SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar, Gujarat
(Reaccredited with 'A' Grade by NAAC (CGPA 3.25)
Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE

M.Sc. Botany Semester: III

Programme Outcome (PO) - For M.Sc. Botany Programme	Students completing M.Sc. Botany course of four semesters will gain thorough knowledge and develop relevant practical skills on different areas of Botany, both the fundamental and traditional aspects as well as the advanced and application oriented aspects such as plant structural and functional diversity and its role in human livelihood, ecological services and human influenced environmental issues, evolution processes resulting the diversified plant groups, their morphological, anatomical, and physiological adaptations to different environmental conditions, plant interactions with microbes and insects, genetic makeup and inheritance of various levels of plants, cell and molecular biology of plants, horticultural crops, physiology, biochemistry, biotechnology, recombinant DNA technology, proteomics and transgenic technology. Students will develop skills of plant explorations and identifications, herbarium preparation and preservation techniques, nursery establishment and management techniques, principles and methods of biodiversity conservation, microscopy and microtomy, reproduction, genetics, genetic structure of populations, microbiology, molecular biology, identification of various pests and diseases of crop plants and their controlling mechanisms, various analytical techniques, acquaintance with the use of bioinformatics tools and databases and application of statistics to biological data, biotechnological tools and techniques used for mass *in vitro* propagation, genetic transformation of plants, transgenic technology. By performing practical experiments relevant to the theory papers and taking one elective paper of their choice in each semester and a dissertation course in the fourth semester, students will get trained in experimental design and execution, firsthand experience on tools and techniques of research, quantitative and qualitative data analysis and interpretation of data. By presenting seminars in each semester, students will develop science communication and presentation skills.

Programme Specific Outcome (PSO) - For MSc Botany Semester - I	Having studied the four prescribed papers, by the end of this semester, students will be able to: 1. Recognize and appreciate diversity, classification, ecological and economic significance of various groups of lower plants and higher plants including archibacteria and eubacteria. 2. Understand how cell interacts with environment, how cell growth and death are regulated. 3. Understand evolutionary trends among different groups of plants. 4. Have clear understanding about various tools and techniques to study cells, different cell organelles and their functions. 5. Become familiar with appropriate statistical methods required for designing a scientific experiments, formulate appropriate hypothesis for a scientific investigation.

To Pass	(1) At least 40% marks in each paper at the University Examination and 40% aggregate marks in Internal and External Assessment. (2) At least 33% Marks in each paper in Internal Assessment.

Course Type	Course Code	Name Of Course	Theory/ Practical	Credit	Exam Duration in hrs	Component of Marks		
						Internal Total	External Total	Total Total
Core Course	PS03CBOT51	Genetics and Plant Breeding	T	4	3	30	70	100
	PS03CBOT52	Mycology and Plant pathology	T	4	3	30	70	100
	PS03CBOT53	Plant Developmental Biology	T	4	3	30	70	100
	PS03CBOT54	Practicals	P	4	3	30	70	100
	PS03CBOT55	Practicals	P	4	3	30	70	100
Elective Course (Any One)	PS03EBOT51	Phytoresources	T	4	3	30	70	100
	PS03EBOT52	Horticulture	T	4	3	30	70	100
	PS03EBOT53	Bioinformatics	T	4	3	30	70	100

Master of Science (Botany)
M.Sc. Botany Semester III

Course Code	PS03CBOT51	Title of the Course	Genetics and Plant Breeding
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To develop the knowledge on fundamentals of genetics. 2. To have clear understanding on different tools and techniques of plant breeding. 3. To get familiarised with the applications of plant breeding techniques.

Course Content		
Unit	Description	Weightage* (%)
1.	Fundamentals of Genetics: Mendelian analysis, Mendel's Laws of Inheritance, The principle of segregation, Test cross and back cross; The principle of Independent assortment, pedigree analysis. Chromosome structure and function; Probability & Statistics in Genetics: Probability in genetic analysis; probability of combination of events, mutually exclusive events, use of binomial distribution in Genetics; The Chi-square goodness of fit test and its use in Genetics. Interaction of genes: Incomplete dominance, co-dominance, lethal genes, epistasis, pleiotropy polygenic traits and quantitative inheritance.	25
2.	Chromosome: structure and nomenclature, centromere and telomere Karyotype analysis: Method, banding patterns, karyotype evolution, applications Sex chromosomes and sex-linked inheritance: Transmission of sex-linked traits, sex determination; Linkage and chromosome mapping and its significance: Linkage, Crossing over- two point crosses, three–point crosses tetrad analysis, chromosome maps.	25
3.	Maternal effects and cytoplasmic inheritance: Maternal effects in snails, Streptomycin resistance in Chlamydomonas, mitochondrial mutations in yeast, Kappa particles in paramecium, plastid inheritance in Mirabilis jalapa, male sterility in plants; Alterations in chromosome number and structure: Ploidy: Aneuploidy and euploidy, polyploidy and its significance: alteration in chromosome structure: Deletions, duplications, inversions and translocations; Mutations: Types of mutations, mutagens, molecular basis of mutations; transposable elements; Reverse mutations & suppressor mutations.	25
4.	**Plant Breeding:** History, methods and objectives of plant breeding; Present status and future prospects; Origin, domestication and	25

	introduction of crop plants; Modes of reproduction – asexual and sexual reproduction, determination of mode of reproduction in a species, modes of pollination, mechanism of pollination control, self-incompatibility, male sterility; Breeding in self pollinated crops; Hybridization: History, objectives and procedures in hybridization, consequences of hybridization; Polyploidy in plant breeding; application of polyploidy in crop improvement and its limitations.	

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to:

1.	Gain fundamental knowledge about how the inheritance occur among various species.
2.	Apply the principles of genetics and breeding in development of new varieties of plants.

Suggested References:	
Sr. No.	References
1.	Anna C. Pal & Helen M. Roberts. Genetics – its concepts & implications, Prentic – Hall Inc. Engle clifts, New Jersey. USA.
2.	Edmund W. Sinnot, L. C. Dunn & T. Dobzhansky, Principles of Genetics. McGraw Hill Book company Inc. New York, USA.
3.	Gupta, P. K. Genetics. Rastogi Publications. Shivaji Road Meerut, India.
4.	Robert Weaber & Philip W. Hedrick. Basic Genetics, Second Edition. W. M. C. Brown Publishers Dubuque lowq.
5.	Sr A. M. & R. W. Owen. General Genetics, W. H. Freeman & Company, Sanfrancisco.
6.	Strickberger M. W. Genetics. Third Edition. Macmillan Publishing co. New York.

On-line resources to be used if available as reference material
On-line Resources
Relevant review articles/research papers/handouts of latest development in the subject

Practical Exercises:

1. Preparation of stains, Fixatives, preservatives and pretreatments to plant material
2. Karyotype analysis, preparation of somatic C- metaphase chromosomes of appropriate material and Karyotype analysis in Allium/Aloe.
3. Study of meiotic configuration In maize/ Allium, Rhoe/Aloe, Tradescantia (prophase I, chiasma analysis).
4. Study of chromosomal aberrations in irradiated plant material
5. Problems of Mendelian inheritance and estimation of gene frequencies and heterozygotic frequencies, population genetics and Linkage.
6. Pedigree analysis – problems on pedigree analysis to establish autosomal/sex-linked dominance and recessive transmission in humans
7. Problems related to probabilities by using binomial and chi-square analysis
8. Linear differentiation of chromosomes through banding techniques such as C-Banding, G-Banding and Q-Banding.
9. Floral Biology, study of Pollen Viability, germination in vitro and staining of any two major crops.
10. Use of Colchicine for induction of polyploidy in appropriate plant material.

Master of Science(Botany)
M.Sc. Botany Semester III

Course Code	PS03CBOT52	Title of the Course	Mycology and Plant pathology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	By the end of this course students will have: 1. To understand the fungal classification. 2. To study the structure and reproduction fungi. 3. To understand modern techniques in mushroom cultivation 4. To understand structure and reproduction of lichens. 5. To understand various diseases caused by bacteria fungi and virus.

