Semester VII

DISCIPLINE SPECIFIC COURSE (DSC) – CRYPTOGAMS

No. of Hours-75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
CRYPTOGAMS	4	3	0	1	Bachelor of Science in Botany	Nil

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT DSC7	**Course Title: Cryptogams**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Develop understanding about the diversity of different algae, fungi, bryophytes and pteridophytes.
2. Understand the origin, diversity, evolution, different classificatory systems of cryptogams.
3. Develop conceptual skill about identifying various cryptogams.
4. Understand the general characteristics and life cycle of different groups of algae, fungi, bryophytes and pteridophytes.
5. Gain knowledge about the uses of algae, fungi, bryophytes and pteridophytes in various fields.

Credits: 4	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (45)
1	General characteristics, pigmentation and economic importance of Algae; Classification of Algae (R.L. Smith) Salient features of Cyanophyta, Chlorophyta, Xanthophyta, Phaeophyta and Rhodophyta.	**10**
2	General characteristics and economic importance of Fungi, Heterothallism, Para sexuality and Heterokaryosis. Classification of Fungi (G.C. Ainsworth), Recent trends in classification of fungi Salient features of Myxomycotina, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina.	**15**
3	General characteristics and economic importance of Bryophytes, Evolution of Sporophytes, Classification of Bryophytes (Schuter and Riemer) Salient features of Hepatocopsida, Anthocerotopsida and Bryopsida.	**10**
4	General characteristics and economic importance of Pteridophytes, Stealer system, Telome theory, heterospory and homospory, seed habit, evolution of sorus, classification of Pteridophytes (K. R. Sporne) and PPG system. Salient features of Psilophytopsida, lycopodiopsida, Sphenopsida, Polypodiopsida.	**10**

Practical/Lab Course BOT DSC 7P

Unit	Topic	No. of Hours (30)
1	To study and identify the following algal material by preparing the temporary slides: *Sytonema, Chlamydomonas, Eudorina, Tetraspora, Hydrodictyon, Oedogonium, Sargassum, Chara, Gelidium* including some genera available at local level.	**6**

2	Study of working principle of various instruments used in Mycology laboratory. Preparation of media and isolation of fungi from different substrates. Study of Mycorrhizae: Ectomycorrhiza and Endomycorrhiza through photographs. To study and identify the following fungi by preparing the temporary slides: *Albugo, Rhizopus, Penicillium, Puccinia, Alternaria*, *Agaricus:* Specimens of button stage and mature basidiocarp	**8**
3	Study of general habit, external and internal morphology of vegetative and reproductive features of the bryophytes (*Marchantia, Plagiochasma, Asterella, Cryptomitrium, Targionia, Conocephalum, Frullania, Porella Anthoceros, Notothylas, Sphagnum*, *Polytrichum)*	**6**
4	*Lycopodium:*L.S. of cone *Selaginella*: Morphology, whole mount leaf with ligule, strobilus, microsporophyll and megasporophyll (temporary slides), T.S. stem, L.S.strobilus (permanent slide). *Equisetum*: Morphology, T.S. internode, T.S and L.S. Strobilus, whole mount sporangiophore, spores (wet and dry) (temporary slides); T.S. rhizome (permanent slide). *Psilotum, Azolla,* *Marsilea:* Rhizome Morphology of *Adiantum* and *Botrychium* T.S. of fern sori/sporophyll	**10**

Suggested readings

- Alexopoulas, C.J. and Mims C.W. (1995). Introductory Mycology. John Wiley and Sons. New York. Fourth Edition.
- Sambamurty, A.V.S.S. (2006). A text book of Algae. I.K International Publishing House,Pvt. Ltd.
- Barsanti, L. and Gualtieri, P. (2014). Algae: Anatomy, Biochemistry and Biotechnology, 2nd Edition. CRC/ Taylor & Francis, NY.
- Lee, R.E. (2018). Phycology, Fifth Edition. Cambridge University Press, Cambridge.
- Marjorie, Kelly and Cowan, Heidi Smith. (2017). Microbiology: A Systems Approach. McGraw Hill New York, 5th edition.
- Pandey, S.N and Trivedi, P.S. (2015). A text book of Botany Vol.I Vikas publishingHouse Pvt/ Ltd, New Delhi.
- Mehrotra, R.S. and K.R. Aneja. (1999). An Introduction to Mycology. New Age International Publisher.
- Pelczar M.J., Chan E.C.S and Kreig N.R. (1997). Microbiology. Tata MacGraw Hill.

- Robert Edward Lee. (2018). Phycology. Cambridge University Press, U.K. 5th edition.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillanPublishers Pvt. Ltd., Delhi.
- Sharma, O. P. (2011). Algae. Tata McGraw Hill Education Private Limited, U.K. 1st edition.
- Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge UniversityPress. Cambridge and New York.
- Willey, J M., Sherwood, L.M. and Woolverton, C.J. (2017). Prescott's Microbiology, 11thEdition, McGraw-Hill, USA.
- Kaur I.D., Uniyal P.L. (2019). Text Book of Bryophytes. New Delhi, Delhi: Daya Publishing House.
- Pandey, B.P. (2010). College Botany Vol II. S. Chand and Company Ltd., New Delhi, India.
- Parihar, N.S. (1976). Biology and Morphology of Pteridophytes. Central Book Depot.

Semester VII

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant Biotechnology	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Honours Degree in Botany***	**Year: IV**	**Semester: VII**
Subject: Botany		

Course: BOT DSE 5	Course Title: Plant Biotechnology

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the process and techniques involved in bio- technology and plant tissue culture.
2. Analyze the tools and methodologies used in genetic engineering
3. Evaluate the methods and applications of recombinant DNA technology.
4. Understand the blotting techniques, DNA sequencing, and plant genetic engineering.

Credits: 4	Discipline Specific Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: Asper Univ. rules

Unit	Topic	No. of Hours(60)
1	Biotechnology: Principle and scope, bio-safety guidelines. Plant cell and tissue culture: Concept of cellular totipotency, principle of root and shoot generation *in vitro*, clonal propagation, applications of cell and tissue culture. Callus culture, organ culture, cell suspension culture, cryopreservation, protoplast culture, organogenesis, somatic embryogenesis, artificial seed, somatic hybridization, hybrids and cybrids, and somaclonal variation.	15
2	Recombinant DNA technology: Tools of genetic engineering, enzymes, cloning vectors (plasmids, cosmids, lamda phage, shuttle vectors, BACs, and YACs). Cloning strategies, Screening and selection of transformants.	15
3	Gene libraries (a general account): Genomic DNA libraries, cDNA libraries. Hybridization- colony hybridization, Southern hybridization, Northern hybridization, Western hybridization, DNA sequencing techniques: Maxam and Gilbert sequencing, Sanger sequencing Genetic Engineering of plants: Aims, transformation techniques (*Agrobacterium* mediated transformation, electroporation, microinjection, and biolistics), strategies for development of	15

	transgenic plants with suitable examples (Golden rice, flavr savr tomato, Bt cotton, moondust carnations). Biosafety of transgenic plants.	
4	Micro pipetting Techniques (Learn accurate pipetting techniques). Preparation of Solutions and Buffers (Prepare standard solutions and buffers used in biotechnology labs). DNA Extraction (Extract and purify DNA from biological samples). Polymerase Chain Reaction (PCR) (Amplify specific DNA sequences).	**15**

Suggested readings

- Brown,T.A.(2018).Genomes 4. John Wiley and Sons (Asia) Pvt. Ltd. Singapore.
- Chrispeels, M.J. and Gepts, P. (2017). Plants, Genes and Agriculture. Oxford University Press.
- Rai, A. C. (2009). Plant Biotechnology Laboratory Manual. I.K. International Publishing House. (A comprehensive manual offering a wide range of plant biotechnology experiments).
- Jolles, O. and Jornvall, H. (2000). Proteomics in Function Genomics. Birkhauser.Verlag, Basel, Switzerland.
- Shantharam, S. and Montogmery, J.F. (1999). Biotechnology, Biosafety and Biodiversity. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Collins, H.A. and Edwards, S. (1998). Plant Cell Culture. Bioscientific Publishers, Oxford, UK.
- Callow, J.A., ford-Lioyd, B.V. and Newbury, H.J. (1997). Biotechnology and Plant Genetic Resources: Conservation and Use. Cab International, Oxon, UK.
- Jain, S.M., Sopory, S.K. and Veilleus, R.E. (1996). In Vitro Haploid Production in Higher Plants, Vols, 1-5., Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherland.
- Glazer, A.N. and Nikaido, H. (1995). Microbial Biotechnology, W.H. Freeman and Company, New York, USA.
- Primose, S.B. (1995). Principles of Genome Analysis. Blackwell Science Ltd, Oxford, UK.
- Vasil, I.K. and Thorpe, T.A. (1994). Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.
- Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
- Kartha, K.K. (1985). Cryopreservation of Plant Cells and Organs. CRC Press, Boca Raton. Florida, USA.

