Department of Botany

Semester-I

DISCIPLINE SPECIFIC COURSE (DSC)- Plant diversity I (Microbes, Fungi and Algae)

No. of Hours: 75

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 diversity I (Microbes, Fungi and Algae)	**4**	**3**	**0**	**1**	**Passed Class XII with Biology**	**Nil**

UNDERGRADUATE CERTIFICATE IN BOTANY		
Programme : ***Undergraduate Certificate in Botany***	**Year: I**	**Semester: I**
Subject: Botany		
Course: BOT DSC 1	**Course Title: Plant diversity I (Microbes, Fungi and Algae)**	

Course Outcomes:

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

1. Develop an understanding about the classification and diversity of different microbes Algae, Fungi & Lichens & their economic importance.
2. Develop conceptual skill about identifying microbes, pathogens, biofertilizers & lichens.
3. Gain knowledge about developing commercial enterprise of microbial products.
4. Learn about the host –pathogen relationship and disease management.
5. Gain Knowledge about uses of microbes in various fields.
6. Understand the structure and reproduction of certain selected bacteria algae, fungi and lichens
7. Gain insight into the structure and replication mechanisms of viruses.

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, habitat, ecology and economic importance of microbes, fungi and algae.	**9**
2	Viruses-discovery, general structure, replication (general account), Lytic and lysogenic cycle, DNA virus (T-phage), RNA virus (TMV). Bacteria–discovery, general characteristics, cell structure, reproduction–vegetative, asexual and recombination (conjugation, transformation and transduction).	**12**
3	Range of somatic thallus organization, cell wall composition, nutrition, reproduction andclassification of fungi (G.C. Ainsworth); life cycle of *Albugo* (Mastigomycota) *Rhizopus* (Zygomycota) *Penicillium* (Ascomycota), *Puccinia, Agaricus* (Basidiomycota); *Alternaria* (Deutromycota), General account of lichen and mycorrhiza.	**12**
4	Range of thallus organization, reproduction and classification of algae (F. E. Fritsch); morphology and life-cycles of: *Nostoc, Chlaymydomonas, Volvox, Oedogonium, Chara* and *Sargassum*.	**12**

Practical/Lab Course BOT DSC 1P

Unit	Topic	No. of Hours (30)
1	EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle. Types of Bacteria from temporary/permanent slides/photographs; EM of bacterium; Binary Fission; Conjugation; Structure of root nodule; Gram staining technique.	**6**

2	Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs), *Volvox, Oedogonium, Chara* and *Sargassum* through temporary preparations and permanent slides/specimens.	**10**
3	*Rhizopus and Penicillium*: Asexual stages from temporary mounts. *Alternaria:* Specimens/photographs and tease mounts. *Puccinia*: Herbarium specimens of Black Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on wheat and permanent slides of both the hosts. *Agaricus*: Specimens of button stage and full grown mushroom.	**10**
4	Lichens: Study of growth forms of lichens (crustose, foliose and fruticose). Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs).	**4**

Suggested readings

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- 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, 11th Edition, McGraw-Hill, USA.
- Purohit, S.D., Kundra, G. K. and Singhvi, A. (2013). Practical Botany (part I). ApexPublishing House Durga Nursery Road Udaipur, Rajasthan

Semester-II

Undergraduate Certificate in Botany

DISCIPLINE SPECIFIC COURSE (DSC)- Plant Diversity II (Bryophyta, Pteridophyta and Gymnosperms)

No. of Hours-75

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 Diversity II (Bryophyta, Pteridophyta and Gymnosperms)	**4**	**3**	**0**	**1**	**Passed Class XII with Biology**	**Nil**

UNDERGRADUATE CERTIFICATE IN BOTANY		
Programme : ***Undergraduate Certificate in Botany***	**Year: I**	**Semester:II**
Subject: Botany		
Course: BOT DSC 2	**Course Title: Plant Diversity II (Bryophyta, Pteridophyta and Gymnosperms)**	

Course Outcomes:

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

1. Develop a critical understanding of the morphology, anatomy and reproduction of Bryophyta, Pteridophyta and Gymnosperms.
2. Understand plant evolution and their transition to land habitat.
3. Learn the major patterns of diversity among plants, and the characters and types of data used to classify them.
4. Compare different approaches of classification.