Course Content		
Unit	Description	Weightage* (%)
1.	Introduction to Fungi: History and classification of Fungi (Alexopoulas, 1962, Ainsworth 1973, Kirk et.al. 2008). Fungi: General characteristics. Economic importance of fungi. Life cycle, morphology, structure and reproduction in Kingdom: Fungi, Kingdom: Chromista and kingdom:Protozoa.	25
2.	Lichens: Morphology, reproduction and economic importance. Techniques of mushroom cultivation: Schedule and systems of cultivation; composting; peak heating; spawn preparation and mushroom stains spawning and mycelia growth; supplementation; cultivation technique from casing to ruffling and recovery growth to harvesting; pests and diseases and its protection.	25
3.	The disease triangle: Role of environment, host and pathogen in disease formation. Symptoms, life cycle and control of fungal diseases: Rusts, smuts, blast, red-rot, powdery mildew and tikka diseases. Symptoms, life cycle and control of bacterial and viral diseases: Leaf blight, canker, leaf spot, Mosaic, panama and leaf curl diseases.	25
4.	Control measures for plant diseases. Chemical control, biological control and integrated disease and pest management. Host- pathogen	25

	interactions, plant defense mechanisms. HR and SAR in plant defense. Molecular mechanisms and signaling pathways in plant defenses.	

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, student will have clear understanding of:	
1.	Fundamentals of various classifications of fungi.
2.	Reproduction of various classes of fungi.
3.	Various techniques involved in cultivation of mushrooms and their economic importance.
4.	Biology and economic importance of lichens.
5.	Various plant diseases caused by fungi and their control methods.

Suggested References:	
Sr.	References

No.	
1.	Alexopoulos, C. J., Mims, C. W., & Blackwell, M. (1996). *Introductory mycology* (No. Ed. 4). John Wiley and Sons.
2.	Dube, H. C. (2013). *An introduction to fungi*. Scientific Publishers.
3.	Singh, R. S. (1980). Principles of Plant pathology.
4.	Singh, R. S. (2018). *Plant diseases*. Oxford and IBH Publishing
5.	
6.	
7.	

On-line resources to be used if available as reference material
On-line Resources
Relevant review articles/research papers/handouts of latest development in the subject

Practicals.

1. Observation of permanent slides of various fungi.

2. Semi permanent slide preparation, staining and identification of fungi.

3. Observation and slide preparation and lichens.

4. Study of various diseased plant material and identification. (Leaf blight, canker, leaf spot, Mosaic, panama and leaf curl diseases)

Master of Science (Botany)
M.Sc. Botany Semester III

Course Code	PS03CBOT53	Title of the Course	Plant Developmental Biology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To understand the various types of tissue system in plant 2. To know the processes of plant growth and development 3. To understand the phenomena of formation of various parts of the plant 4. To understand the various events during the life cycle of plants.

Course Content		
Unit	Description	Weightage* (%)
1.	Overview of plant structure and development**:** Major groups of plants; Geeral structure of higher plants- The cell and meristems. Seed to seedling: Seed germination, seedling growth; Primary vegetative body of the plant Tissue systems: Simple tissue; complex tissues and tissue systems, Protective systems, Absorbing systems, Supporting systems, Photosynthetic systems, Storage systems, Transporting systems; Secretory and Excretory systems, Aerating systems; Movement systems of positional perception, Intra-organismal communication systems. Concepts of plant growth and development from an organismal perspective.	25
2.	Growth,Development and Differentiation of the Shoot- Organization and maintenance of shoot apical meristem,Organogenesis and organ polarity,Floral transition, Floral organ patterning and determinacy,Secondary growth in plant, The structure, development and function of vascular cambium, secondary xylem, secondary phloem, periderm; Leaf- Basic leaf structure, leaf development, Morphological variation in structure and arrangement, structure of leaf in C_3 and C_4 plants, leaf abscission; Root- External Morphology of roots, Organization and maintenance of root apical meristem, radial patterning during vascular development, Root branching; lateral root development, Modifications of root.	25
3.	Reproduction **:** Floral evocation and development of the floral meristem, formation of floral organs, Structure and development of microsporangium and megasporangium, microsporogenesis and formation of the male gametophyte, Megasporogenesis and formation of the female gametophyte; embryo sac development, Pollen-pistill interaction, Fertilization.	25

4.	Seed and Fruit formation: Post-fertilization features-Endosperm development and embryogenesis, various types of embryo; Modern techniques in development- Apomixis, Apospory, Parthenogenesis. Structure and Development of Seed and Fruit; Fruit growth and ripening, Dormancy of seeds and buds. Alternative development strategies: Embryonic development of somatic cell and pollen grains, Abnormal growth.	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to:	
1.	Identify different tissue systems and their location in plant body.
2.	Develop deep knowledge of plant development from seed to giant tree.
3.	Get clear idea on the formation of tissues and plant parts and their organization.

Suggested References:	
Sr. No.	References

1.	Carlquist, S. Comparative Wood Anatomy, Springer – Verlag, Berlin.
2.	Cutter, D. F., Applied Plant Anatomy, Logman, London.
3	Cutter, E. G. Plant Anatomy: Experiment and Interpretation: Part 2 – Organs. EdwardArnold, London.
4	Cutter, E. G., Plant Anatomy: Part – 1 Cells and Tissues, 2nd Edition, Edward Arnold, London.
5	Eames, A. J. and Mac Daniels, L. H. An Introduction to Plant Anatomy, 2nd Edition, McGraw – Hill, New York.
6	Fahn, A., Plant Anatomy, 4th Edition, Butterworth, Heinemann Ltd.
7	Fosket, D. E., Plant Growth and Development: A Molecular Approach. Academic press, San Diego.
8	Kozolowski, T. T., Growth and Development of Trees. Vols. I and II. Academic Press, New York.
9	Lyndon, R. F., Plant Development: The cellular basis. Unwin Hyman, London.
10	Maheshwari, P. An Introduction to the Embryology of Angiosperms. McGraw-Hill Book Co., New York.
11	Mauseth, J. D. Plant Anatomy, The Benjamin/Cummings Publishing Co. California.
12	Metcalfe, C. R. and Chalk. L. Anatomy of the Dicotyledons, Vol. I and II, Clarendon Press, Oxford.
14	Metcalfe, C. R. and Chalk. L. Anatomy of the Dicotyledons. Vol – III, 2nd Edition Clarendon Press, Oxford.
15	Murphy, T. M. and Thompson, W. F. Molecular Plant Development, Prentice Hall, New Jersey.
16	Peter, W., Jeske, H., Jurgens, G., Kloppstech, K. and Link, G. Molecular Plant Development: from gene to plant. Oxford University Press, Oxford, NY.
17	Raghavan, V. An Introduction to the Embryology of Angiosperms. McGraw Hill Book Co., NY.
18	Raghavan, V. Developmental Biology of Flowering Plants. Springer – Verlag, NY.

19	Romberger, J. A., Hejnowicz, Z. and Hill, J. F. Plant Structure: Function and Development: A Treatise on Anatomy and Vegetative Development, with special reference to woody plants, Springer – Verlag, NY.
20	Zimmerman, M. H. and Brown, C. L. Trees – Structure and Function, Springer Verlag, Berlin.

On-line resources to be used if available as reference material
On-line Resources
Relevant review articles/research papers/handouts of latest development in the subject

Practical Exercises:

1. Pollen tube growth and development
2. Shoot Apical meristem: structure, organization and allied organs
3. Root apical meristem: structure and organization
4. Primary vascular tissues and secondary vascular tissues
5. Floral meristem: structure and organization
6. Diversity of Trichome in different plant species
7. Demonstration of microsporogenesis
8. Stomatal diversity in different plant species
9. Different types of Tissues system of plant
10. Study of various types of cells in wood by maceration techniques
11. Different stages of embryo development
12. Structure and organization of bundle sheath and leaf blades
13. Demonstration of megasporogenesis
14. Demonstration of fertilization process
15. Study of seed germination: ratio and vigor index
16. Study of different types of tropism in plants
17. Stages of mitosis

Course Code	PS03CBOT54	Title of the Course	LAB-I
Total Credits of the Course	04	Hours per Week	08

Course Objectives:	1. To observe different kinds of chromosomes and chromosomal sets, chromosomal abberations and karyograms. 2. To understand and resolve various kinds problems related to Mendelian inheritance, pedigree analyses, propability. 3. To observe the influence of various factors on pollen viability and in vitro germination. 4. To observe the diversity among different groups of fungi. 5. To study the symptoms and causative organisms of different fungal diseases in plants.

