K. C. E. Society's
Moolji Jaitha College
An 'Autonomous College' Affiliated to
K.B.C. North Maharashtra University, Jalgaon.
NAAC Reaccredited Grade - A (CGPA : 3.15 - 3rd Cycle)
UGC honoured "College of Excellence" (2014-2019)
DST(FIST) Assisted College

KNOWLEDGE IS POWER
ESTD. 1945

के. सी. ई. सोसायटीचे
मूळजी जेठा महाविद्यालय
क.ब.चौ. उत्तर महाराष्ट्र विद्यापीठ, जळगाव संलग्नित
'स्वायत्त महाविद्यालय'
नॅकद्वारा पुनर्मानांकित श्रेणी – 'ए' (सी.जी.पी.ए. : ३.१५ – तिसरी फेरी)
विद्यापीठ अनुदान आयोगाद्वारा घोषित 'कॉलेज ऑफ एक्सलन्स' (२०१४-२०१९)
डी.एस.टी. (फीस्ट) अंतर्गत अर्थसहाय्य प्राप्त

Date :- 01/08/2024

NOTIFICATION

Sub :- CBCS Syllabi of M. Sc. in Botany (Sem. III & IV)

Ref. :- Decision of the Academic Council at its meeting held on 27/07/2024.

The Syllabi of M. Sc. in Botany (Third and Fourth Semesters) as per **NATIONAL EDUCATION POLICY – 2020 (2023 Pattern)** and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2024-25.

Copy of the Syllabi Shall be downloaded from the College Website (www.kcesmjcollege.in)

Sd/-
Chairman,
Board of Studies

To :

1) The Head of the Dept., M. J. College, Jalgaon.
2) The office of the COE, M. J. College, Jalgaon.
3) The office of the Registrar, M. J. College, Jalgaon.

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समर्थ कॉलनी जवळ, जळगांव – ४२५ ००२. (महाराष्ट्र, भारत) । दूरध्वनी क्र. : +९१ २५७–२२३७३६३, २२३४२८१ । ई–मेलः mjcollege@kces.in । वेबसाईटः mjcollege.kces.in

Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College"

Affiliated to KBC North Maharashtra University, Jalgaon

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SYLLABUS

M. Sc.-II Botany

Under Choice Based Credit System (CBCS)

and

as per NEP-2020 Guidelines

[w. e. f. AcademicYear: 2024-25]

Preface

Skilled human resource is a prerequisite in higher education, and it is to be acquired through in-depth knowledge of theoretical concepts and hands-on laboratory methods of the subject. The present syllabus of M.Sc. part I in the subject of Botany has been prepared as per the guidelines of UGC, NEP-2020 and Government of Maharashtra. It cultivates theoretical and practical know-how of different fields of Botany. The contents of the syllabus have been prepared to accommodate the fundamental aspects and advanced developments in various disciplines of Botany and to complement the needs of various applied sectors of Botany. Besides this, the students will be enlightened with knowledge in the newer areas of Bioinstrumentations, Genetics and plant breeding, Ecology, phytogeography, plant metabolism, tissue culture, microbial fermentations, IPR, Patents, bioethics etc. Furthermore, the syllabus is structured to cater to Botany's present and future needs in the research field, industrial and environmental sectors, Entrepreneurship etc., emphasizing imparting hands-on skills. Hence, the curriculum is endowed with more experiments that shall run hand-in-hand with theory. The detailed syllabus of each paper is appended with a list of suggested readings.

The overall curriculum of one/ two-year covers plant taxonomy, lower cryptogames, biostatics, plant pathology, plant biotechnology, plant physiology and biochemistry, cell biology, molecular biology and microbial genetics, industrial and applied botany, environmental botany, and also covers various advance biotechniques such as genetics and plant breeding, bio-analyticaltechniqes, Tissue culture etc. Furthermore, the syllabus is structured to cater to Botany's present and future needs in the research field, Industrial and Environmental Sector, Entrepreneurship etc., emphasizing imparting hands-on skills. Hence, the curriculum is endowed with more experiments that shall run hand-in-hand with theory. The detailed syllabus of each paper is appended with a list of suggested readings.