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, ecological and economic importance of bryophytes, pteridophytes and gymnosperms.	**9**
2	Classification of Bryophyta (G. M. Smith); Morphology, anatomy and reproduction of *Marchantia, Anthoceros* and *Funaria*.	**12**
3	Classification of Pteridophyta (K. R. Sporne); Morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*; heterospory and seed habit, stelar evolution, telome theory.	**12**
4	Classification of Gymnosperm (K. R. Sporne); Morphology, anatomy and reproduction of *Cycas, Pinus, Ginkgo* and *Ephedra*.	**12**

Practical/Lab Course BOT DSC 2P

Unit	Topic	No. of Hours (30)
1	*Marchantia*, *Anthoceros*: Morphology of thallus, rhizoids and scales, V.S. thallus through gemma cup, gemmae whole mount (all temporary slides), V.S. antheridiophore, archegoniophore, L.S. sporophyte through slides. *Funaria*- Morphology, whole mount leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, L.S. capsule and W.M. protonema.	**10**

2	*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. o f internode, L.S. o f strobilus and T.S Strobilus, whole mount sporangiophore, spores (wet and dry) (temporary slides); T.S. rhizome through permanent slides. *Pteris*: Morphology and anatomical features of rachis, rhizome and sporophyll through permanent slides.	**10**
3	*Cycas*: Morphology (coralloid roots, bulbil, leaf), T.S. coralloid root and rachis, V.S. leaflet and microsporophyll, whole mount spores (temporary slides), L.S. of ovule, T.S. of root (permanent slide). *Pinus*: Morphology (long and dwarf shoots, male and female cones), T.S. Needle and stem, L.S./T.S. of male cone, whole mount microsporophyll and microspores (temporary slides), L.S. of female cone, T.L.S. and R.L.S. stem (permanent slide).	**10**

Suggested readings

- Pandey, B.P. (2014). Modern Practical Botany Vol. II. S. Chand and Company Ltd., New Delhi.
- Bendre, A.M. and Kumar A. (2003). Manual of Practical Botany Vol. II. Rastogi Publications, Meerut.
- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
- Gangulee H.C., Kar, A.K. and Santra S.C. (2011). College Botany Vol II. 4th EditionNew Central Book Agency.
- Kaur I.D., Uniyal P.L. (2019). Text Book of Gymnosperms. New Delhi, Delhi: Daya Publishing House.
- 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.
- Parihar, N.S. (1991). An Introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
- Sharma, O.P. (1990). Textbook of Pteridophyta. MacMillan India Ltd. Delhi.
- The Pteridophyte Phylogeny Group (PPG Classification) (2016): A community –derived classification for extant lycophytes and ferns. Journal of Systematics and Evolution. 54(6): 563-603. Doi:10.1111/jse.12229.
- Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Bryophyta, S. Chand. Delhi, India.
- Vashishta, P.C., Sinha, A.K. and Kumar, A. (2010). Gymnosperms, S. Chand and Company Ltd., Ramnagar, New Delhi, India.

Semester-III

Undergraduate Diploma in Botany

No. of Hours- 75

DISCIPLINE SPECIFIC COURSE (DSC)- Plant Systematics and Developmental Biology (Angiosperm, Embryology and Anatomy)

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 Systematics and Developmental Biology (Taxonomy, Embryology and Anatomy)	4	3	0	1	Undergraduate certificate in Botany	Nil

UNDERGRADUATE DIPLOMA IN BOTANY		
Programme : ***Undergraduate Diploma in Botany***	**Year: II**	**Semester: III**
Subject: Botany		
Course: BOT DSC 3	**Course Title: Plant Systematics and Developmental Biology (Angiosperm, Embryology and Anatomy)**	