PS03CBOT54 (Lab IA)
(Genetis and Plant Breeding)

Sr.No.	**Practical Exercises**
1	Preparation of stains, Fixatives, preservatives and pretreatments to plant materials
2	Karyotype analysis, preparation of somatic C- metaphase chromosomes of appropriate material and karyotype analysis in Allium/Aloe.
3	Study of meiotic configuration In maize/ Allium, Rhoe/Aloe, Tradescantia (prophase I, chiasma analysis).
4	Study of chromosomal aberrations in irradiated plant material
5	Problems of Mendelian inheritance and estimation of gene frequencies and heterozygotic frequencies, population genetics and Linkage.
6	Pedigree analysis – problems on pedigree analysis to establish autosomal/sex-linked dominance and recessive transmission in humans
7	Problems related to probabilities by using binomial and chi-square analysis
8	Linear differentiation of chromosomes through banding techniques such as C-Banding, G-Banding and Q-Banding.
9	Floral Biology, study of pollen viability, in vitro germination and staining of any two major crops.
10	Use of Colchicine for induction of polyploidy in appropriate plant material.

PS03CBOT54 (Lab IB)
(Mycology and Plant Pathology)

Sr.No.	Practical Exercises
1	Observation of permanent slides of various fungi.
2	Semi permanent slide preparation, staining and identification of fungi.
3	Observation and slide preparation and lichens.
4	Study of various diseased plant material and identification. (Leaf blight, canker, leaf spot, Mosaic, panama and leaf curl diseases)

Learning Methodology	Practical exercises will be conducted by supplying live collections/fixed materials/ permanent slides of relevant practicals. Students will be encouraged to make field surveys of local areas for collection of live materials infected with fungi relevant to their course and studying them in the lab. Students will be encouraged to make live collections of pollen of crop plants from local area and perform pollen viability tests in the lab. Students will be encouraged to make live collections of seeds of crop plants from local fields and perform seed viability tests in the lab. Various problems related to genetic inheritance will be offered to get resolved.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	20%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce and Attendance (As per CBCS R.6.8.3)	10%
3.	University Examination	70%

Course Outcomes: Having completed this course, students will be able to	
1.	Recognise the symptoms of various fungal diseases in plants.
2.	Identify various causative organisms of various crop diseases.
3.	Observe various factors involved in pollen and seed viability.

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	References:
1.	Gupta, P. K. Genetics. Rastogi Publications. Shivaji Road Meerut, India.
2.	Dube, H. C. (2013). *An introduction to fungi*. Scientific Publishers.
3.	Singh, R. S. (1980). Principles of Plant pathology.
4.	Singh, R. S. (2018). *Plant diseases*. Oxford and IBH Publishing

M.Sc. (Botany) Sem. 3

Course Code	PS03CBOT55	Title of the Course	LAB-II
Total Credits of the Course	04	Hours per Week	08

Course Objectives:	1. To observe and record various developmental stages of vegetative and reproductive organs in plants. 2. To observe and record diversity of various tissue systems in different organs of plants.

PS03CBOT55 (Lab IIA)

(Plant Developmental Biology)

Sr.No.	Practical Exercises
1	Pollen tube growth and development
2	Shoot Apical meristem: structure, organization and allied organs
3	Root apical meristem: structure and organization
4	Primary vascular tissues and secondary vascular tissues
5	Floral meristem: structure and organization
6	Diversity of Trichome in different plant species
7	Demonstration of microsporogenesis
8	Stomatal diversity in different plant species
9	Different types of tissue systems of plant
10	Study of various types of cells in wood by maceration techniques
11	Different stages of embryo development
12	Structure and organization of bundle sheath and leaf blades
13	Demonstration of megasporogenesis
14	Demonstration of fertilization process
15	Study of seed germination: ratio and vigor index
16	Study of different types of tropism in plants
17	Stages of mitosis

M.Sc. (Botany) Sem. 3

PS03CBOT55 (Lab II-B)

·	**Practical Exercises will be related to elective papers**

Learning Methodology	Practical exercises will be conducted in the regular M.Sc. Labs or in the Central microscopy and instrumentation labs depending upon the requirement of equipment. Some of the exercises will be performed individually by each student, whereas someother will be done in a group, based on the nature of the experiment. Some exercises may be limited to demonstration.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	20%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce and Attendance (As per CBCS R.6.8.3)	10%
3.	University Examination	70%

Course Outcomes: Having completed this course, students will be able to:	
1.	Identify and recognise various tissue systems, developmental stages and changes in vegetative and reproductive organs of plants.
2.	Develop skills in taking fine sections of plant materials in different dimensions and staining techniques to differentiate different tissue systems.

M.Sc. (Botany) Sem. 3

	References:
1.	Raghavan, V. Developmental Biology of Flowering Plants. Springer – Verlag, NY.
2.	Romberger, J. A., Hejnowicz, Z. and Hill, J. F. Plant Structure: Function and Development: A Treatise on Anatomy and Vegetative Development, with special reference to woody plants, Springer – Verlag, NY.
3.	Cutter, E. G. Plant Anatomy: Experiment and Interpretation: Part 2 – Organs. EdwardArnold, London.
4.	Cutter, E. G., Plant Anatomy: Part – 1 Cells and Tissues, 2nd Edition, Edward Arnold, London.

Master of Science (Botany)
M.Sc. Botany Semester III

Course Code	PS03EBOT51	Title of the Course	Phytoresources
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	By the end of this course students will have: 1. Clear understanding on extant of diversified local, regional and global phytoresources available for mankind. 2. Fair understanding about various kinds of little known phytoresources 3. Greater concern towards the exploration and utilization of traditional or local varieties of crop plants. 4. Greater concern to recognize and appreciate the knowledge of tribal and traditional societies on phytoresources, and conservation of such knowledge.

Course Content		
Unit	Description	Weightage* (%)
1.	Concept and extant of plant diversity in wild and cultivation. Innovations meeting for world food demands. Origin and history of plant of domestication and agriculture; centers of crop plant origin and diversity; geographical distribution of crops of Indian origin. Plant genetic resources, their importance in crop improvement, collection and managing genetic resources. Role of biotechnology in germplasm conservation.	25
2.	A brief account on the following major and minor crops of Indian origin, their products and uses. (i) food grains (ii) oil yielding crops (iii) medicinal and aromatic plants. A brief account on the sources, active principles and uses of (i) alcoholic and non-alcoholic beverages (ii) coloring agents (iii) spices (vi) sweetening agents (iv) petrocrops and biofuels.	25
3.	Ethnomedicobotany: Scope and potential applications; collection methods of ethnomedicobotanical data; field methods and scrutiny of Herbarium specimens and folklore; verification of data; collection of materials for voucher specimen and for phytochemical screening; Avenue trees: concept, role, site specific selection criteria for urban	25

	habitations, industrial zones, and highways. Indoor plants: different kinds of indoor plants and their significance; site specific selection and care of indoor plants.	
4.	Forest products: Important timber yielding plants, timber identification/ diagnostic features. Non-timber forest products: bamboos, rattans, gums, resins, tannins. Plants as sources of drugs and pharmaceuticals. Drugs of botanical origin: Structure and physical properties; chemistry of secondary metabolites: phenols, phenolic glycosides, saponins, steroids, alkaloids, vitamins and hormones and natural antibiotics.	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

1.	Appreciate the extant and significance of different wild and domesticated plants.
2.	Recognize the extant of traditional knowledge and importance of documenting such knowledge.
3.	Develop the spirit of exploring uses unconventional plants and unconventional uses of popular plants.

Suggested References:

Sr. No.	References
1.	Arora, R., K., Nayar, E., R.,(1984). Wild Relatives of Crop Plants in India. National Bureau of Plant Genetic Resources Science Monograph, New Delhi
2.	Bole, P., V., Vaghani, Y., (1986). Field Guide to Common Indian Trees. Oxford University Press, Mumbai.
3.	Chandel, K., P., S., Shukla, G., Sharma, N., (1986). Biodiversity in Medicinal and Aromatic Plants in India: Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
4.	Ambasta, S., P., (1986). Council of Scientific & Industrial Research. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
5.	Jain, S., K., (2004). A Manual of Ethnobotany. 2nd Edn. Scientific Publishers Journals Department, Jodhpur.
6.	Jain, S., K., Sinha, B., K., Gupta, R., C., (1991). Notable plants in Ethnomedicine of India. Deep Publications, New Delhi.
7.	Jain, S., K., (2015). Dictionary of Indian Folk medicine and Ethnobotany. S K Jain Publications, New Delhi.