Semester VII

DISCIPLINE SPECIFIC ELECTIVE (DSE) – AN INTRODUCTION TO MICROBIOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Microbiology	4	4	0	0	Bachelor of Science in Botany	Nil

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor of Botany With Honours***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT DSE 6	**Course Title: An Introduction to Microbiology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the occurrence, general characters, types, reproduction and life cycle of the major microbial groups and their role in food, clinical and industrial microbiology.
2. Evaluate the classificatory approaches and advances in bacterial, viral and lichen taxonomies.
3. Demonstrate proficiency in basic microbiological techniques, including microscopy, bacterial staining, culture methods, and biochemical tests for microbial identification.
4. Explain the factors affecting microbial growth, including environmental conditions, nutritional requirements, and growth kinetics, and apply principles of microbial control and sterilization.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	General account of Microorganisms: History of microbiology, Golden Era of Microbiology, characteristic features of bacteria, General account of actinomycetes, classification of microorganism-five kingdom classification, Microbial growth- measurement of microbial growth, Batch, Fed-batch and continuous culture, endophytic microorganisms.	**15**
2	Morphology and structure of bacterial cells: Morphology of bacterial cells based on size, shape and arrangement, fine structure of bacterial cells (of both Gram negative and Gram positive bacteria) capsule, cell wall, cell appendages (flagella, fimbrae, pilli), Structure of plasma membrane, cytoplasmic inclusions-mesosomes, chlorosome. Ribosome- Site of protein synthesis, Microbial genetics- transformation, conjugation and transduction.	**15**
3	Morphology and structure of viruses: History, morphology, fine structure, shape and classification of viruses. Mycophages and prions, Tobacco mosaic virus (TMV), T4 Bacteriophage and HIV- their fine structure, genome organization and multiplication, Bacteriophage therapy, Overview of Corona virus. Medical microbiology, Aquatic microbiology, Aero microbiology, Food microbiology, Soil Microbiology, Industrial microbiology, Geochemical microbiology.	**15**
4	Microscopy Techniques (Introduce students to basic microscopy techniques and observation of microorganisms). Bacterial Staining: Gram Staining (Differentiate between Gram-positive and Gram-negative bacteria). Microbial Identification: Biochemical Tests (Identify unknown bacterial species based on biochemical characteristics). Antimicrobial Sensitivity Test (Determine the susceptibility of bacteria to antibiotics).	**15**

Suggested readings

- Tortora, G. J., Funke, B.R. and Case C.L.(2021). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 13th edition.
- Madigan, Bender, Buckley, Sattley, Stahl. (2019). Brock Biology of Microorganisms. Pearson. 15th edition.
- Cappuccino, J. G., Welsh, J. (2019). Microbiology: Laboratory Manual. Pearson.
- Marjorie, Kelly. and Cowan, Heidi Smith. (2017). Microbiology: A Systems Approach. McGraw Hil lNew York, 5th edition.
- Kathleen Park, Talaro and Barry Chess. (2017). Foundations in Microbiology. Mc Graw Hill New York, 10th edition.
- Willey, Joanne, Sherwood, Linda., Woolverton, Christopher J.(2017). Prescott's Microbiology. McGraw Hill New York, 11th edition.
- Cappuccino, J. G., Sherman, N. (2016). Microbiology: A Laboratory Manual. Pearson.
- Harley, J. P. (2013). Microbiology: Laboratory Exercises. McGraw-Hill Education.
- Mukherjee, K.G. and Singh V.P (1997). Frontiers in Applied Microbiology. Rastogi Publ. Meerut.
- Power, C.B. and Daginawala H.F. (1996). General Microbiology. Vol 2. Himalaya Pub. House, New Delhi.
- Kaushik, P. (1996). Introductory Microbiology. Emkay Publ, Delhi.
- Pelczar, M.J., Chan, ECS and Kreig, N.R. (1993). Microbiology. McGraw Hill, New York. Fifth Edition.
- Alexander, M. (1991). Microbial Ecology. John Wiley and Sons. New York.
- Doelle, H.W. and C.G, Heden (1986). Applied Microbiology, Kulwer Academic Press, London.
- Miller, B.M. and W. Litsky (1976). Industrial Microbiology. Mc Graw Hill New York.

Semester VII

No. of Hours-60

DISCIPLINE SPECIFIC ELECTIVE (DSE) – PLANT DEVELOPMENT AND REPRODUCTIVE BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant Development and Reproductive Biology	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT DSE 7	**Course Title: Plant Development and Reproductive Biology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the morphological characteristics of flower.
2. Study the fundamental concepts of root, shoot and leaf development.
3. Understand various stages of plant development.
4. Understand the developmental biology of male and female gametophyte, pollen-pistil interaction.
5. Study the basic idea of embryogenesis and seed development process, apomixes and polyembryony.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Morphology: Morphology of flower, stamen and carpel, Floral characteristics, structure of the pistil, Pollen stigma interactions, Plant adaptations–physiological and their morphological characteristics (xerophyte, hydrophyte and halophyte). Shoot development: Organization of the shoot apical meristem (SAM): control of cell division and tissue differentiation especially xylem and phloem: secretary ducts and laticifers. Leaf growth and differentiation, structural development and classification of stomata and trichomes.	**15**
2	Root Development: Organization of root apical meristem (RAM), vascular tissue differentiation, lateral root, root hairs, ABCD model of flower, Florigen pathway. Male gametophyte: Structure of anthers, microsporogenesis, role of tapetum, pollen development, pollen germination, pollen tube growth and guidance, pollen allergy. Female gametophyte: Ovule development, megasporogenesis, development and organization of the embryo sac, structure of the embryo sac cells.	**15**
3	Pollination: pollination mechanism and vectors. Pollen-pistil interaction and fertilization: pollination mechanism and vectors, sporophytic and gemetophytic self-incompatibility, double fertilization. Seed development and fruit growth: Endosperm development during early maturation and desiccation stages: embryogenesis, cell lineages during late embryo development, polyembryony, apomixis. Latent life- dormancy: Importance and types of dormancy, seed dormancy, bud dormancy.	**15**

4	Study the androecium and gynoecium of different families. To study the type of inflorescence of different families. Study of meristems through permanent slides and photographs. Tissues (parenchyma, collenchyma and sclerenchyma), complex and secretary tissues. Anatomy of monocot and dicot stem; monocot and dicot leaf; monocot and dicot root. Adaptive anatomy: Xerophytes, Hydrophytes, Epiphytes Normal and abnormal secondary growth in different plants. To study the type of anthers and T.S. of the anther To study the pollen grains of different families. To study the types of placentation. To study the types of pollination and seed dispersal mechanisms (photographs and specimens)	**15**

Suggested readings

- Bhatnagar S.P, Dantu, P.K. Bhojwai S.S. (2018). The embryology of Angiosperms. Vikas Publ. House. New Delhi.
- Lalit M. Srivastava. (2002). Plant Growth and Development. Hormones and Environment.Academic Press. 1st Edition.
- Raghavan V. (1999). Developmental biology of flowering plants. Springer Velag. New York.
- Howell, S.H. (1998). Molecular genetics of plant Development. Cambridge Univ. Press.
- Fonkot, De. (1994). Plant growth and Development. A molecular approach. Academic Press. San Diego.
- Lyndon. R.F. (1990). Plant Development. The Cellular Basis. Unnin Hyman. London.

Semester VII

GENERIC ELECTIVE (GE)- MOLECULAR BIOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Molecular Biology	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Master of Science in Botany***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT GE7	**Course Title: Molecular Biology**	

Course outcomes:

After the completion of the course the students will be able to

1. Learn the structure and function of nucleic acids at molecular level.
2. Understand the concept of central dogma and genetic code.
3. Learn molecular details of DNA replication and its types.
4. Understand transcription and translation including post-transcriptional and post-translational modifications of transcripts and polypeptides/proteins

Credits: 4	**Generic Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Nucleic acids as carriers of genetic information : Experiments that established nucleic acids (DNA & RNA) as the carrier of genetic information: Griffith's, Hershey & Chase, Avery, McLeod & McCarty and Fraenkel-Conrat's experiment. Structure and organization of the genetic material : DNA double helix structure (Watson and Crick model); salient features of DNA double helix. Types of DNA: A, B & Z conformations, denaturation and renaturation (only melting profile- Tm), types of RNA (mRNA and rRNA, tRNA).	**12**
2	Central Dogma and Genetic Code : The Central Dogma, Genetic code and its salient features, Experiments for deciphering Genetic code (Experiments by Nirenberg & Metthaei and Har Gobind Khorana). **Replication of DNA :** Mechanism - initiation, elongation and termination; Enzymes and other proteins involved in DNA replication; General principles – bidirectional, semiconservative and semi discontinuous replication (Replisome), RNA priming (Primase & Primosome); Various modes of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA. Replication of the 5'end of linear chromosome (end replication problem & Telomerase).	**20**
3	**Mechanism of Transcription :** Transcription process in prokaryotes (Initiation, Elongation and Termination); structure and function of RNA polymerase enzyme; concept of promoters and transcription factors; major differences between prokaryotic and eukaryotic transcription; concept of post transcriptional modifications (eukaryotic mRNA processing: 5' capping;	**20**