Course Outcomes:

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

1. Learn the major patterns of diversity among plants, and the characters and types of data used to classify plants.
2. Compare the different approaches of classification with regard to the analysis of data.
3. Become familiar with major taxa and their identifying characteristics, and to develop indepth knowledge of the current taxonomy of major plant families.
4. To discover and use diverse taxonomic resources, reference materials, herbarium collections, publications.
5. Understand plant morphology, anatomy and embryology.
6. Understand the role of tissues in plant functions.
7. Understand the composition, modifications, internal structure and architecture of plants.
8. Understand reproduction and developmental changes in plants.

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

Unit	Topic	No. of Hours (45)
1	Identification, classification, nomenclature of plants, functions of herbarium, overview of important herbaria and botanical gardens of the India and world. Important floras, botanical nomenclature [principles and rules (ICN)]; ranks andnames, binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations). Classification: Types of classification-artificial, natural and phylogenetic, Bentham and Hooker's (up to series), Hutchinson's classification and Angiosperm Phylogeny Group (APG IV) classification.	**15**
2	Salient features of families; Ranunculaceae, Malvaceae, Rutaceae, Fabaceae, Apiaceae, Asteraceae, Solanaceae, Lamiaceae, Euphorbiaceae, Orchidaceae and Poaceae.	**10**
3	Pollination, structure of anther and pollen, development of male and female gametophytes, types of ovule, polygonum type of embryosac, double fertilization.	**10**

	Endosperm; types of endosperm, dicot and monocot embryo.	
4	Types of tissues; root and shoot apical meristems, simple, complex and secretary tissues, RAM and SAM theories. Structure of dicot and monocot root, stem and leaf, root-stem transition, vascular tissue and secondary growth, abnormal or anomalous secondary growth.	**10**

Practical/Lab Course BOT DSC 3P

Unit	Topic	No. of Hours (30)
1	Taxonomic Identification: Description of an angiospermic plant (one plant per family), study of vegetative and floral characters (description, V.S. of flower, section of ovary, floral diagram/s, floral formula/e) and systematic position of the following families (Ranunculaceae, Malvaceae, Fabaceae, Asteraceae, Solanaceae and Poaceae) according to Bentham and Hooker's system of classification.	**10**
2	Herbarium techniques: Plant collection, preservation and mounting of two properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book), digital/virtual herbarium.	**5**
3	Structure of anther (young and mature). Types of ovule: anatropous, orthotropous, circinotropous, amphitropous, campylotropous. Female gametophyte: Polygonum (monosporic) type of embryo sac development (permanent slide/photograph), Pollination types and seed dispersal mechanism (photograph and specimens).	**8**
4	Study of meristems through permanent slides and photographs. Tissues (parenchyma, collenchyma and sclerenchyma), complex and secretary tissues. Anatomy of monocot and dicot stem leaf and root. Anomalous secondary growth (*Dracaena, Nyctanthus*).	**7**

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.