On-line resources to be used if available as reference material
On-line Resources
Relevant review articles/research papers/handouts of latest development in the subject

Practical Exercises:

1. Examining various food crop plants (live or Herbarium specimens) and their products.
2. Examining various cash crop plants, their products.
3. Examining various medicinal plants and their products.
4. Collection, preparation and preservation of voucher herbarium specimens.
5. Study of little known plants used as food or used in food preparations.
6. Diagnostic and identification features of important timbers.
7. Study of various non timber forest produce.
8. Study of various Avenue trees and their qualities.
9. Study of various indoor plants.

(Master of Science) (Botany)
M.Sc. Botany Semester (Third)

Course Code	PS03EBOT52	Title of the Course	Horticulture
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To know the importance of horticulture in economy and employment. 2. To know the horticultural and climatic zones of India and Gujarat. 3. To understand the cultivation of horticultural crops. 4. To understand the working mechanisms and benefits of specialized cultivation structure. 5. To learn postharvest processing and value addition of fruits and vegetables.

Course Content		
Unit	Description	Weightage* (%)
1.	**Fundamentals of horticulture (History, nature and scope of horticulture)** Origin of Horticulture – Domestication of plants, definitions ofhorticulture (importance of horticulture in terms of economy, production and employmentgeneration, classification of horticultural crops) – pomology, olericulture, spices and plantation,ornamental horticulture – climatic zones of India and Gujarat in relation to horticulture, development of horticulture in India - Divisions of horticulture and their importance(Horticultural zones of India and Gujarat) – nutritive value and nutraceutical properties ofhorticultural crops. **Factors influencing horticultural crop production in India** Factors influencing growth and development – soil, light, temperature, rainfall, humidity,wind etc.	25
2.	Role of plant growth regulators in growth and development of horticultural crops—seed and bud dormancy, juvenility, maturity andsenescence, flowering, pollination, fruit-set includingparthenocarpy, fruit growth, fruit dropand fruit ripening (climacteric and non- climacteric) and fruit colour development, tuber andbulb formation and sex expression and extension of shelf life in fruits, vegetables andflowers. Role of growth regulators in plant propagation. Nutrition of horticultural crops – Introduction to soil fertility and productivity- factors affecting. Essential plant nutrient elements-functions, deficiency systems, transformations and availability. Acid, calcareous and salt affected soils – characteristics and management. Soil organic matter, pH in plant nutrition, soil buffering capacity.	25

	Nutrients deficiency symptoms and visual diagnosis. Pruning and training, theirobjectivesand methods. Flower and fruitdrop,stages, causes and remedial measures. Fruit thinning, objectives, advantages anddisadvantages. Unfruitfulness, reasons and remedial measures.	
3.	**Methods of propagation of horticultural crops - P**lant propagation methods: Definitions of various types of propagation structures, seed propagation – merits anddemerits, crops propagated through seeds, Factors affecting seed germination and pre-germination treatments and viability tests – vegetative propagation – merits and demerits, cutting, layering, grafting and budding rootstock influence – stock / scion relationship, specialized structures for propagation,Micro-propagation and its Importance. Role of growth regulators in propagation.	25
4.	Importance & scope of post-harvest management of horticultural crops in India. Structure of fruits, vegetables and cut flowers related to physiological changes after harvest. Maturity indices, harvesting, pre cooling, sorting and grading of fruit, vegetables, cut flowers, plantation crops, spices, medicinal and aromatic plants. Pre-harvest factors affecting quality. Factors responsible for deterioration of horticultural produce. Physiological and bio-chemical changes during ripening. Hastening and delaying ripening process. Pre and Post-harvest treatments ofHorticultural crop viz. pre-harvest sprays, curing, degreening, pre cooling, waxing, fumigation, irradiations, HWT, VHT, etc. Different systems/methods of storage including cold storage, CA & MA storage, low cost cooling structures, etc. Packaging methods (vacuum packaging, poly shrink packaging, grape guard packing), types of packages and recent advances in packaging. Types of containers and cushioning materials. Transportation of fresh horticultural produce to local and distant market.	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage

1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	Understand the cultivation of horticultural crops.
2.	Start their own enterprenureship, if they wish, in horticultural crops.
3.	Develop essential skill to start a small-scale nursery.

Suggested References:

Sr. No.	References
1.	Adams, C.R. and M. P. Early. 2004. Principles of horticulture. Butterworth – Heinemam,Oxford University Press.
2	Chadha, K.L. 2001, Handbook of Horticulture, ICAR, New Delhi.
3	Chandra, R. and M. Mishra. 2003. Micropropagation of horticultural crops. InternationalBook Distributing Co., Lucknow.
4	Chattopadhyaya, P.K.2001. A text book on Pomology (Fundamentals of fruit growing) Kalyani Publication, New Delhi
5	Christopher, E.P. 2001. Introductory Horticulture, Biotech Books, New Delhi
6	Edmond, J.B. T.L.Senn, F.S. Andrews and P.G.Halfacre, 1975. Fundamentals of Horticulture,Tata MC. Graw Hill Publishing Co.New Delhi
7	George Acquaah, 2002, Horticulture-principles and practices. Prentice-Half of India Pvt. Ltd.,New Delhi.
8	Hartman, H.T. and Kester, D.E. 1986. Plant propagation – Principles and Practices – PrenticeHall of India Ltd., New Delhi.
9	Jitendra Singh. 2006. Basic Horticulture. Kalyani Publishers, New Delhi.

10	Kumar, N.1997. Introduction to Horticulture, Rajalakshmi Publication, Nagercoil.
11	Rajan, S. and B.L. Markose. 2007. Propagation of horticultural crops. New India Publishing,New Delhi.
12	Shanmugavelu, K.G., N. Kumar and K.V. Peter. 2005. Production technology of spices andplantation crops. Agrobios, Jodhpur.
13	Singh, N.P. 2005. Basic concepts of fruit science. International Book Distributing Co., Lucknow.
14	Surendra Prasad and U. Kumar. 1999. Principles of horticulture, Agro-botanica, Bikaner,India.

On-line resources to be used if available as reference material
On-line Resources
Biodiversity: **Author:** John Spicer
Brian W. van Wilgen: Biological Invasions in South Africa
Recent review articles and research papers

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1. Grafting of watermelon and bottle guard
2. Preparation of different kinds of fertilizers
3. Demonstration of horticultural tools used in gardening, nursery and fruit crop cultivation
4. Demonstration of various specialized structure for plant cultivation: glass house, green house, poly house etc.
5. Analysis of micronutrient deficiency in plants based on visual symptoms
6. Analysis of macronutrient deficiency in plant based on visual symptoms
7. Demonstration of different types of plantation methods for horticultural crops
8. Visit to nearby facility to demonstrate the specialized cultivation structures
9. Demonstration of postharvest techniques: sorting, grading, packaging etc.
10. Seed viability test
11. Different types of artificial pollination techniques
12. Practicing Cutting and pruning of ornamental plants
13. Media for propagation of plants in nursery beds, potting and repotting
14. Preparation ofnursery beds and sowing of seeds
15. Raising of rootstock. Seed treatments for breakingdormancy and inducing vigorous seedling growth.
16. Preparation of plant material for potting.
17. Hardening plants in the nursery.
18. Practicing different types of cuttings, layering, grafting andbuddings.
19. Preparation of plant growth regulators forseed germination and vegetative propagation.
20. Collection of medicinal and aromatic plants from their natural habitat and study their morphological description, nursery techniques, harvesting, curing and processing techniquesand extraction of essential oils.

Master of Science in Botany
M.Sc. Botany Semester III

Course Code	PS03EBOT53	Title of the Course	Bioinformatics
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To get knowledge and awareness of the basic principles and concepts of biology, computer science and mathematics 2. To explore existing software effectively to extract information from large databases and to use this information in computer modelling 3. To get problem-solving skills, including the ability to develop new algorithms and analysis methods. 4. To train student for understanding of the intersection of life and information sciences, the core of shared concepts, language and skills the ability to speak the language of structure-function relationships, information theory, gene expression, and database queries.