Program Outcomes (PO) for M.Sc. Program

Upon successful completion of the M.Sc. program, student will be able to:

PO No.	PO
PO 1	Understand the fundamental principles of science along with their applied aspects
PO 2	Aquaint the skills in handling sophisticated scientific instruments
PO 3	Relate various scientific phenomena and their relevancies in the day-to-day life.
PO 4	Analyse experimental data critically and systematically to draw the conclusions.
PO 5	Develop various skills such as communication, teamwork, social, research and entrepreneuership etc., which will help in expressing ideas and views clearly
PO 6	Develop interdisciplinary approach for overall development .
PO 7	

Program Specific Outcome PSO (M.Sc. Botany):

After completion of this course, students are expected to learn/understand the:

PO No.	PSO
PSO 1	Understand the various plant groups lowar as well as highe w.r.t. Morphology, Anatomy and reproduction
PSO 2	To study and classify the algae, fungi, bryophytes and lichens
PSO 3	To study the higher plants with respect to their morphology and reproduction
PSO 4	To know the applied aspects of phycology, mycology and paleobotany
PSO 5	To know and understand the range of variations in angiospermic families and families of

	biological importance
PSO 6	Methods of transformation of plants and to underst and alternative biotechnological methods
PSO 7	To incorporate with knowledge of scientific research its different methods and tools
PSO 8	To oncorporate the knowledge of vommunitysturcuture different omteractions in environment, environmental hazards and its impact

Credit distribution structure for two years/one-year PG MSc programme

Level	Sem	Major (Core) Subjects		Minor Subjects	OJT/Int, RP	Cumulative Credits/Sem	Degree/ Cumulative Cr.
		Mandatory (DSC)	Elective (DSE)				
6.0	I	DSC-1 (4T) DSC-2 (4T) DSC-3 (4T) DSC-4 (2P)	DSE-1(2T) A/B DSE-2(2P) A/B	RM (4T)		22	First-year PG OR One year PG diploma after 3 years UG
	II	DSC-5 (4T) DSC-6 (4T) DSC-7 (4T) DSC-8 (2P)	DSE-3(2T) A/B DSE-4(2P) A/B		OJT/Int (4)	22	
	Cum. Cr.	28	8	4	4	44	
	Exit option: PG diploma (44 Credits) after three-year UG degree						
6.5	III	DSC-9 (4T) DSC-10 (4T) DSC-11 (4T) DSC-12 (2P)	DSE-5(2T) A/B DSE-6(2P) A/B	--	RP (4)	22	Second-year PG after 3 years UG OR PG degree after 4 years UG
	IV	DSC-13 (4T) DSC-14 (4T) DSC-15 (2P) DSC-16 (2P)	DSE-7(2T) A/B DSE-8 (2P) A/B	...	RP (6)	22	
	Cum. Cr.	54	16		4+10	88	
2 Years-4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree							

Sem- Semester, **DSC**- Department Specific Course, **DSE**- Department Specific Elective, **T**- Theory, **P**- Practical, **RM**- Research Methodology, **OJT**- On Job Training, **Int**- Internship, **RP**- Research Project, **Cum. Cr.** : Cumulative Credits

Multiple Entry and Multiple Exit options:

The multiple entry and exit options with the award of UG certificate/ UG diploma/ or three-year degree depending upon the number of credits secured;

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
6.0	One-year PG Diploma program after 3 Yr Degree	40	44	2	1
6.5	Two-year master's Degree program After 3-Yr UG Or PG Degree after 4- Yr UG	80	88	4	2

M. Sc. Botany Course Structure 2024-25 (NEP Auto)						
Sem	**Course Module**	**Credit**	**Hours/ Week**	**TH/ PR**	**Code**	**Title**
III	DSC	4	4	TH	BOT-DSC-611	Plant Biotechnology
	DSC	4	4	TH	BOT-DSC-612	Reproductive biology of Angiosperm
	DSC	4	4	TH	BOT-DSC-613	Genetics and Plant Breeding special paper-I
	DSE	2	2	TH	BOT-DSE-614 A	Plant Biochemistry
	DSE	2	2	TH	BOT-DSE-614 B	Plant Metabolism
	DSC	2	4	PR	BOT-DSC-615	Practical Based on BOT-DSC-611 and BOT-DSC-612
	DSE	2	4	PR	BOT-DSE-616 A	Practical Based on BOT-DSE-614 A
	DSE	2	4	PR	BOT-DSE-616 B	Practical Based on BOT-DSE-614 B
	DSC	4	8	RP	BOT-RP-617	Research Project I
IV	DSC	4	4	TH	BOT-DSC-621	Genetics and Plant Breeding special paper-II
	DSC	4	4	TH	BOT-DSC-622	Genetics and Plant Breeding-III
	DSE	2	2	TH	BOT-DSE-623 A	Natural Resource Management
	DSE	2	2	TH	BOT-DSE-623 B	Cell and Molecular biology
	DSC	2	4	PR	BOT-DSC-624	Practical Based on BOT-DSC-621
	DSC	2	4	PR	BOT-DSC-625	Practical Based on BOT-DSC-622
	DSE	2	4	PR	BOT-DSE-626 A	Practical Based on BOT-DSE-623 A
	DSE	2	4	PR	BOT-DSE-626 B	Practical Based on BOT-DSE-623 B
	DSC	6	12	RP	BOT-RP-627	Research Project II