	3' tailing). **Mechanism of Translation :** Translation in prokaryotes: Initiation, Elongation and Termination; concept of charging of tRNA and role of aminoacyl synthetases; ribosome structure and assembly (in prokaryotes and eukaryotes); major differences between prokaryotic and eukaryotic translation; post-translational modifications (concept of phosphorylation, glycosylation-briefly).	
4	Demonstration of double helical structure of DNA, replication, transcription and translation with 3-D structure through power point presentation	**8**

Suggested Readings

- Lodish, H., Berk, A., Zipursky, S.L. Maztsudaira, P., Baltimore, Dand Darnell, l. (2016). Molecular Cell Biology (8th Edition). W.H. Freeman and Co., New York, USA.
- Alberts, B., Bray,D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2014). Molecular Biology of the Cell. Garland Publishing Inc., New York.6th edition.
- Watson, J.D. (2013). Molecular Biology of the Genes, Banjamin.7th Edition.
- Wolfe, S.L. (1993).Molecular and Cellular Biology. Wadsworth Publishing Co.California.
- Stent, G.S. (1986).Molecular genetics. Bishen Singh Mahendra Pal Singh, Dehradun.
- Barry, J.M. and Barry. B.M. (1973). Molecular Biology, Prentice Hall of India. New Delhi.

Semester VII

GENERIC ELECTIVE (GE)- FUNDAMENTALS OF BIOCHEMISTRY

No. of Hours- 60

CREDITDISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Fundamentals of Biochemistry	**4**	4	0	0	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT GE 8	**Course Title: Fundamentals of Biochemistry**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the structure, classification and functions of biochemical compounds.
2. Understand the structure, functions and biochemical pathway of secondary metabolites.
3. Understand the catalytic mechanism of enzymes, their inhibitors and regulation.

Credits: 4	**Generic Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Carbohydrates: structure and function of monosaccharides oligosaccharides, polysaccharides, Glycolysis, Feeder pathway Lipids: Fat metabolism (simple lipids, compound lipids, derived lipids), fat metabolism, β-oxidation of fats.	**15**
2	Proteins: Amino acids, structure of primary, secondary, tertiary, quaternary proteins, Ramachandran plot, protein Sequencing. Secondary metabolites: Alkaloids, flavanoid, terpenoid and their biosynthetic pathway.	**15**
3	Enzymology: General aspects, allosteric mechanism ,regulatory and active sites, isozymes, kinetics of enzymatic analysis, Michaelis- Menten equation and its significance, enzyme inhibition (competitive, uncompetitive and non-competitive).	**20**
4	To test the presence of different substrates in given samples. To estimate R.Q. of different substrates.	**10**

Suggested readings

- Nelson, D. L. and Cox, M. M. (2021). Lehninzer. Principles of Biotechnology. Macmillan, 8th Edition.
- Srivastava,H.S.(2003).Elements of Biochemistry. Rastogi Publications, Meerut.
- Cooper, T.G.(1977).Tools in Biochemistry. Wiley New York.
- Bosch,C.(1972).Mechanism of Protein Synthesis and its Regulation. Elsevier Pub. Comp. N. York.
- Ribonsen,T.(1968).The biochemistry of Alkaloides Springer Verlog, Berlin
- Meister,A.(1965).Biochemistry of the Amino acids. 2vols. Academic Press, New York

Semester VIII

DISCIPLINE SPECIFIC COURSE (DSC) – PHANEROGAMS

No. of Hours- 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Phanerogams	4	3	0	1	Bachelor of Science in Botany	Nil

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT DSC 8	**Course Title: Phanerogams**	

Course outcomes: After the completion of the course the students will be able to:

1. Understand about the diversity and general characteristics of Gymnosperms and Angiosperms.
2. Understand the different classificatory systems of Gymnosperms and Angiosperms.
3. Understand the morphology, anatomy and reproduction of different groups of Gymnosperms.
4. Understands description, Identification, Nomenclature and classification of plants.
5. Study the characteristic features and economic importance of some important families.

Credits:	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (45)
1	General Characteristics, and economic importance of gymnosperms, classification (K. R. Sporne).	**10**
2	Salient features of Cycadales, Coniferales, Ginkgoales, Ephedrales, Welwitschiales and Gnetales.	**12**
3	Important system of classification of Angiosperms; (Bentham & Hooker, J. Hutchinson and A. Takhtajan classification and their merits and demerits); APG system. Concept of ICBN and ICN. A very brief account on International Code of Nomenclature of Cultivated Plants (ICNCP); The species concept; Taxonomic tools.	**9**
4	Distinguishing features of the following families and their economic importance. Ranunculaceae, Rutaceae, Fabaceae, Rosaceae, Apiaceae, Asteraceae, Apocynaceae, Solanaceae, Lamiaceae, Orchidaceae, Liliaceae and Poaceae.	**14**

Practical/Lab Course BOT DSC 8 P

Unit	Topic	No. of Hours (30)
1	*Cycas*: Morphology (coralloid roots, bulbil, leaflet) T.S. coralloid root and rachis, V.S. leaflet and microsporophyll, whole mount spores (temporary slides), L.S. of ovule, *Pinus*: Morphology (long and dwarf shoots, male and female cones), T.S. of needle and stem, L.S./T.S. of male cone, L.S. female cone, T.L.S. and R.L.S. stem (permanent slide), T.S. of spur (dwarf shoot).	**6**

2	*Ginkgo:* Morphology (long and dwarf shoots), leaves, T.S. of rachis, T.S. of leaves. *Cupressus:* Morphology of leaves and seeds *Araucaria:* Morphology of leaves. *Taxus:* Morphology, T.S. of leaves. *Cedrus:* Morphology (long and dwarf shoots, male and female cones), T.S. of needle and stem.	**6**
3	To identify the flowering twigs of given families by studying the taxonomic characters using technical terms: At least two specimens from each family should be studied: Magnoliaceae, Myrtaceae, Scrophulariaceae, Verbenaceae, Loranthaceae, Cannabaceae, Moraceae, Fagaceae, Orchidaceae, Zingiberaceae, Cyperaceae, Poaceae.	**10**
4	To study the vegetation type(s) and flora(s) of different local areas, and training in collection and preservation.	**8**

Suggested readings

- Angiosperm Phylogeny Group (APG-2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
- Sharma O.P. (2013). Plant Taxonomy. Mc Graw hill India.
- Saxena N.B. and Saxena S. (2012). Plant Taxonomy Pragati Prakashan.
- Sambamurty, A.V.S.S. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd.
- Gaur, R.D. (1999). Flora of District Garhwal, N.W. Himalaya Transmedia, Srinagar Garhwal.
- Vashishta, P.C., Sinha, A.K. and Kumar, A. (2012). Botany for degree students. Pteridophytes. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms New Age International, Pvt Ltd (P) New Delhi.
- Chamberlain, C.J. (1980) Gymnosperms Structure and Evolution. CBS Publishers and Distributors.
- Pant, D.D. and Osborne, R. and Birbal Sahni. (2002). An introduction to gymnosperms, cycas, and cycadales. Birbal Sahni Institute of Palaeobotany.