Course Content

Unit	Description	Weightage* (%)
1.	❖ **Introduction to Bioinformatics:** ▪ Introduction and Bioinformatics Resources: ▪ Knowledge of various databases and bioinformatics tools available at these resources, the major content of the databases, Literature databases: ▪ Describe about various approaches in genome sequencing and NGS ▪ Overview of Sequence trace files (or chomatograms) raw data output from sequencer machines, Assembling and storing of the sequencer data files. ▪ Nucleic acid sequence databases: GenBank, EMBL, DDBJ ▪ Protein sequence databases: SWISS-PROT, TrEMBL, PIR, PDB, SCOP, CATH ▪ Genome Databases at NCBI, EBI, TIGR, SANGER ▪ Other Databases of Patterns/Motifs/System Biology (Gene and protein network database and resources) ❖ **Sequence analysis:** ▪ Various file formats for bio-molecular sequences: GENBANK, FASTA, GCG, MSF, NBRF-PIR etc. ▪ Basic concepts of sequence similarity, identity and homology, Definitions of homologues, orthologues, paralogues, xenologus. ▪ Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series.	25%

	▪ Database Searches: what are sequence-based database searches, BLAST and FASTA algorithms, various versions of basic BLAST and FASTA. ▪ Pairwise and Multiple sequence alignments: basic concepts of sequence alignment, Needleman & Wuncsh, Smith & Waterman algorithms for pairwise alignments, Progressive and hierarchical algorithms for MSA. ▪ Use of pairwise alignments and Multiple sequence alignment for analysis of Nucleic acid and protein sequences and interpretation of results.	
2.	❖ **Gene prediction:** ▪ Gene structure in Prokaryotes and Eukaryotes, Gene prediction methods: Neural Networks, Pattern Discrimination methods, Signal sites Predictions, Evaluation of Gene Prediction methods. ❖ **Computational RNA Structure analysis:** ▪ Secondary and tertiary structure of RNA. Various algorithms of RNA folding and their analysis. Energy minimization in RNA folding. RNA sequence alignment based on secondary structure and its applications in functional genomics and phylogeny. ❖ **Transcriptomics:** ▪ Complete transcript cataloguing and gene discovery sequencing ▪ Microarray based technologies and computation based technologies	25%
3.	❖ **Genomics:** ▪ Concepts and tools for genomics and comparative Genomics ▪ Ancient conserved regions ▪ Horizontal gene transfer ▪ Functional classification of genes ▪ Gene order (synteny) is conserved on chromosomes of related organisms. ▪ Prediction of gene function based on a composite analysis. ▪ Functional genomics. ▪ Putting together all of the information into a genome database. ❖ **Phylogenetic analysis:** ▪ Definition and description of phylogenetic trees and various types of trees, Molecular basis of evolution, Method of construction of Phylogenetic trees: Distance based method (UPGMA, NJ), Character Based Method (Maximum Parsimony and Maximum Likelihood method).	25%
4.	❖ **Proteomics and Protein Computational Biology:** ▪ Tools for proteomics: Acquisition of protein structure	25%

	information, databases and applications. ▪ Structural classification of proteins, Protein structure analysis structure alignment and comparison, ▪ Secondary structure and evaluation: algorithms of Chou Fasman, GOR methods. ▪ Tertiary Structure: Basic principles and protocols, Methods to study 3D structure; Prediction of specialized structures. Protein folding, Protein modelling, Method of protein structure evaluation; Active site prediction. ▪ Protein-protein and protein-ligand interaction/Docking; Drug Designing, QSAR studies. ❖ **Protein structure comparison and classification:** ▪ Classes, Folds, Motif, Domain; ▪ Purpose of structure comparison ▪ Algorithms such as FSSP, VAST and DALI. ▪ Principles of protein folding and methods to study protein folding.	

Teaching-Learning Methodology	Online / Offline / Presentation / Videos	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	To get introduced to the basic concepts of Bioinformatics and its significance in Biological data analysis.
2.	To get introduced to the basics and advance of sequence alignment and analysis.
3.	To get overview about biological macromolecular structures and structure prediction methods.
4.	To understand the structural organisation, structural properties and various techniques employed in the structure determination of Biological macromolecules – DNA & Protein.

5.	To get exposed to computational methods, tools and algorithms employed for Biological Data Interpretation.
6.	To have hands on training on various computational tools and techniques employed in Biological sequence analysis.
7.	To get exposed to various tools and methodologies used in multiple sequence alignment, phylogenetic analysis and genetic diversity analysis observed in biological sequences.
8.	To impart knowledge on chemical databases, various advanced techniques and tools like docking, QSAR studies etc employed in computational drug discovery.
9.	To get knowledge about various approaches in genome sequencing and NGS.

Suggested References:

Sr. No.	References
1.	Bioinformatics: A Beginners Guide, Clavarie and Notredame
2.	Bioinformatics: David Mount
3.	Bioinformatics: Rastogi
4.	Introduction to Bioinformatics: Arthur M. Lesk
5.	Bioinformatics: Principles and applications, Ghosh and Mallick
6.	Bioinformatics: Genes, Proteins and Computer, C A Orengo
7.	Protein Structure Prediction: Methods and Protocols, Webster, David (Southern Cross Molecular Ltd., Bath, UK)

On-line resources to be used if available as reference material

On-line Resources

Nucleotide Sequence Databases (the principal ones)

- NCBI - National Center for Biotechnology Information
- EBI - European Bioinformatics Institute
- DDBJ - DNA Data Bank of Japan

Protein Sequence Databases

- SWISS-PROT & TrEMBL - Protein sequence database and computer annotated supplement

- **UniProt** - UniProt (Universal Protein Resource) is the world's most comprehensive catalog of information on proteins. It is a central repository of protein sequence and function created by joining the information contained in Swiss-Prot, TrEMBL, and PIR.
- PIR - Protein Information Resource
- MIPS - Munich Information centre for Protein Sequences
- HUPO - HUman Proteome Organization

Database Searching by Sequence Similarity

- BLAST @ NCBI
- PSI-BLAST @ NCBI
- FASTA @ EBI
- BLAT Jim Kent's Blat is just superb in terms of speed and the integrated view you get for viewing the results

Sequence Alignment

- USC Sequence Alignment Server - align 2 sequences with all possible varieties of dynamic programming
- T-COFFEE - multiple sequence alignment
- ClustalW @ EBI - multiple sequence alignment
- MSA 2.1 - optimal multiple sequence alignment using the Carrillo-Lipman method
- BOXSHADE - pretty printing and shading of multiple alignments
- Splign - Splign is a utility for computing cDNA-to-Genomic, or spliced sequence alignments. At the heart of the program is a global alignment algorithm that specifically accounts for introns and splice signals.
- Spidey - an mRNA-to-genomic alignment program

Protein Domains: Databases and Search Tools

- InterPro - integration of Pfam, PRINTS, PROSITE, SWISS-PROT + TrEMBL
- PROSITE - database of protein families and domains
- Pfam - alignments and hidden Markov models covering many common protein domains
- SMART - analysis of domains in proteins
- ProDom - protein domain database
- PRINTS Database - groups of conserved motifs used to characterise protein families
- Blocks - multiply aligned ungapped segments corresponding to the most highly conserved regions of proteins

Protein 3D Structure

- PDB - protein 3D structure database
- RasMol / Protein Explorer - molecule 3D structure viewers
- SCOP - Structural Classification Of Proteins
- UCL BSM CATH classification
- The DALI Domain Database
- FSSP - fold classification based on structure-structure alignment of proteins
- SWISS-MODEL - homology modeling server
- Structure Prediction Meta-server
- K2 - protein structure alignment
- DALI - 3D structure alignment server
- DSSP - defines secondary structure and solvent exposure from 3D coordinates

- HSSP Database - Homology-derived Secondary Structure of Proteins
- PredictProtein & PHD - predict secondary structure, solvent accessibility, transmembrane helices, and other stuff
- Jpred2 - protein secondary structure prediction
- PSIpred (& MEMSAT & GenTHREADER) - protein secondary structure prediction (& transmembrane helix prediction & tertiary structure prediction by threading)

Phylogeny & Taxonomy

- The Tree of Life
- Species 2000 - index of the world's known species
- TreeBASE - a database of phylogenetic knowledge
- PHYLIP - package of programs for inferring phylogenies
- TreeView - user friendly tree displaying for Macs & Windows