Examination Pattern for M.Sc.

Theory Question Paper Pattern:

- 60 (External) +40 (Internal) for 4 credits
  - External examination will be of three hours duration
  - There shall be 5 questions, each carrying equal marks (12 marks each), while the tentative pattern of question papers shall be as follows;
  - Q1 Attempt any 3 out of 4 sub-questions; each 4 marks
  - Q 2, Q3, Q4 and Q5 Attempt any 2 out of 3 sub-question; each 6 marks.
- 30 (External) +20 (Internal) for 2 credits
  - External examination will be of 1½ hours duration
  - There shall be 3 questions Q1 carrying 6 marks and Q2, Q3 carrying 12 marks each. while the tentative pattern of question papers shall be as follows;
  - Q1 Attempt any 2 out of 3 sub-questions; each 3 marks
  - Q 2 and Q3 Attempt any 2 out of 3 sub-question; each 6 marks.

Rules of Continuous Internal Evaluation:

The Continuous Internal Evaluation for theory papers shall consist of two methods:

1. Continuous & Comprehensive Evaluation (CCE): CCE will carry a maximum of 30% weightage (30/15 marks) of the total marks for a course. Before the start of the academic session in each semester, the subject teacher should choose any three assessment methods from the following list, with each method carrying 10/5 marks:

i. Individual Assignments
ii. Seminars/Classroom Presentations/Quizzes
iii. Group Discussions/Class Discussion/Group Assignments
iv. Case studies/Case lets
v. Participatory & Industry-Integrated Learning/Field visits
vi. Practical activities/Problem Solving Exercises
vii. Participation in Seminars/Academic Events/Symposia, etc.
viii. Mini Projects/Capstone Projects
ix. Book review/Article review/Article preparation
x. Any other academic activity
xi. Each chosen CCE method shall be based on a particular unit of the syllabus, ensuring that three units of the syllabus are mapped to the CCEs.

2. Internal Assessment Tests (IAT): IAT will carry a maximum of 10% weightage (10/5 marks) of the total marks for a course. IAT shall be conducted at the end of the semester and will assess the remaining unit of the syllabus that was not covered by the CCEs. The subject teacher can decide which units will be assessed using CCEs and which unit will be assessed based on IAT.

The overall weightage of Continuous Internal Evaluation (CCE + IAT) shall be 40% of the total marks for the course. The remaining 60% of the marks shall be allocated to the semester-end examinations.

The subject teachers must communicate the chosen CCE methods and the corresponding syllabus units to the students at the beginning of the semester to ensure clarity and proper preparation.

Practical Examination Credit 2: Pattern (30+20)

External Practical Examination (30 marks):

- Practical examination shall be conducted by the respective department at the end of the semester.
- Practical examination will be of 3 hours and shall be conducted as scheduled.
- There shall be 05 marks for journal and viva voce. A certified journal is compulsory to appear for practical examination.
- The practical examination will be of a minimum of 3 hours duration and shall be conducted as per schedule for 2 consecutive days in case of practical where incubation conditions and allied aspects are essential.

Internal Practical Examination (20 marks):

- Internal practical examination of 10 marks will be conducted by the department as per the schedule given.
- For internal practical examination, students must produce the laboratory journal of practicals completed along with the completion certificate signed by the concerned teacher and department head.

- There shall be continuous assessment of 30 marks based on student performance throughout the semester. This assessment can include quizzes, group discussions, presentations and other activities the faculty assigns during regular practicals. For details, refer to internal theory examination guidelines.
- Finally, 40 (10+30) students' performance will be converted into 20 marks.