Semester VIII

DISCIPLINE SPECIFIC ELECTIVE (DSE) - CYTOGENETICS

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Cytogenetics	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: IV**	**Semester: VIII**
Subject: Botany		
Course: BOT DSE 8	**Course Title: Cytogenetics**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Apply the concepts of Mendelian genetics to solve problems on linkage, crossing over and gene mapping.
2. Analyze human pedigree and apply the principles of population genetics to work out problems on genotype frequency and Hardy-Weinberg equilibrium. Understand the Chromosomal aberrations and their role in genome evolution with special reference to crop plants.
3. Understand modern breeding methods in improving agricultural crop varieties.
4. Understand the process of cell cycle its regulation and the mechanism of apoptosis.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Mendelian principles: Dominance, Segregation, independent assortment; extension of Mendelian principles (co dominance, incomplete dominance, gene interactions, pleiotropy); linkage and crossing over, sex linked, sex limited and sex influenced characters. Genetic recombination and gene mapping: Recombination, role of Rec A and Rec B,C,D enzymes, gene mapping methods (linkage maps, tetrad analysis, mapping with molecular markers); population genetics - gene pool, gene frequency, Hardy-Weinberg law.	**15**
2	Structural and numerical alterations in chromosome: Origin, meiotic behaviour and consequences of duplication, deletion, inversion and translocation. Mutation: spontaneous and induced mutation; physical and chemical mutagens; molecular basis of mutation; DNA damage and repair mechanisms; transposable elements, mutations induced by transposons; cell cycle and apoptosis, cancer at cellular level.	**15**
3	Chromosome structure: Packaging of DNA, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes; euchromatin and heterochromatin; Nuclear DNA content, C- value paradox; Cot-curves and their significance Gene structure and expression: genetic fine structure; cis-trans test; introns and exons; RNA splicing multiple alleles, pseudoallele, regulation of gene expression in prokaryotes and eukaryotes.	**15**
4	To study Mendelian and Non- Mendelian gene interaction ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4) through seeds. Evaluate the genetic hypothesis employing the Chi square test To observe the various stages of mitosis and meiosis with the help of onion root tip and bud respectively.	**15**

Suggested readings

- Lodish, H., Berk, A., Zipursky, S.L. Maztsudaira, P., Baltimore, Dand Darnell, l. (2016). Molecular Cell Biology (8th Edition). W.H. Freeman and Co., New York, USA.
- Alberts, B., Bray,D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2014). Molecular Biology of the Cell. Garland Publishing Inc., New York.6th edition.
- Watson, J.D. (2013).Molecular Biology of the Genes, Banjamin.7th Edition.
- Buchanan, B.B., Gruissem, W. and Jones, R.L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
- Lewin, B. (2000). Genes VII. Oxford University Press, New York.
- Atherly, A.G., Girton, J.R. and McDonald, J.F. (1999). The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
- Gupta, P.K. (1998). Cytogenetics. Rastogi Publications, Meerut. Hartl, D.L. and Jones, E.W. (1998). Genetics: Principles and Analysis (4nd Edition). Jones and Bartlett Publishers, Massachusetts, USA.
- Malacinskim G.M.D. and Freifelder, D. (1998). Essentials of Molecular Biology (3rdEdition). Jones and Bartlett Publishers, Inc. London.
- Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology (2nd Edition). Harper Collins College Publishers, New York, USA.
- Wolfe, S.L. (1993).Molecular and Cellular Biology. Wadsworth Publishing Co.California.

Semester VIII

DISCIPLINE SPECIFIC ELECTIVE (DSE) - ECOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Ecology	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany with Honours***	**Year: IV**	**Semester: VIII**
Subject: Botany		
Course: BOT DSE 9	**Course Title: Ecology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the scope and concepts of ecology and discuss the biosphere, biomes and biogeography.
2. Analyze the process of ecological succession.
3. Evaluate the importance of the major world ecosystems.
4. Distinguish between species, populations, communities, ecosystem and biomes.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Major terrestrial biomes; Zonoecotones, Orobiomes and Pedobiomes, Fresh water aquatic ecosystems; Marine ecosystems. Community structure and attributes; Edges and ecotones; Keystone species and control of community structure. Types of species interactions, herbivory, carnivory, pollination, symbiosis (obligate and facultative symbiosis).	**15**
2	Population Ecology: Characteristics of population; population growth curves; population regulation life history strategies (r and k selection); population genetics and natural selection. Habitat and niche: Concept of habitat and niche; niche width and overlap, fundamental and realized niche. Biodiversity: Levels of Biodiversity, Uses of biodiversity; Biodiversity, ecosystem services and functions.	**15**

	Distribution of biodiversity; Gradients of biodiversity; Hotspots; Threats to biodiversity. Extinction of species: Biodiversity assessment and inventory; Conservation of biodiversity; Indices; Biodiversity and its conservation; International efforts for conserving biodiversity. Climate change and conservation: Greenhouse gases; sources, trends and role; ozone layer and ozone hole; Consequences of climate change; Principles of conservation.	
3	Ecological succession: Causes, mechanism and types, changes involved in succession; Concept of climax. Ecosystem: Structure and functions; energy dynamics (Tropical organization, energy flow pathways, ecological efficiencies); litter fall and decomposition (mechanism, substrate quality and climatic factors); Global biogeochemical cycles of C, N, P and S (pathways, processes in terrestrial and aquatic ecosystems); nutrient use efficiency; Global hydrological cycle.	**15**
4	Vegetation analysis for Community Structure: Quadrat Method, Importance Value Index (IVI), Distribution pattern, Shannon Index (Shannon and Weiner Index), Simpson's index (Concentration of dominance). Population Structure and Regeneration Status, Estimation of Plant Biomass. Estimation of Net Primary Productivity, Forest Floor Biomass, Measurement of leaf area.	**15**

Suggested readings

- Kormondy, E.J.(2017). Concept of Ecology. Pearson India.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
- Baskin and Baskin, (2001). Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination Elsevier.
- Smith, R.L. (1996). Ecology and Field Biology Harper Collins, New YorkBarbour, M.G., Burk, J.H. and Pitts, W.D. (1987). Terrestrial Plant Ecology. Benjamin/Cummings Publication Company, California
- Odum, E.P. (1983). Basic Ecology Saunders, Philadelphia.

Semester VIII

DISCIPLINE SPECIFIC ELECTIVE (DSE) - PLANT SYSTEM PHYSIOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITYAND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant System Physiology	**04**	**4**	0	0	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany with Honours***	**Year: IV**	**Semester: VIII**
Subject: Botany		
Course: BOT DSE 10	**Course Title: Plant System Physiology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the mechanism of transport and translocation of water and analyze the mechanisms of acclimation and adaptation of plants to stress conditions.
2. Understand the process of transpiration, photosynthesis and respiration and analyze these processes in various groups of plants.
3. Gain awareness on the nitrogen cycle and the role of microbes and plants in the nitrogen cycle.
4. Understand the role of plant growth regulators and photoreceptors in plant growth and development.
5. Demonstrate the ability to measure the rate of photosynthesis using various techniques and interpret the results in relation to light intensity and other environmental factors.
6. Perform chlorophyll extraction and use spectrophotometry to quantify chlorophyll a and b in plant tissues, understanding their role in photosynthesis and plant health.

7. Design and conduct experiments to study the effects of various environmental factors, including light and temperature, on seed germination and seedling development.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	**Topic**	**No. of Hours (60)**
1	Membrane transport and translocation of water and solutes: Plant – water relations, mechanism of water transport through xylem, phloem loading and unloading, passive and active solute transport, membrane transport of proteins. Signal transduction and sensory photobiology: Receptors, phospholipids signaling, phytochromes and cryptochromes.	**15**
2	Photosynthesis: General concepts and historical background, steps of photosynthesis, Emerson's effect, two pigment systems, Calvin cycle, photorespiration and its significance. C4 cycle, CAM pathway Respiration: Glycolysis. TCA cycle, electron transport chain and ATP synthesis, pentose- phosphate pathway, glyoxylate cycle. Nitrogen fixation and metabolism: Biological nitrogen fixation, mechanism of nitrate uptake and reduction, ammonia assimilation.	**15**
3	Plant growth regulators: Physiological effects and mechanism of auxins, gibberellins, cytokinins, ethylene, abscisic acid, polyamines, jasmonic acid, Hormone receptors and vitamins, phytochrome and cryptochrome. Photoperiodism and vernalization and their significance; Floral induction and development Stress physiology: Plant responses to biotic and abiotic stresses, mechanisms of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, freezing and heat stress, oxidative stress.	**15**
4	To measure the rate of photosynthesis in aquatic plants using the floating leaf disk assay. To determine the stomatal density on the leaves of different plant species.	**15**

	To measure the rate of transpiration in plants using a potometer. Measure the rate of respiration in plant tissues. To extract and quantify chlorophyll from plant leaves using spectrophotometry.	

Suggested readings

- Taiz, L; Zeiger, E; Moller, I. M. and Murphy A. (2023). Plant Physiology and Development. Publisher:Sinauer Associates print of Oxford University Press. 6th Edition.
- Huner, N.P.A, and Hopkins, W. G. (2008). Introduction to Plant Physiology. Wiley 4th Edition.
- Devi, P. (2000). Principles and methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios.
- Buchanan, B.B, Gruissem W. and Jones, R.L. (1996). Biochemistry and Molecular Biology of plants by Enzymes: A practical introduction to structure, mechanism and data analysis. R. A. Copeland.
- Scott, R.P.W. (1995). Techniques and Practice of Chromatography. Taylor and Francis, Routlledge.

Semester VIII

GENERIC ELECTIVE (GE) – METHODS IN PLANT BIOLOGY AND THEIR APPLICATIONS

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITYAND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Methods in Plant Biology and their Applications	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany with Honours***	**Year: IV**	**Semester: VIII**
Subject: Botany		
Course: BOT GE 9	**Course Title: Methods in Plant Biology and their Applications**	

Course outcomes: After the completion of the course the students will be able to:

1. Gain the knowledge of various techniques and instruments used for the study of plant biology.
2. Understand the principles and use of light, confocal and electron microscopy, Principles of centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques.