- Beck, C.B. (2010). An Introduction to Plant Structure and Development, II edition.
- Bhatnagar S.P, Dantu, P.K. Bhojwani S.S. (2018). The embryology of Angiosperms. Vikas Publ. House. New Delhi.
- Bhojwani, S.S. and Bhatnagar, S.P. (2010). The Embryology of Angiosperms. VikasPublication House Pvt. Ltd. New Delhi. ^{5}th edition.
- Johri, B.M. (1984). Embryology of Angiosperms. Springer-Verlag, Berlin.
- Leins, P., Tucker, S.C. and Endress, P.K. (1988). Aspects of floral development. J. Cramer. Germany.
- Maheshwari, P. (1971). An Introduction to Embryology of Angiosperms. McGraw HillBook Co. London.
- Pandey, B.P. (2001) Plant Anatomy. S. Chand and Company Ltd., New Delhi.
- Raghwan, (1997). Molecular embryology of flowering plants. Cambridge Univ. Press. Cambridge.
- Sharma, M.K. (2013) Plant Structures (An Introduction to Plant Anatomy). Vayu Education of India.
- Sambamurty, A.V.S.S. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd.
- Saxena N.B. and Saxena S. (2012). Plant Taxonomy Pragati Prakashan.
- Sharma O.P. (2013). Plant Taxonomy. MC GRAW HILL INDIA.
- Sharma, P.C. (2017). Text Book of Plant Anatomy. Arjun Publishing House.
- Shivanna, K.R. (2003). Pollen Biology and Biotechnology, Science Publishers. Verlag.
- Pandey, B.P. (2014). Modern Practical Botany Vol. II. S. Chand and Company Ltd.Ramnagar, New Delhi.
- Pandey, B.P. (2001). Plant Anatomy. S. Chand and Company Ltd., Ram Nagar, NewDelhi.
- Sundara, R.S. (2002). Practical Manual Anatomy and Embryology. Anmol Publisher,New Delhi.

Semester-IV

Undergraduate Diploma in Botany

No. of Hours- 75

DISCIPLINE SPECIFIC COURSE (DSC)- Cytology, Genetics and Biotechnology

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		
Cytology, Genetics and Biotechnology	4	3	0	1	**Undergraduate certificate in Botany**	

UNDERGRADUATE DIPLOMA IN BOTANY		
Programme : ***Undergraduate Diploma in Botany***	**Year: II**	**Semester: IV**
Subject: Botany		
Course: BOT DSC 4	**Course Title: Cytology, Genetics and Biotechnology**	

Course Outcomes:

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

1. Understand the structure and chemical composition of chromatin and concept of cell division.
2. Interpret the Mendel's principles; acquire knowledge of cytoplasmic inheritance and sex- linked inheritance.
3. Understand cell structure, nucleic acids, organization of DNA in prokaryotes and eukaryotes, DNAreplication mechanism, genetic code and transcription process.
4. Understand the basic tools and techniques used in Plant tissue culture.

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

Unit	Topic	No. of Hours (45)
1	An overview of cells and cell theories, prokaryotic and eukaryotic cells, cell organelles (nucleus, mitochondria, chloroplast, ER, golgi body, lysosomes, peroxisomes, glyoxysomes), nucleus, chromatin, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosomestructure, cell membrane and cell wall; models of plasma/cell membrane. Cell cycle and cell division (overview of mitosis and meiosis). Eukaryotic chromosome: structure, composition, karyotype analysis. Structure and function of Polytene and Lampbrush chromosomes.	**15**
2	Brief life history of Mendel, laws of Inheritance, chromosomal theory of inheritance, modified Mendelian ratio, lethal genes, co-dominance, incomplete dominance, multiple allelism, sex-determination and sex-linked inheritance, cytoplasmic inheritance.	**10**
3	Linkage: concept and history, complete and incomplete linkage, Bridges experiment, Crossing over: Concept and significance, cytological proof of crossing over, mutations and chromosomal aberrations (types of mutations, effects of physical and chemical mutagens, numerical chromosomal changes: (euploidy, polyploidy and aneuploidy); structural chromosomal changes: (deletions, duplications, inversions and translocations).	**10**
4	Introduction to Biotechnology: Role in modern life, history and ethical issues associated with Biotechnology. Recombinant DNA Technology, enzymes and vectors involved in genetic engineering, gene cloning.	**10**

Practical/Lab Course BOT DSC 4P

Unit	Topic	No. of Hours (30)
1	Structure of prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs. Study of the photomicrographs of cell organelles, structure of plant cell through temporary mounts. Study of mitosis and meiosis (temporary mounts and permanent slides).	**8**
2	Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square. Monohybrid cross (dominance and incomplete dominance)Dihybrid cross and gene interactions.	**10**
3	Study of polyploidy in plants. Photographs/permanent slides showing translocation ring, laggards and inversion bridge.	**5**
4	Contribution of G. J. Mendel, H. G. Khurana, Watson and Crick, Griffith, Harshey and Chase, Kary Mullis. Instruments used in Biotechnology.	**7**