Gene Prediction

- Genscan - eukaryotes
- GeneMark
- Genie - eukaryotes
- GLIMMER - prokaryotes
- tRNAscan - SE 1.1 - search for tRNA genes in genomic sequence
- GFF (General Feature Format) Specification - a standard format for genomic sequence annotation

Metabolic, Gene Regulatory & Signal Transduction Network Databases

- KEGG - Kyoto Encyclopedia of Genes and Genomes
- BioCarta
- **DAVID** - **D**atabase for **A**nnotation, **V**isualization and **I**ntegrated **D**iscovery - A useful server to for annotating microarray and other genetic data.
- stke - Signal Transduction Knowledge Environment
- BIND - Biomolecular Interaction Network Database
- EcoCyc
- WIT
- **PathGuide** A very useful collection of resources dealing primarily with pathways
- SPAD - Signaling Pathway Database
- CSNDB - Cell Signalling Networks Database
- PathDB
- Transpath
- DIP - Database of Interacting Proteins
- PFBP - Protein Function and Biochemical Networks

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Practical Exercises:

1. Exploration of the resources available in NCBI and PUBMED
2. Exploration of the resources available for primary and secondary Nucleotide Databases
3. Exploration of the resources available for primary, secondary and tertiary Protein Structural Databases
4. Retrieval and detailed study of a Genbank Entry using an accession number
5. Retrieval and analysis of a gene sequence "AF375082" in FASTA format
6. Finding the official Symbol, alias name, chromosome number and ID for gene using NCBI
7. Retrieval and analysis of a protein sequence from protein database
8. Primary structure analysis of a protein by various tools
9. Secondary structure analysis of a protein by various tools
10. Tertiary protein structure analysis using RASMOL / SPDBV
11. Similarity Search using BLAST and Interpretation of Results
12. Pair-wise and multiple sequence alignment using BLAST with PAM and BLOSUM Matrix
13. Pair-wise and multiple sequence alignment using ClustalW PAM and BLOSUM Matrix

SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar, Gujarat
(Reaccredited with 'A' Grade by NAAC (CGPA 3.25)
Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE
M.Sc. Botany Semester: IV

Programme Outcome (PO) - For M.Sc. Botany Programme	Students completing M.Sc. Botany course of four semesters will gain thorough knowledge and develop relevant practical skills on different areas of Botany, both the fundamental and traditional aspects as well as the advanced and application oriented aspects such as plant structural and functional diversity and its role in human livelihood, ecological services and human influenced environmental issues, evolution processes resulting the diversified plant groups, their morphological, anatomical, and physiological adaptations to different environmental conditions, plant interactions with microbes and insects, genetic makeup and inheritance of various levels of plants, cell and molecular biology of plants, horticultural crops, physiology, biochemistry, biotechnology, recombinant DNA technology, proteomics and transgenic technology. Students will develop skills of plant explorations and identifications, herbarium preparation and preservation techniques, nursery establishment and management techniques, principles and methods of biodiversity conservation, microscopy and microtomy, reproduction, genetics, genetic structure of populations, microbiology, molecular biology, identification of various pests and diseases of crop plants and their controlling mechanisms, various analytical techniques, acquaintance with the use of bioinformatics tools and databases and application of statistics to biological data, biotechnological tools and techniques used for mass *in vitro* propagation, genetic transformation of plants, transgenic technology. By performing practical experiments relevant to the theory papers and taking one elective paper of their choice in each semester and a dissertation course in the fourth semester, students will get trained in experimental design and execution, firsthand experience on tools and techniques of research, quantitative and qualitative data analysis and interpretation of data. By presenting seminars in each semester, students will develop science communication and presentation skills.

Programme Specific Outcome (PSO) - For MSc Botany Semester - IV	Having studied the four prescribed papers, by the end of this semester, students will be able to: 1. Recognize and appreciate diversity, classification, ecological and economic significance of various groups of lower plants and higher plants including archibacteria and eubacteria. 2. Understand how cell interacts with environment, how cell growth and death are regulated. 3. Understand evolutionary trends among different groups of plants. 4. Have clear understanding about various tools and techniques to study cells, different cell organelles and their functions. 5. Become familiar with appropriate statistical methods required for designing a scientific experiments, formulate appropriate hypothesis for a scientific investigation.

To Pass	(1) At least 40% marks in each paper at the University Examination and 40% aggregate marks in Internal and External Assessment. (2) At least 33% Marks in each paper in Internal Assessment.

Course Type	Course Code	Name Of Course	Theory/ Practical	Credit	Exam Duration in hrs	Component of Marks		
						Internal	External	Total
						Total	Total	Total
Core Course	PS04CBOT51	Plant Physiology and Biochemistry	T	4	3	30	70	100
	PS04CBOT52	Plant Biotechnology	T	4	3	30	70	100
	PS04CBOT53	Practicals	P	4	3	30	70	100
	PS04CBOT54	Viva-Voce	=	1	=	=	50	50
Elective Course (Any Two)	PS04EBOT51	IPR and Biosafety	T	4	3	30	70	100
	PS04EBOT52	Biodiversity and Conservation	T	4	3	30	70	100
	PS04EBOT53	Practicals	P	4	3	30	70	100
		OR						
Core Course	PS04CBOT51	Plant Physiology and Biochemistry	T	4	3	30	70	100
	PS04CBOT52	Plant Biotechnology	T	4	3	30	70	100
	PS04CBOT53	Practicals	P	4	3	30	70	100
	PS04CBOT54	Viva-Voce	=	1	=	=	50	50
Elective Course	PS04EBOT54	Dissertation	=	12	=	=	300	300

(Master of Science) (Botany)
M.Sc. Botany Semester (IV)

Course Code	PS04CBOT51	Title of the Course	Plant Physiology and Biochemistry
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To understand the conversion of light energy to chemical energy 2. To understand plant growth and growth regulators 3. To understand plant mineral nutrition. 4. To understand defense mechanism in plants 5. To understand stress tolerence

Course Content		
Unit	Description	Weightage* (%)
1.	Water Relations of Plants: Water potential, osmotic potential and pressure potential - water and ion absorption and transport- passive and active absorption, Transpiration. Translocation of organic solutes – source – sink relationship. Mineral nutrition, Mineral deficiency, hydroponics. Phytochrome, Physiological effects of Phytochrome, mechanism of Phytochrome action. Photoperiodism and Rhythmic Phenomena: the Biological Clock, photoperiodism, and rhythms.	25
2.	Photosynthesis: Light reactions; sequence of photosynthetic pathway - Electron Transport Chain, Photophosphorylation. Pathways of CO2 fixation. Respiration: Photorespiration, glycolysis, metabolic significance of TCA cycle, electron transport and oxidative phosphorylation, pentose phosphate pathway and dark respiration.	25
3.	Nitrogen Metabolism: sources of nitrogen, molecular nitrogen-inorganic nitrogen-organic nitrogen, Conversion of nitrate into ammonia. Biological nitrogen fixation – non symbiotic and symbiotic-reductive amination and Transamination. Plant Growth Hormones: Auxins, Gibberellins, Cytokinins and Brassionosteroids- their physiological effects and mode of action. Plant Growth Retardants: Absicic acid and ethylene. Senescence and aging, Photoperiodisam. Phytochromes: In movements and flowering.	25
4.	Secondary metabolites and plant defense: Terpenes- phenolic compoundsnitrogen containing compounds. Plant response to stresses – Biotic stress- induced plant defenses against insect herbivores and pathogen. Abiotic- water deficit, salinity stress - heat and chilling stress- mechanism of tolerance and resistance. Classification and structure of carbohydrates, Amino acids, Proteins and Lipids.	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed the course, students will develop clear understanding of

1.	Ability of plants to fix the atmospheric carbon
2.	Growth mechanism of plants
3.	Mineral nutrition in plants, and several symptoms of mineral deficiency
4.	Plants defense mechanism against herbivores and pathogens
5.	Ability of plants to overcome various stress factors

Suggested References:

Sr. No.	References
1.	Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John wiley & sons.
2.	Dey, P. M. (1978). Biochemistry of plant galactomannans. In *Advances in Carbohydrate Chemistry and Biochemistry* (Vol. 35, pp. 341-376). Academic Press.
3.	Heldt, H. W., & Piechulla, B. (2010). *Plant biochemistry*. Academic Press.