Credits: 4	**Generic Elective**
Max. Marks:	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Plants and Intelligence Introduction to plant Intelligence and memory - Historical perspective, Sensory Biology, Cell to cell communication, Self-recognition, Recognition of neighbors and relatives.	**15**
2	Principles of Microscopy Dissection and light and compound microscope, electron microscope (SEM and TEM), importance of sample preparation for microscopy, staining techniques, micrometry. Histo-chemical and Immuno techniques Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flowcytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.	**20**

3	Biophysical Method Molecular analysis using UV/visible and fluorescence, spectrophotometer, circular dichroism, NMR and ESR spectroscopy, Molecular structure determination using X-ray diffraction and NMR, molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.	**15**
4	Demonstration of different instruments used in plant biology	**10**

Suggested Readings

- Trewavas A. (2017). The foundations of plant intelligence. Interface Focus 7: 20160098. http://dx.doi.org/10.1098/rsfs.2016.0098
- Wilson, K., Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press.
- Koller, D. (2011). The Restless Plant. Edited by Elizabeth Van Volkenburgh, Haward University Press, Cambridge, Massachusetts, and London, England.

Semester VIII

GENERIC ELECTIVE (GE) – TRADITIONAL KNOWLEDGE SYSTEM

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITYAND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Traditional Knowledge System	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany with Honours***	**Year: IV**	**Semester: VIII**
Subject: Botany		
Course: BOT GE 10	**Course Title: Traditional Knowledge System**	

Course outcomes: After the completion of the course the students will be able to:

1. Understand the concept, scope and importance of traditional knowledge.
2. Study the traditional knowledge systems of major tribal communities of Uttarakhand.
3. Explain the need for and importance of protecting traditional knowledge.
4. Interpret the concepts of Intellectual property in order to protect the traditional knowledge.

Credits: 4	**Generic Elective**
Max. Marks:	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Traditional knowledge: Introduction, nature and characteristics, scope and importance, Kinds of traditional knowledge (Unani/Siddha/Ayurveda), Indigenous Knowledge (IK), characteristics, traditional knowledge *vis-a-vis* indigenous knowledge, traditional knowledge of Uttarakhand. Protection of traditional knowledge: The need for protecting traditional knowledge Significance of TK Protection, value of TK in global economy, Role of Government to harness TK.	**20**
2	Traditional knowledge and intellectual property: Systems for protection of traditional knowledge, Legal concepts for the protection of traditional knowledge, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge, Geographical Indications (GI).	**15**

3	Aspects of Biodiversity and Indian Traditions: Traditional knowledge of Uttarakhand: With special reference to food, agriculture and medicine. Tribal communities (Raji, Bhotia, Tharu and Boxa) of Uttarakhand: their culture and traditional knowledge on the uutilization of plants. Traditional Knowledge and it implication in modern society, Traditional Knowledge Digital Library (TKDL).	**15**
4	Methods of documenting uses of plants in traditional practices	**10**

Suggested readings

- Jha, A. (2009). Traditional Knowledge System in India,
- Kappor, K. (). Knowledge Traditions and Practices of India.
- Pande, P.C. Madhya Himalayi Sanskriti mein Gyan, Vigyan evam Paravigyan.
- Ram Reddy,S. Surekha ,M. and Krishna Reddy,V (2016). Biodiversity Traditional Knowledge Intellectual Property Rights .Scientific Publishers.
- Unnikrishna,P and Suneetha, M. (2012). Biodiversity, traditional knowledge and community health: strengthening linkages. Institute for Advanced Studies, United Nations University ,Tokyo.
- TKDL (www.tkdl.res.in) online resources.

Semester IX

DISCIPLINE SPECIFIC COURSE (DSC) – PLANT RESOURCE UTILIZATION AND CONSERVATION

No. of Hours-75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Plant Resource Utilization and Conservation	**4**	**3**	**0**	**1**	**Honours Degree in Botany**	**Nil**

MASTER IN SCIENCE IN BOTANY		
Programme : ***Master in Science in Botany***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT DSC 9	**Course Title: Plant Resource Utilization and Conservation**	

Course outcomes: After the completion of the course the students will be able to:

1. Describe economically important plants with botanical names, family and uses.
2. Understand the various uses of plants; biodiversity status, loss and management strategies.
3. Understand the biogeography and initiatives for biodiversity conservation.

Credits: 4	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (45)
1	Sustainable development: Basic concepts. World centers of primary diversity of domesticated plants: The Indo-Burmese centre plant introduction and secondary centers. Overview of (i) Food, forage and fodder crops. (ii) Fibre crops. (iii) Medicinal and aromatic Plants and (iv) Vegetable oil- yielding crops and their uses.	**8**
2	Important fire-wood and timber-yielding and non-timber forest products (NTFPs) such as bamboos, rattans, raw materials for paper-making, gums, tannins, dyes, resins and fruits. Lesser known plants of Uttarakhand and their economic importance; Wild edible plants of Uttarakhand. Green revolution: Benefits and adverse consequences. Plants used as avenue trees: for shade, pollution control and aesthetics. Principles of conservation: extinctions: environmental status of plants based on International Union for Conservation of Nature (IUCN).	**12**
3	Strategies for conservation- in-situ conservation: International efforts and Indian initiatives; Protected areas in India- sanctuaries, National Parks, biosphere reserves, wetlands, mangroves and coral reefs for the conservation on wild biodiversity.	**10**
4	Strategies for conservation- Ex-situ conservation: Principles and practices; botanical gardens, field gene banks, seed banks, in vitro repositories, cryo-banks, General account of the activities of botanical Survey of India (BSI), National Bureau of Plant Genetic resources (NBPGR), Indian Council of Agriculture Research (ICAR), Council of Scientific and Industrial Research (CSIR) and Department of Biotechnology (DBT) for conservation, non- formal conservation efforts.	**15**

Practical/Lab Course BOT DSC 9P

nit	Topic	No. of Hours (30)
1	To study the economically important plants and their parts (available in the area) Cereals: Wheat, Rice, Maize, Barley. Millets: Finger millet, Pearl millet, Foxtail. Pulses: Gram, Green gram, Pea, Pigeon pea, Soybean, Chick pea, Timbers: Sheesham, Sal, Teak, Deodar, Pine Medicinal plants: Withania, Dhatura, Bergenia, Hedychium, Zanthoxylum, Basil, Barberry, Rauwolfia. Oils: Mustard, Seseame, Coconut, Linseed, Groundnut, Castor, Laung, Sandal wood, Mentha. Spices: Coriander, Cardamom, Curcuma, Cinnamom, Laung, Cumin, Thyme, Nigella, Cinnamon leaf Fibers: Jute, Coconut, Hemp, Urtica, Cotton Fruits and vegetables. Gums and Resins. Wild edible plants of Uttarakhand. Non-timber forest products (NTFPs)	**18**
2	Collection of plant samples for Herbarium preparation. To study the principles and practices of Conservation. To study the different National Institutions actively involved in conservation of Biodiversity.	**8**
3	To study and comment on the given specimens/slides/photographs.	**4**

Suggested readings

- Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
- Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
- Kochhar, S.L. (2016). Economic Botany: A comprehensive study, Fifth edition, Cambridge University Press, NY.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.
- Wickens, G.E. (2004). Economic Botany: Principles and Practices, Springer, ISBN.