Suggested readings

- 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.
- Berk, A., Kaiser, C.A., Lodish, H., Amon, A., Ploegh, H, Bretscher (Author), Monty Krieger, A.,Martin, K.C. (Eds). (2016) Molecular Cell Biology. Freeman & Co., USA.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
- Gardner, E.J., Simmons, M.J. and Snustad, D.P. (1991). Principles of Genetics, John Wiley & Sons.
- Rastogi, V.B. (2019). Genetics. 4th Edition. MEDTECH: A Division of Scientific International.
- Russel P. J. (2010). Genetics-A Molecular Approach, Pearson Education Inc.
- Singh R. J. (2002). Plant Cytogenetics, CRC Press
- Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice.Elsevier Science Amsterdam. The Netherlands.
- Singh, R.J. (2021). Practical Manual on Plant Cytogenetics. CRC Press, Taylor andFrancis Group, Routledge.

Semester-V

Bachelor of Science in Botany

No. of Hours-75

DISCIPLINE SPECIFIC COURSE (DSC)- Plant Physiology and Biochemistry

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 Physiology and Biochemistry	**4**	**3**	**0**	**0**	**Undergraduate diploma in Botany**	**Nil**

BACHELOR OF SCIENCE IN BOTANY		
Programme : ***Bachelor of Science in Botany***	**Year: III**	**Semester: V**
Subject: Botany		
Course: BOT DSC 5	**Course Title: Plant Physiology and Biochemistry**	

Course Outcomes:

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

1. Understand the role of physiological and metabolic processes for plant growth anddevelopment.
2. Learn the symptoms of mineral deficiencies in crops and their management.
3. Assimilate knowledge about the biochemical composition of plant diversity.
4. Know the role of plants in development of natural products, nutraceuticals, dietary supplements, antioxidants.

Credits: 1	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (45)
1	Plant water relations, water potential and its components, diffusion and osmosis, transpiration and its significance, factors affecting transpiration, root pressure and guttation. Mineral nutrition: Essential elements, macro and micronutrients; criteriaof essentiality of elements, role of essential elements; transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.	**12**
2	Photosynthesis: photosynthetic Pigments (Chl a, b, xanthophylls, carotene), photosystem I and II, electron transport and mechanism of ATP synthesis, C_3, C_4 and CAM pathways of carbon fixation, photorespiration. Respiration: glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation and glyoxylate cycle.	**13**
3	Biological nitrogen fixation, nitrate and ammonia assimilation Plant growth regulators: discovery and physiological roles of auxins, gibberellins, cytokinins, abscisic acid and ethylene.	**10**
4	General introduction to carbohydrates, lipids and proteins. Enzymes (structure and properties, mechanism of enzyme catalysis and enzyme inhibition, factors affecting enzyme action), Michaelis- Menten kinetics.	**10**

Practical/Lab Course BOT DSC 5P

Unit	Topic	No. of Hours (30)
1	Demonstration of process of diffusion, osmosis and plasmolysis. Demonstration of transpiration in dorsivental leaf by four leaf and cobalt chloride method. Determination of rate of transpiration by Ganong's/Farmer's potometer.	**10**
2	Demonstration of the effect of light intensity and bicarbonate	**14**

	concentration on O_2 evolution in photosynthesis by Wilmott's bubbler Determination of R.Q. of different respiratory substrates by Ganong's respirometer. Demonstration of anaerobic respiration in germinating seeds.	
3	Test of carbohydrates, proteins and fats.	**6**

Suggested Readings

- Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. NarosaPublishing House, New Delhi.
- Buchanan, B., Gruissem, G. and Jones, R. (2000). Biochemistry and Molecular Biology of Plants,American Society of Plant Physiologists, USA.
- Davies P J. (2004). Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd Edition,Kluwer Academic Publisher, Dordrecht, The Netherlands.
- Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley andSons, U.S.A. 4th Edition.
- Nelson, D.L., and Cox, M.M. (2008). *Lehninger Principles of Biochemistry* (5th ed.). W.H.Freeman & Co., New York.
- Taiz, L., Zeiger, E., (2014). Plant Physiology. Sinauer Associates Inc., U.S.A. 6thEdition
- Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-HillPublishing Co. Ltd. New Delhi. 3rd edition.

