scope of different types of Nursery & Gardening
CO5	Summarized the Nursery, Gardening and cultivation of various vegetables and marketing procedures of vegetables.
CO6	Design the idea of Nursery and Gardening.

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.
4. Pidigam Saidaiah, Surum Sindhuja and Geetha Amarapalli. 2019. Text Book of Nursery, Gardening and Floriculture. Kalyani Publisher, New Delhi

Reference Book

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

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	0	2	2	2	2	0	1	3	2	0	0	3	2	3	2
CO2	0	3	2	2	1	2	2	2	3	2	3	1	2	2	2	0
CO3	3	2	2	3	2	2	0	2	3	1	3	2	2	0	2	2
CO4	2	1	0	2	2	0	1	3	2	0	2	0	3	2	1	3
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	0
CO6	3	3	2	3	1	2	2	2	0	3	2	3	2	3	3	2

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