Semester IX

DISCIPLINE SPECIFIC ELECTIVE (DSE) – EVOLUTIONARY BIOLOGY OF PLANTS

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Evolutionary Biology of Plants	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT DSE 11	**Course Title: Evolutionary Biology of Plants**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the essential theories of evolution
2. Differentiate between micro and macroevolution and the forces shaping evolution
3. Construct phylogenetic trees based on morphological and molecular data
4. Understand the evolution of life and different group of plants.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	**Historical Perspective of evolutionary concepts:** Pre-Darwinian ideas, Lamarckism, Darwinism, Post-Darwinian era – Modern synthetic theory, Neo-Darwinism, Pre-biotic conditions and events; Evolution of eukaryotes from prokaryotes.	**15**
2	**Evidences of Evolution:** Paleobiological– Concept of Stratigraphy and geological timescale; fossil study, Taxonomic –Transitional forms/evolutionary intermediates, living fossils. **Microevolution and Macroevolution:** Hardy Weinberg equilibrium; Founder effect, Natural and artificial selection. Levels of selection. Gene trees, species trees; Patterns of evolutionary change, Mutation, Gene flow, Selection, Genetic Drift, Co-evolution.	**15**
3	**Evolution of Land Plants**: Species concept, Modes of speciation – Allopatric; sympatric; peripatric; Origin of land plants – Terrestrial algae and bryophytes; Early vascular plants – Stelar evolution; seed habit and evolution of seed, adaptive strategies of different group of plants.	**15**
4	Study of Lamarckism, Darwinism, and Neo-Darwinism through the (Specimens/slides/photographs) various examples. Study of different types of fossils, connecting links/transitional forms and Living fossils (Specimens/slides/photographs) To study the various evolutionary events in geological timescale through the (specimens/slides/photographs). Sampling of quantitative characters (continuous and discontinuous) in a population (height, weight, number of nodes etc).	**15**

Suggested readings

- Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2020). Biology. San Francisco, SF: Pearson Benjamin Cummings.
- Ridley, M. (2004). Evolution. III Edn. Blackwell Pub., Oxford.
- Hall, B. K., Hallgrimson, B. (2008) Strickberger's Evolution. IV Edn. Jones and Barlett.
- Zimmer, C., Emlen, D. J. (2013). Evolution: Making Sense of Life. Roberts & Co.
- Futuyma, D. (1998). Evolutionary Biology. III Edn. Sinauer Assoc. Inc.
- Barton, Briggs, Eisen, Goldstein and Patel. (2007). Evolution. Cold Spring Harbor Laboratory Press.
- K, M. (2017). Evolution, 4th Ed. Sinauer, Sunderland, MA: Sinauer Associates.

Semester IX

DISCIPLINE SPECIFIC COURSE (DSE) – PLANT PATHOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant Pathology	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT DSE 12	**Course Title: Plant Pathology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the general characteristics of plant pathogenic organisms including fungi, bacteria, viruses and mycoplasma.
2. Study the interactions between plant and pathogen in relation to the environment and mechanism of disease development by pathogens.
3. Understand the genetics of host parasite interaction.
4. Understand the various enzymes and toxins involved in disease development.
5. Study various important plant diseases, their disease cycle and control measures.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	A brief history of plant pathology in India Types of pathogens, symptoms of different plant diseases. **Inoculum:** Inoculum types, theory of inoculums, survival and longevity of inoculums, inoculums production, potential and density. **Plant microbe interaction:** molecular basis of host recognition, pathogenesis: pre-penetration, penetration and post penetration events, factors affecting disease development (host factors, environmental factors, virulence susceptibility). **Dissemination of pathogens:** Means of dissemination (active and passive dissemination). **Genetics and host parasite interaction:** Concept of compatibility and specificity, gene for gene relationship, genetics of resistance, source of resistance, inheritance of resistance in the host. **Enzymes and toxins:** Enzymes involved in disease development, toxins and their role in plant health.	**15**
2	**Disease resistance:** (i) Protection (structural, chemical, absence of nutrients and common antigens). **Defense** (histological defense, chemical- polyphenols, prohibitins, inhabitins, phytoalexins, lectins). **Genetic resistance:** resistant genes, biotechnological approaches for transfer of R- genes into susceptible plant. **Seed pathology:** Seed borne pathogens, mechanism of seed infections in field and during storage, transmission of pathogens through seeds, seed health testing methods, market disease of fruits and vegetables. **Disease control:** Cultural practices, chemical methods (insecticides, systemic and non-systemic chemical), biological control: Introduction, Biological control of insects and pests, use of resistance varieties and plant quarantine.	**15**
3	Brief account, structure, importance, disease cycle and control of the following diseases: (i)Damping-off, (ii) Wilt, (iii) Root rot, stem rot and fruit rot (iv) Mildews (powdery and downy), (v) Rusts, smuts, (vi) Leaf	**15**

	spots and leaf blights. General characteristics, importance, disease cycle and control of the following: (i) Bacterial disease, (ii) Viral disease, (iii) Mycoplasma disease.	
4	Study of various instruments used in Plant Pathology laboratory. Media preparation, isolation and culturing of plant pathogens Study of various fungal, bacterial and viral diseases - symptoms with the help of live or preserved specimens /digital resources. Study of causal organism with the help of temporary tease/section mounts.	**15**

Suggested readings

- Mehrotra, R. S. (2013). Plant Pathology. Tata Mc Grow Hill Publishing Co Ltd. New Delhi.
- Agrios, G.N. (2011). Plant Pathology. Elsevier.
- Bouarab, N. K., N. Bissow and F. Daayf. (2009). Molecular Plant Microbe Interactions.
- Mehrotra, R. S. and Agrawal, A. (2003). Plant Pathology. Tata Mc Grow Hill Publishing Co Ltd. New Delhi.
- Lucas, J.A. (1988). Plant Pathology and Plant Pathogens. Third edition. Blackwell.
- Singh, R. S. (1988). "Plant diseases". Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Singh R.S. (2018). Plant Diseases. 10th Edition Medtech, New Delhi.
- Sharma, P.D. (2014). Plant Pathology. Rastogi Publications, Meerut.

Semester IX

DISCIPLINE SPECIFIC COURSE (DSE) – Protected Agriculture – Hydroponics and Organic Cultivation

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Protected Agriculture: Hydroponics and Organic Cultivation	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT DSE 13	**Course Title: Protected Agriculture: Hydroponics and Organic Cultivation**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand various aspects of hydroponics, aquaponics and organic cultivation.
2. Become economically self-reliant by growing and marketing organic herbs, vegetables, microgreens and fruits.
3. Gain practical training in establishing a hydroponic facility.
4. Understand good agricultural practices associated with protected agriculture.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Introduction to protected agriculture: Types of protected agriculture (hydroponics, aquaponics and organic farming), definition, history, terminology, importance and advantages over traditional agriculture, limitations and challenges.	**15**
2	Plant growth requirements : Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters- mineral nutrient requirements, deficiencies, toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media- types, properties, uses, nutrient formula and preparation of solutions.	**15**
3	Hydroponic growing systems: Basic concepts and designs (closed and open systems techniques, Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), systems layout. Strengths and weaknesses of various systems, site considerations, components and methods for nutrient delivery. Organic farming and its management: Organic farming and associated management practices. Marketing of the organic produce.Government institutes and policies related to protected farming. Pest and disease management.	**15**
4	Study of various instruments used in hydroponics. Preparation of growth media for hydroponics. Estimation of NPK, DO, TDS, pH of growing media. Demonstration of different irrigation techniques in hydroponics	**15**

Suggested readings

- Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech. Bull. TB-ICN 188/2018. Publ. by I.A.R.I., New Delhi-110012 INDIA.
- Misra S., Misra S., Misra R.L. (2017). Soilless Crop production. Daya Publishing House, Astral International (P) Ltd., New Delhi.
- Palaniappan S. P., Annadurai K. (2018). Organic Farming: Theory & Practice. Scientific Publisher. 5. Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems. Springer, Cham.
- Jones, J. B. (2014). Complete Guide for Growing Plants Hydroponically. CRC Press.
- Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Akta Prakashan, Nadiad.

Semester IX

GENERIC ELECTIVE (GE) – FOREST ECOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITYAND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisiteof the course(if any)
		Lecture	Tutorial	Practical/Practice		
Forest Ecology	4	4	0	0	Honours Degree in Botany	Nil

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT GE 11	**Course Title: Forest Ecology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the structure and function of forest ecosystem.
2. Understand methods for studying vegetation, community pattern and processes, ecosystem function, biodiversity, carbon stock and carbon sequestration.
3. Understand the students to understand the linkage between humans and forests.

Credits: 4	**Generic Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	General Aspects of Forests: Forest ecology and forest ecosystems, Importance of forests in environmental conservation Primary Productivity and Detritus Pool; Formulations of Primary Productivity: Photosynthetic pathways and their significance; Allocation of Net primary production and biomass accumulation; Measurement of biomass and primary productivity in forest ecosystems of the world; Plant biomass and turnover; Human Use of productivity.	15
2	Litter fall in Forest Ecosystems; determining litter fall, factors affecting it; Forest litter: type of litter; Coarse Woody debris;	15

	forest floor litter mass. Detritus Pathway of Energy Flow and Decomposition Processes: Decomposer organisms and their trophic interactions; decomposition processes; Measurements of Litter decomposition; decomposition rate. Nutrient cycling in forest ecosystems: nutrient cycle models in forest ecosystem. Nutrient supply and uptake , Role of mycorrhizae in nutrient cycling; Nutrient concentration and storage in vegetation.	
3	Succession: Overview on forest succession with focus on Himalayan forest ecosystem; Attributes of species of different successional stages Major forest types of forest India: Forest classification of India; Forest of Himalaya with particular reference to Sal, Pine and Oak forests. Global climate changes and forests. Man and forest: Commercial exploitation of forest, shifting agriculture; settled agriculture; structure and functioning of Central Himalayan Agroecosystem. Regeneration status of major forest trees with respect to acute vs. chronic human disturbance; Shifting cultivation practices.	20
4	Assessment of forest biomass, carbon sequestration, primary productivity and regeneration pattern of different forests.	10

Suggested readings

- Bir, S.S. and Chatha, G.S. (1988). Forest Vegetation Characteristics of Indian Hills. Today and Tomorrow's Printers & Publ., New Delhi.
- Misra, R. (1968). Ecology Work Book. Oxford & IBH Publishing Co. New Delhi.
- Puri, G.S., Meher-Homji V.M., Gupta R.K. and Puri R.K. (1960). Forest Ecology. Oxford and IBH Pub.Co. Pvt. New Delhi.