4.	Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (No. Ed. 6). Sinauer Associates Incorporated.

On-line resources to be used if available as reference material
On-line Resources
Recent review articles and research papers

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Practical Exercises:

1. Separation of plant pigments by Thin Layer Chromatography.
2. Estimation of Chlorophyll
3. Estimation of Carotenoid pigments.
4. Determination of Total Antioxidant activity by DPPH method.
5. Determination of Superoxide radical scavenging activity
6. Estimation of Nitrate reductase activity.
7. Calculation of stomatal index of upper and lower epidermal peelings.
8. Estimation of Curcumin

M.Sc. (Botany) Semester - 4

Course Code	PS04CBOT52	Title of the Course	Plant Biotechnology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1.To make the students understand the concepts of modern techniques in plant propagation 2.To facilitate the students with knowledge on recent developments in crop improvement 3. To address the pros and cons of GM crops. 4. To facilitate technical and theoretical know how for the application of molecular tools in crop improvement and crop production.

Course Content		
Unit	Description	Weightage* (%)
1.	Cell & tissue culture in plants; in-vitro morphogenesis, organogenesis and embryogenesis; Artificial Seeds, Micro propagation (Clonal propagation); Haploidy; anther and ovule cultures, Embryo cultures; Protoplast isolation, culture and protoplast fusion and somatic hybridization, Cybrids, Somaclonal Variation;; Virus elimination, pathogen indexing; Cryopreservation	25%
2.	Production of secondary metabolites; Sources of plant secondary metabolites;criteria for cell selection, factors affecting the culture of cells; different bioreactorsand their use in secondary metabolite production; biochemical pathways for theproduction of different secondary metabolites; and biotransformation.	25%
3.	Methods for genetic transformation and transgenic plants production through*Agrobacterim tumefaciens* and *A. rhizogenes*; Gene transfer methods in plants; PEG mediated, particle bombardment, Molecular markers and their importance in plant breeding, Marker Assisted Selection (MAS).	25%
4.	Commercially grown Transgenic plants: BT crops, Golden rice, transgenic crops for herbicide tolerance, disease and abiotic stress resistance**.** Indian laws and regularions for the release and cultivation of transgenic plants. Biotechnology and intellectual property rights (IPR); Plant geneticresources GATT & TRIPS; Patent for higher plant genes and DNA sequence	25%

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the significance of plant biotechnology for improving crop productivity
2.	They can apply this knowledge to establish clonal propagation methods for important as well as endangered plants
3.	Students will also understand the pros and cons of transgenic plants as well as intellectual property management and handling of GMOs.
…	

Suggested References:	
Sr. No.	References
1.	Plant Biotechnology: The genetic manipulation of plants – Adrial Slater, Nigel W. Scott and Mark R. Fowler
2.	An Introduction to Plant Biotechnology: H.S. Chawla

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On-line resources to be used if available as reference material
On-line Resources

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Practicals for Plant Biotechnology

1. Preparation of MS medium and Hormone stocks
2. Callus induction from Tobacco leaf/carrot explants (Medium preparation, surface sterilization, inoculation, observation and interpretation of results)
3. Micropropagation of banana
4. Shoot induction through organogenesis from tobacco callus
5. Somatic embryogenesis induction from carrot cell suspension
6. Tobacco anther culture for haploid plant production
7. Culture of zygotic embryos (embryo isolation and culture)
8. Synthetic seed preparation.

Course Code	PS04CBOT53	Title of the Course	LAB-I
Total Credits of the Course	04	Hours per Week	08

Course Objectives:	1. To make biochemical estimations of various plant pigments and metabolites in different organs. 2. To get skills developed involved in plant micropropagation. 3. To get trained in production of synthetic seeds.

PS04CBOT54 (Lab IA)
(Plant Physiology and Biochemistry)

Sr.No.	**Practical Exercises**
1	Separation of plant pigments by Thin Layer Chromatography.
2	Estimation of Chlorophyll
3	Estimation of Carotenoid pigments.
4	Determination of Total Antioxidant activity by DPPH method.
5	Determination of Superoxide radical scavenging activity
6	Estimation of Nitrate reductase activity.
7	Calculation of stomatal index of upper and lower epidermal peelings.
8	Estimation of Curcumin

PS04CBOT54 (Lab IIB)
(Plant Biotechnology)

Sr.No.	Practical Exercises
1	Preparation of MS medium and Hormone stocks.
2	Callus induction from Tobacco leaf/carrot explants (Medium preparation, surface sterilization, inoculation, observation and interpretation of results).
3	Micropropagation of banana.
4	Shoot induction through organogenesis from tobacco callus.
5	Somatic embryogenesis induction from carrot cell suspension.
6	Tobacco anther culture for haploid plant production.
7	Culture of zygotic embryos (embryo isolation and culture).
8	Synthetic seed preparation.

Learning Methodology	Lab exercises will be performed by the students after understanding the principles and methodologies involved in each experiment. Some of the exercises will be performed individually by each student and others will be done by small groups.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	20%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce and Attendance (As per CBCS R.6.8.3)	10%
3.	University Examination	70%

Course Outcomes: Having completed this course, students will be able to:	
1.	Estimate quantitatively various compounds and metabolites from plant materials.
2.	Accurately perform all the stages of exercises involved in plant micropropagation

	References:
1.	Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John wiley & sons.
2.	Heldt, H. W., & Piechulla, B. (2010). *Plant biochemistry*. Academic Press.
3.	Chawla, H.S. An Introduction to Plant Biotechnology

Master of Science in Botany
M.Sc. Botany Semester IV

Course Code	PS04EBOT51	Title of the Course	IPR and Biosafety
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To introduce basic concepts of ethics and safety that are essential for different disciplines of science and procedures involved and protection of intellectual property and related rights. 2. To understand balanced integration of scientific and social knowledge in sustainable development.

Course Content		
Unit	Description	Weightage* (%)
1.	**Biotechnology and society:** Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs private funding. **Bioethics:** Social and ethical issues in biotechnology. Principles of bioethics. Ethical conflicts in biotechnology- interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics vs business ethics. Introduction and need of bioethics, its relation with other branches, types of risk associated with genetically modified microorganisms, Ethical Issues involving GMOs; ethics related to human cloning, human genome project, prenatal diagnosis, agriculture and animal rights, data privacy of citizens health**;** ethical issues in India and abroad through case studies; Socio-economic impact of biotechnology.	25%
2.	**Bio- safety:** Definition of bio-safety; History, evolution and concept of biosafety; need and application of biosafety in laboratories and industries; biosafety guidelines and regulations, international and national norms of biosafety; Implementation of biosafety guidelines; Classification and Description of Biosafety levels; Design of clean rooms and biosafety cabinets; Risk assessment and containment levels; biohazard, bio-medical and hazardous wastes, handling and disposal; transportation of biological materials; bio-terrorism; biosafety protocol (Cartagena biosafety protocol) regulations to protect nature, growers and consumers interest and nation interest; Good laboratory practice (GLP) and Good manufacturing practice (GMP), Use of GMO's and their release, GM products, issues in use of GMO's, risk for animal/human/agriculture and environment owing to GMOs., Biotechnology and bio-safety concerns at the level of individuals,	25%

	institutions, society, region, country and world. Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions.	
3.	**IPR I:** The Concept/History of Intellectual Property; Intellectual Property System in India; Kinds of Intellectual Property Rights; Advantages and Disadvantages of IPR. International Instruments concerning Intellectual Property Rights: the Berne Convention, Universal Copyright Convention, The Paris Convention, Patent Co-operation Treaty, Trade Related Intellectual Property Rights (TRIPS), The World Intellectual Property Organization (WIPO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Intellectual Property Organisation (WIPO); World Trade Organization (WTO) European Patent Office (EPO). Patents Act, 1970 ; Trade Mark Act, 1999; The Designs Act, 2000; The Geographical Indications of Goods (Registration and Protection) Act, 1999; Copyright Act, 1957 ; The Protection of Plant Varieties and Farmers' Rights Act, 2001; The Semi Conductor Integrated Circuits Layout Design Act, 2000; Trade Secrets; Utility Models; IPR & Biodiversity; The Convention on Biological Diversity (CBD) 1992; Application forms of IPR and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property.	25%
4.	**IPR II:** Classification of patents in India, Classification of patents by WIPO, Categories of Patent, Special Patents, Patenting Biological products, Patent document, Granting of patent, Rights of a patent, Patent Searching, Patent Drafting, filing of a patent, different layers of the International patent system, Utility models, Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents. Indian patent act and foreign patents. Patentability, Patent application, Revocation of patent, Infringement and Litigation with case studies on patent, Commercialization and Licensing. Patent Cooperation Treaty (PCT); Copyright Overview of Copyright, Importance of Copyrights, Process for copyright, case studies. Overview of Trademarks & Trade Secret, Importance of Trademarks & Trade secret, Rights of Trademark & Trade Secret, Types of Trademarks, Registration process for Trademark & Trade Secret, Duration of Trademark and trade secret, Case Studies Geographical Indications Overview of Geographical Indications, Importance of Geographical Indication Protection, Case studies	25%