Semester-VI

Bachelor of Science in Botany

No. of hours-75

DISCIPLINE SPECIFIC COURSE (DSC)- Plant Ecology and Biostatistics

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 Ecology and Biostatistics	4	3	0	1	**Undergraduate diploma in Botany**	**Nil**

BACHELOR OF SCIENCE IN BOTANY		
Programme : ***Bachelor of Science in Botany***	**Year: III**	**Semester: VI**
Subject: Botany		
Course: BOT DSC 6	**Plant Ecology and Biostatistics**	

Course Outcomes:

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

1. Acquaint with complex interrelationship between organisms and environment;
2. Understand methods for studying vegetation, community patterns and processes,ecosystem functions, and principles of phytogeography.
3. Understand the strategies for sustainable natural resource management and biodiversity conservation.
4. Develop practical knowledge of the different statistical tools and techniques.

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

Unit	Topic	No. of Hours (45)
1	Plant adaptation in relation to water **(**Hydrophytes and xerophytes), light (Sciophytes and heliophytes) and temperature. Pollution: water, soil and radioactive.	**12**
2	Ecosystem: Types, structure, energy flow, trophic organization, food chains and food webs, ecological pyramids, ecological factors and ecosystem productivity. Biogeochemical cycles: Cycling of carbon, nitrogen and phosphorous.	**12**
3	Population: Characteristics, Growth curves, Ecotypes and Ecads, Plant communities: Characteristics, plant succession, biological spectrum.	**9**
4	Definition and scope of statistics, sampling techniques, representation of grouped and ungrouped data. Measures of dispersion: range, mean deviation, variation, standard deviation; Chi-square test, regression analysis. Measures of central tendency: Arithmetic mean, mode, median.	**12**

Practical/Lab Course BOT DSC 6P

Unit	Topic	No. of Hours (30)
1	Observation and study of different ecosystems mentioned in the syllabus. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, rain gauge and lux meter. Determination of pH, and analysis of soil samples for soil moisture, organic carbon, nitrogen and phosphorus.	**10**

2	Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats. Study of ecological adaptations in hydrophytes and xerophytes. Study of biotic interactions of stem parasite (*Cuscuta)*, root parasite (*Orobanche*), epiphytes, predation (insectivorous plants) through specimen or diagrams.	**8**
3	Determination of minimum quadrat size for the study of herbaceous vegetation by species area curve method (species to be listed). Quantitative analysis of herbaceous vegetation in the college campus for frequency, density, abundance and A/F ratio. Population structure of dominant tree species of the locality.	**8**
4	Analysis of statistical data: mean, median and mode by analyzing the given data of individual, discrete and continuous series, standard deviation and error.	**4**

Suggested readings

- Banerjee, P.K. (2006). Introduction to Biostatistics. S. Chand and Company Ltd., RamNagar, New Delhi.
- Chapman, J.L. and Reiss, M.J. (2003). Ecology: Principles and Applications. Second Edition. Cambridge University Press, UK. ISBN 0 521 58802 2. 335 pages.
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- Odum, E.P. (2011). Fundamental of Ecology. 5th Edition. Saunders. ISBN 9780030584145. 613 pages.
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- Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
- Shukla, R.S. and Chandel P.S. (2005). A text book of Plant Ecology. S. Chand andCompany Ltd., Ram Nagar, New Delhi.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
- Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-HillPublishing Co. Ltd. New Delhi. 3rd edition.
- Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

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 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 only 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.	**6**

	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.	
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 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 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 Approaches to and principles of restoration	**5**

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