- Singh, J.S. and. Singh, S.P. (2014). Forest of Himalaya: structure, Function and Impact of Man. Gyanodaya Prakashan, Nainital, India.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
- Waring, R.H. and Schlesinger, W.H. (1985). Forest Ecosystems: Concepts and Management. Academic Press, New York.

Semester IX

GENERIC ELECTIVE (GE) – HERBARIUM TECHNIQUES

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITYAND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Herbarium Techniques	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT GE 12	**Course Title: Introduction of Herbarium And Its Significance**	

Course outcomes: After the completion of the course the students will be able to

1. Understand the processing and importance of Herbarium.
2. Learn about the preparation of Flora.
3. Learn the basic techniques of classification.
4. Understand the collection and identification of plants.

Credits: 4	**Generic Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Herbarium: History, Introduction, Methods of Collection of Specimens, Tools and Equipment, Botanical Gardens. Herbarium Preparation (a. Poisoning, b. Pressing, c. Drying, d. Mounting, e. Documentation, f. Arrangement, g. Maintenance h. Cataloging)	**20**
2	Types of herbaria (International, National, Regional and University, Medicinal plant, Economically important plant, Agricultural herbaria), Important herbaria of the World, Major Herbaria in India, Acronym.	**15**
3	Role of Herbarium in Teaching and Research, Function of Herbarium and Conservation, Digitization, Virtual Herbarium.	**15**
4	Visit to herbarium; demonstration and preparation of herbarium from local flora	**10**

Suggested readings

- Saxena, N.B. and Saxena, S. (2012). Plant Taxonomy. Pragati Prakashan.
- Jain, S.K. and Rao, R.R. (1976). A Hand book of Field and Herbarium Methods.
- Sambamurty A.V.S.S. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd.
- Singh, G. (2010). Plant Systematics. CBS PUB & DIST PVT Limited INDIA.
- Sharma,O.P. (2009). Plant Taxonomy. Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Gaur R.D. (1999). Flora of District Garhwal, N.W. Himalaya Transmedia, Srinagar Garhwal.

Semester X

No. of Hours-75

DISCIPLINE SPECIFIC COURSE (DSC) – ENVIRONMENTAL MONITORING AND ECOLOGICAL RESTORATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Environmental Monitoring and Ecological Restoration	**4**	**3**	**0**	**1**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT DSC 10	**Course Title: Environmental monitoring and ecological restoration**	
Course Outcomes: After the completion of the course the students will be able to: 1. Understand and apply the basic concept of ecosystem and other sciences in environmental science 2. Analyse the relationship between ecology, ecosystem and environment		

Credits: 4	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (45)
1	Environment: Definition, major components and scope of environment science, Environmental impact assessment. Global environmental changes: Drivers of climate change, Ozone layer depletion, green house gases and their sources, greenhouse effects, drivers of climate change, green house gases and their sources; Effects of increased CO2 on plants; International efforts on climate change issues	11
2	Monitoring of atmospheric deposition: Causes and consequences of the excessive atmospheric deposition of nutrients and trace elements, Eutrophication ; Acid rain and its effect on plants, animals, microbes and ecosystems Bio-monitoring and bio-indication	10
3	Definition and concept of reclamation, remediation, restoration and rehabilitation Causes and impact of disturbances on the structure and functioning of terrestrial and aquatic ecosystems Degradation and restoration of natural ecosystems: Forests, grassland, wetlands	14
4	Restoration of degraded soils, restoration of contaminated soils and soil fertility Restoration of biological diversity: Augmentation, reintroduction and introduction of species	10

Practical/Lab Course BOT DSC 10P

Unit	Topic	No. of Hours (30)
1	Water and soil analysis: Introduction, sampling techniques and methods of collection of water and soil samples Analysis of physico- chemical characteristics of water and soil samples	**10**
2	Types of ecosystems and ecosystem services	**5**

	Approaches to and principles of restoration	
3	Assess and present methods, results, and interpretation of restoration activities Restoration plan based on examples of various ecosystems Develop a restoration and management plan for a local site	**8**
4	Case study examples, Field visit to restoration sites	7

Suggested readings

- Paul E Hardisty 2010. Environmental and economic sustainability CRC Press.
- S.C. Santra 2011. Environmental Science. New Central Book Agency.
- R.K. Sapru 1987. Environmental Management in India (Vol I & II). Ashish Publishing house
- Andel, J. and Aronson, J. (Eds). (2005). Restoration Ecology: The New Frontier. Blackwell Publishing
- Singh, J.S. Singh S.P. and Gupta, S.R. 2014. Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
- Govind Prasad 2012. Restoration and Conservation ecology. Discovery Publishing Pvt.Ltd; First Edition (1 January 2012)
- Andre F. Clewell and, James Aronson 2013. Ecological Restoration (Second Edition): Principles, Values, and Structure of an Emerging Profession. Part of: The Science and Practice of Ecological Restoration
- Kim Y.J. and Platt U. (Eds.) (2008) Advanced Environmental Monitoring, XXII, 420 p. Springer.
- Laboratory Analytical Techniques Series (LATS), published by CPCB.
- Roa M. (2008) Environmental Science Activities Kit, Jossey-Bas.
- Wagner T.P. and Robert S. (2009) Environmental Science: Active Learning Laboratories and Applied Problem Sets, 2nd Edition, Wiley.
- Wells E. (2009) Lab Manual for Environmental Science, Cengage Learning
- Case studies: Websites
- Journals: Environmental Management, Environmental Pollution, Environmental Science and Technology

Semester X

DISCIPLINE SPECIFIC ELECTIVE (DSE) – BIOINFORMATICS AND BIOSAFETY NORMS

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Bioinformatics and Bio-safety Norms	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT DSE 14	**Course Title: Bioinformatics and Biosafety Norms**	

Course outcomes: After the completion of the course the students will be able to

1. Understand the basics of bioinformatics and develop awareness of the interdisciplinary nature of this field.
2. Learn about biological databases, sequence retrieval, alignment, and phylogenetic analysis using various tools.
3. Understand the basic concept of Intellectual Property rights

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Introduction to Bioinformatics Historical background; Aims and scope; Genomics, Transcriptomics, Proteomics, Metabolomics, Systems biology. Role of bioinformatics in drug discovery; Applications and Limitations of bioinformatics.	**15**
2	Biological databases Introduction to biological databases - Primary, secondary and composite databases; Study of following databases: NCBI (GenBank, PubChem, PubMed and BLAST; introduction to EMBL, DDBJ, UniProt, PDB and KEGG.	**15**
3	Basic concepts of Intellectual Property Rights (IPRs). The implications of the Intellectual Property Rights on the Convention on Biological Diversity (CBD).	**15**
4	Biological databases (NCBI, EMBL, UniProt, PDB) Literature retrieval from PubMed. Protein Structure retrieval from PDB (in pdb format) and visualisation by viewing tools (Ras Mol/ J mol/Mol*/Swiss 3D Viewer/Pymol).	**15**

Suggested readings

- Ghosh, Z., Mallick, B. (2008). Bioinformatics – Principles and Applications, 1st edition. New Delhi, Delhi: Oxford University Press.
- Baxevanis, A.D., Ouellette, B.F., John (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.
- Roy, D. (2009). Bioinformatics, 1st edition. New Delhi, Delhi: Narosa Publishing House.
- Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition. New Jersey, U.S.: John Wiley and Sons.
- Paroda. R.S. & R.K. Arora (1991). Plant Genetics Resources Conservation and Management concepts and approaches. New Delhi.
- Krattigar. F. Anatole. et al. (1994 Ed.) Widening Perspectives on Biodiversity. Dehradun.
- Yamin. F. (1995) The Biodiversity Conservation and Intellectual Property Rights. Switzerland.