	Infringement: Direct, Contributory, and Induced Infringement; How Infringement is Determined; Who Is an Infringer; Official Machinery, Controller, Powers and Functions Defences to Infringement; Case studies	

Teaching-Learning Methodology	Online / Offline / Presentation / Videos

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Interpret basics of biosafety and bioethics and its impact on all the biological sciences and the quality of human life.
2.	Recognize importance of biosafety practices and guidelines in research.
3.	Comprehend benefits of GM technology and related issues.
4.	Recognize importance of protection of new knowledge and innovations and its role in business.

Suggested References:	
Sr. No.	References
1.	Fleming, D.A., Hunt, D.L., (2000). Biotechnology and Safety Assessment (3rd Ed) Academic press.ISBN-1555811804, 9781555811808.
2.	Thomas, J.A., Fuch, R.L. (1999). Biotechnology and safety assessment (3rd Ed). CRC press, Washington. ISBN: 1560327219, 9781560327219

3.	Law and Strategy of biotechnological patents by Sibley. Butterworth publication.(2007) ISBN: 075069440, 9780750694445.
4.	Intellectual property rights- Ganguli-Tat McGrawhill. (2001) ISBN-10: 0074638602,
5.	Intellectual Property Right- Wattal- Oxford Publicatiopn House.(1997) ISBN:0195905024.
6.	Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nd ed) ISBN-10 3527304320.
7.	Encyclopedia of Bioethics 5 vol set, (2003) ISBN-10: 0028657748.
8.	Thomas, J.A., Fuch, R.L. (2002). Biotechnology and safety Assessment (3rd Ed) Academic press.
9.	B.D. Singh. Biotechnology expanding horizons.
10.	H.K.Das. Text book of biotechnology 3rd edition.
11.	Sateesh, M.K., Bioethics and Biosafety, IK International Publishers (2008)
12.	Singh I. and Kaur, B., Patent law and Entrepreneurship, Kalyani Publishers (2006).
13.	Srinivasan, K. and Awasthi, H.K., Law of Patents, Jain Book Agency (1997)
14.	Deepa Goel, ShominiParashar, (2013), IPR, Biosafety and Bioethics, Pearson.

On-line resources to be used if available as reference material
On-line Resources

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(Master of Science) (Botany)
M.Sc. Botany Semester (IV)

Course Code	PS04EBOT52	Title of the Course	Biodiversity and Conservation
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To impart knowledge of fundamental concepts of biodiversity, the range of its extant and the need for conservation. 2. To provide information of the main threats to biological diversity and the ability to evaluate the effects of human influences on biodiversity. 3. To demonstrate the differences between the different categories of red listed species. 4. To understand different modes of biodiversity conservation, their merits and limitations. 5. To integrate the information generated from scientific investigations and use findings to address conservation and biodiversity issues.

Course Content		
Unit	Description	Weightage* (%)
1.	Biodiversity: Concepts, levels and types, changes in tune and space, evolution, species concept; significance of biodiversity for life security.Biogeography. Terristrial, Marine, Aquatic and Agricultural biodiversity: Changing patterns and practices. Influence of modern lifestyle on biodiversity. Pros and cons of genetically modified species	25
2.	Global conservation measures, institutions and conventions; IUCNconcept of threatened and endangered species. The Red Data Books of Indian plants and animals. Causes and consequences of loss of biodiversity. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): aims, major ratifications and amendments. Exotic andinvasive species: A few case studies of intentional and non-intentional introduction of exotic species and their influence on local biodiversity.	25
3.	Principles and strategiesof biological diversity conservation: *in-situ* conservationand *ex-situ* conservation. Biosphere reserves, major protected areas (sanctuaries, national parks, biosphere reserves) of India and Gujarat.Wetlands, mangroves and coral reefs for conservation of wild biodiversity. Concept of Sacred groves and their role in biodiversity conservation.	25

	Role of botanical gardens, field gene banks, seed banks, in vitro repositories, cryobanks in conservation of plants and animal sperms. Role of Zoos, breeding centers in conservation of animals.	
4.	Biodiversity hot spots in India and world; IndianBiodiversity Act 2002;Major objectives of biodiversity authority board; Biodiversity and economics with special reference to India;People's Biodiversity register: Objectives, importance and modality of preparation. General account of the activities of Botanical Surveyof India (BSI) and Zoological Survey of India (ZSI), National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific & Industrial Research (CSIR), Department of Biotechnology (DBT) and Department of Environment and Forest, Wild life Protection Society of India, Wildlife Instititute of India (WII), Animal Welfare Board of India and Bombay Natural History Society (BNHS) in the context of Indianbiodiversity conservation.	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	Understand the concept of biodiversity, its role for our survival, different direct and indirect threats on biodiversity.
2.	Appreciate the global and national initiatives and local traditions for biodiversity

	conservation.
3.	Become familiar with different modes of conservation, institutes involved in biodiversity conservation.
4.	Learn various guidelines and regulations for utilizing the biodiversity judiciously.

Suggested References:	
Sr. No.	References
1.	Wilson, E., O., (1988). Biodiversity. The National Academies Press. Harvard. Washington, DC.
2.	Hunter, M., L., Gibbs, J.P.,(2007).Fundamentals of Conservation Biology. 3rd Edn. Blackwell Publishing, Malden.
3.	Myers, N., Mittermeier, R., A., Mittermeier, C. G., Fonseca, G., A., da, Kent, J., (2000). Biodiversity Hotspots for Conservation Priorities. Nature, 403, 853-858.
4.	Rodgers, N. A., Panwar, H. S. Planning a Wildlife Protected Area Network inIndia. Vol. 1. The Report Wildlife Institute of India, Dehradun.

On-line resources to be used if available as reference material
On-line Resources
Biodiversity: **Author:** John Spicer
Brian W. van Wilgen: Biological Invasions in South Africa
Recent review articles and research papers

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Biodiversity and Conservation

1. Ecological sampling and census techniques of selected faunal and floral groups
2. Calculation of species richness and diversity indices
3. Measurement of microbial diversity
4. Preparation of GIS maps
5. Study of preservation techniques for taxidermy
6. Study of biogeographical zones and correlation with floral and faunal diversity
7. Adaptations in plants and animals
8. Ethnobotanically and ethno-zoologically important species
9. Floral faunal diversity studies by line, quadrate and belt transect methods

Master of Science (Botany)
M.Sc. (Botany) Semester IV

Course Code	PS04EBOT54	Title of the Course	Dissertation
Total Credits of the Course	12	Hours per Week	12

Course Objectives:	1. Recognize a research problem **(topic)** and approach it in a scientific way 2. Do literature survey form authentic sources. 3. Design experiments to understand and investigate the problem**(topic)** 4. Interpret the results and draw conclusions 5. Write scientific reports

Course Content		
Unit	Description	Weightage* (%)
1.	**Dissertation work**	100%
2.		
3.		
4.		

Teaching-Learning Methodology	Literature and laboratory work

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Thesis evaluation by Internal Examiner	40%
2.	Thesis evaluation by External examiner	40%
3.	Viva voce	20%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Carry out literature survey from various sources relevant to work

2.	Identify the problem **(topic)** and put forth hypothesis and design experiments to investigate the problem**(topic)**
3.	Interpret results and discuss them.
4.	Write report, do scientific writing for publiction

Suggested References:	
Sr. No.	References
1.	As obtained through literature survey

On-line resources to be used if available as reference material
As obtained through literature survey

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