Semester X

DISCIPLINE SPECIFIC ELECTIVE (DSE) – ADVANCES IN PLANT TAXONOMY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Advances in Plant Taxonomy	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY

Programme : ***Master of Science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT DSE 15	**Course Title: Advances in Plant Taxonomy**	

Course outcomes: After the completion of the course the students will be able to

1. Understand the naming of the plant through plant nomenclature.
2. Learn the phylogeny and classification of angiosperms of system their use and utility.
3. Identify various angiosperms families with specific key characters.
4. Learn various advanced tools used to study plant taxonomy.
5. Understand the latest molecular techniques used in plant taxonomy.
6. Explore the impact of bioinformatics on plant classification.
7. Study the role of phylogenetic analysis in plant taxonomy.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	History of different systems of classification (introduction only). Important systems- Bentham and Hooker, Hutchinson, A. Takhtajan, A. Cronquist, Robert Thorne, Angiosperm Phylogeny Group (APG IV) classification. A brief account of major contributions made by the following taxonomists: C. Linnaeus, J.D. Hooker, William Roxburgh and Duthie., International Code of Nomenclature (ICN) for Algae, Fungi, and Plants.	**15**
2	Taxonomic tools, histological, cytological, phytochemical, serological, biochemical, and molecular techniques. Relevance of taxonomy to conservation. Modern techniques in plant taxonomy including: molecular phylogenetic, DNA Bar Coding, DNA extraction, amplification, sequencing and Digital herbarium data base (Access Digital Herbarium Data Base) Search for records of your plant species and related taxa. Compare your specimens with digital records. Use of Electrophoresis, PCR, HPLC and other instruments useful in molecular taxonomy, Operational Taxonomic Unit (OTU) and OTU Clustering.	**15**
3	Some important families: Magnoliaceae, Myrtaceae, Scrophulariaceae, Acanthaceae, Verbenaceae, Amaranthaceae, Cannabaceae, Moraceae, Orchidaceae, Zingiberaceae, Cyperaceae, Poaceae. Update the plant nomenclature with different website (Plants of the World Online (PWO) Kew Science, Global Biodiversity Information Facility (GBIF) International Plant Nomenclature Index (IPNI), Tropicos), e-flora.	**15**
4	To study the vegetation type(s) and flora(s) of different areas in the local areas, and training in collection and preservation. To study the molecular techniques used in plant taxonomy. To study the advanced tools used in plant taxonomy	**15**

Suggested readings

- Kochhar S.L. (2016). Economic Botany. Cambridge University Press, London.
- Angiosperm Phylogeny Group (APG-2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
- Saxena, N.B. and Saxena, S. (2012). Plant Taxonomy. Pragati Prakashan.
- Sambamurty A.V.S.S. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd.
- Singh, G. (2010). Plant Systematics. CBS PUB• & DIST PVT Limited INDIA. Sharma,O.P. (2009). Plant Taxonomy. Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Gaur R.D. (1999). Flora of District Garhwal, N.W. Himalaya Transmedia, Srinagar Garhwal.
- Bhattacharya B. and B.M. Joshi. (1998). Flowering plants. Taxonomy and phylogeny Norsa publishing house New Delhi.
- Heywood V.H. and D.M. Moore. (1984). Current concept in plant taxonomy. Systematic special volume 25. London.
- Davis P.H. and Heywood V.H. (1973). Principles of angiosperms taxonomy. Robert• E. Kreign Pub. Co. New York.
- Heywood V.H. (1970). Plant taxonomy London.
- Bensen L. (1957). Plant Classification reprint. Oxford & IBH N. Delhi.
- Lawrence G.H.M. (1951). Taxonomy of vascular plants. Mac Millan N.York.

Semester X

DISCIPLINE SPECIFIC ELECTIVE (DSE) – PLANT BREEDING

No. of Hours- 60

CREDITDISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant Breeding	**04**	4	0	0	**Bachelor of Science in Botany**	**Nil**

MASTERS OF SCIENCE IN BOTANY		
Programme : ***Masters of science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT DSE 16	**Course Title: Plant Breeding**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the principles of plant breeding, including its important achievements and undesirable consequences of plant breeding.
2. Understand the process of hybridization, advantages and limitations.
3. Understand the plant breeding systems and heterosis and role of mutation in plant breeding.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Plant breeding: Introduction and objectives; breeding systems, important achievements and undesirable consequences of plant breeding); methods of crop improvement; centres of origin and domestication of crop plants, plant genetic resources, acclimatization; selection methods	**15**
2	Hybridization: for self-pollinated, cross-pollinated and vegetatively propagated plants–procedure, advantages and limitations; Inbreeding depression and heterosis (history, genetic basis and applications). Crop improvement and breeding (role of mutations; polyploidy; distant hybridization and biotechnology in crop improvement).	**15**
3	Effects of aneuploidy on plant phenotypes; Transmission of monosomics and trisomics and their uses, Chromosome mapping of diploid and polyploidy species, evolution of major crop plants (wheat and rice).	**15**
4	Introduction to plant breeding techniques: handling and maintenance of breeding populations, Study of pollination mechanisms in self-pollinated and cross-pollinated crops, Selection methods: Demonstration of pure-line selection and mass selection methods. Study of polyploidy and its effects on plant morphology using prepared slides/specimens, Chromosome analysis: Karyotyping and chromosome mapping in diploid and polyploid species.	**15**

Suggested readings

- Gardner, E.J., Simmons, M.J. and Snustad, D.P. (1991).Principles of Genetics, John Wiley & Sons.
- Allard, R.W. (1999). Principles of Plant Breeding. John Wiley & Sons.
- Rastogi, V.B.(2019).Genetics.4thEdition.MEDTECH: A Division of Scientific International.
- Russel P.J.(2010).Genetics-A Molecular Approach, Pearson Education Inc.
- Singh R.J.(2002).Plant Cytogenetics, CRCPress.
- Singh, B.D. (2005). Plant Breeding: Principles and Methods (7th Edition). Kalyani Publishers.
- Strickberger M.W.(2008).Genetics, Pearson (PrenticeHall).
- Acquaah, G. (2012). Principles of Plant Genetics and Breeding. Wiley-Blackwell.

- Watson, J.D. (2013). Molecular Biology of the Genes, Banjamin. 7th Edition.

Semester X

GENERIC ELECTIVE (GE): LICHENOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Lichenology	**4**	**4**	**0**	**0**	**Botany in Honours Degree**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT GE 13	**Course Title: Lichenology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the general characters, structure, types, reproduction and various habitats of lichens.
2. Develop conceptual skill about identifying fungi and lichens.
3. Understand the physiology and biochemistry of lichens.
4. Study the ecological and economic importance of lichens.
5. Gain knowledge about the major lichen families and their representative genera.

Credits: 4	**Generic Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Introduction, General characteristics of lichens, history of Lichenology, collection and preservation of lichens, habitat and growth form of lichens. Classification of lichens. Morphology and anatomy of lichens, Reproduction in lichens.	**20**
2	Physiology and chemistry of lichens, ecological and economic importance of lichens, Overview of some common lichens of Uttarakhand Himalaya.	**15**
3	Salient features of Parmeliaceae, Lecanoraceae, Teloschistaceae, Ramalinaceae, Physciaceae, Collemataceace, Candelariaceae, Peltigeraceae and Usneaceae.	**15**
4	Methods to identify different lichens. Demonstration of different lichen specimens	**10**

Suggested readings

- Arya, V., Kumar, B. and Arya, P. (2019). Lichen Wealth of Uttarakhand Himalaya. Lap Lambert Academic Publishing.
- Awasthi, D.D. (2000). Hand book of lichens, Bishen Singh Mahendrapal Singh: Dehradun India.
- Awasthi, D.D. (2007). A compendium of the macrolichens of India, Nepal and Srilanka. Dehradun Bishen Singh Mahendra pal Singh: Dehradun India.
- Sati, S.C. and Pant, P. (2023). A test Book on Lichens: The Endolichenic Fungi. Elite Publishing House, New Delhi.
- Webster, J. (1985). Introduction to Fungi. Cambridge University Press. New York.

Semester X

GENERIC ELECTIVE (GE): PALAEOBOTANY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisiteof the course(if any)
		Lecture	Tutorial	Practical/Practice		
Paleobotany	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT GE 14	**Course Title: Paleobotany**	

Course Outcomes:

After the completion of the course the students will be able to:

1. To understand the importance of paleobotany in plant science.
2. To understand the process of fossilization and factors affecting the process of fossilization.

Credits: 4	**Generic Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Definition and importance of Paleobotany, Principles of Paleobotany Geological time scale Fossil; Definition, types and mode of preservation Fossilization: Theories and factors affecting the process of fossilization Nomenclature and reconstruction of fossil plants Methods of study of fossils and carbon dating technique	20
2	Origin and evolution of life: Overview of the earliest environment on Earth, Basic concepts and theories about origin of life. Applied Paleobotany: Fundamentals of paleo-floristics, paleogeography, paleoecology and paleoclimatology	15
3	Colonization of land: Emergence of seed plants, appearance of angiosperms, basic concept of continental drift, Paleobotany in India, Gondwana flora	15
4	Demonstration of different types of fossils through preserved specimens	10

Suggested readings

- C.A. Arnold. (1947). An introduction to Paleobotany
- J. Walton. (1940). An introduction to the study of fossil plants