Semester III

M.Sc. II (Botany)
Semester III
BOT-DSC-611: Plant Biotechnology

Total Hours: 60 **Credits: 04**

Course objectives	• To provide the students to understand the function of plant hormones and their molecular mechanisms, • To know different methods for transformation of plants or plant cells, including their specific advantages and applications • To define the terms transcriptomics, proteomics, interactomics, metabolomics and systems biology, and describe their importance in plant biotechnology research, • To learn alternative plant biotechnology methods that can replace genetic modification	
Course outcome	After completion of this course, the student will be able to: • Understand the function of plant hormones and their molecular mechanisms • know different methods for transformation of plants or plant cells, including their specific advantages and applications • Define the terms transcriptomics, proteomics, interactomics, metabolomics and systems biology, and describe their importance in plant biotechnology research, • Learn alternative plant biotechnology methods that can replace genetic modification	
Unit	**Topic Particular**	**Hours**
Unit I	**Credit 1: Plant tissue culture** 1. Totipotency of plant cells and regeneration of plants from differentiated tissues. Molecular events during de- and re-differentiation. Organogenesis and somatic embryogenesis 2. Micropropagation - Multiplication of plants from pre-existing meristems Stages of micropropagation, Factors affecting micropropagation, case studies in plants of economic importance – trees, crop species, medicinal plants 3. Hardening of micropropagated plants and field transfer 4. Secondary metabolite production using plant tissue culture. Bioreactors	15
Unit II	**Recombinant DNA technology and gene cloning** 1. Introduction to recombinant DNA technology 2. Enzymes used in genetic engineering- Restriction endonucleases, other endonucleases, exonucleases, ligases, polymerases, kinases and phosphatases, DNA methylases, topoisomerases 3. Use of vectors in cloning- Plasmids, phages, cosmids, phagemids, BACs and YACs, Gateway system of cloning 4. Polymerase chain reaction- Principles and uses in gene cloning	15
Unit III	**Gene libraries, screening of recombinants and sequencing** 1. Genomic and cDNA libraries – choice of vectors, construction 2. Screening of libraries and isolation of specific genes- Nucleic acid	**15**

	hybridization using specific nucleotide probes, antibodies, PCR amplification using gene specific primers. 3. DNA sequencing methods, sequencing strategies for large regions of DNA, contig maps, chromosome walking. 4. High throughput and next generation sequencing methods	
Unit IV	**Genetic transformation of plants** 1. Agrobacterium: Ti and Ri plasmids, transfer of DNA into host by *Agrobacterium*, mechanism of integration of DNA into plant genomes 2. Vectors for plant transformation: Agrobacterium-based vectors, improved Agrobacterium-based vectors, virus-based vectors for transient expression, vectors for chloroplast transformation, vectors for marker-free selection 3. Transformation techniques: Agrobacterium-mediated, direct DNA transfer. Factors affecting transformation. *In planta* transformation 4. Screening and analysis of transformants in subsequent generations – copy number, heterozygosity, stable expression, silencing	**15**
References	1.Tropp, B. E. (2012). Molecular Biology. Fourth Edition, Jones and Bartlett India Pvt. Ltd, New Delhi. 2.Howe, C., (2007). Gene Cloning and Manipulation. 2nd Edition. 3.Watson, D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., and Losick, R. (2008). Molecular Biology of Gene. 6th Edition, Cold Spring HarborLaboratory Press Cold Spring Harbor, New York, U.S.A. 4.Clark, D., Pazdernik, N., McGehee, M. (2018). Molecular biology. 3rd Edition. 5.Freifelder, D. (1990). Molecular Biology. 2ndEdition,Narosa Publishing HouseNew Delhi. 6.Nicholl, D. S. T. (2008). An Introduction to Genetic Engineering. 3rd Edition. 7.Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London. 8.Grierson, D. and Covey, S. (1984). Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC. 9.Henry, R. J. (2005). Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. 10.Shaw, C. H. and Brown. T.A. (1988, 2020). Gene Cloning and DNA Analysis: An Introduction. 8th Edition. 11.Primrose, S. B. and Twyman, R. (2006). Principles of Gene Manipulation and Genomics. 7th Edition. 12.Tewari, K. K. and Singhal, G. S. (1997). Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi.	

M.Sc. II (Botany)
Semester III
BOT-DSC-612: Reproductive biology of Angiosperm

Total Hours: 60 **Credits: 04**

Course objectives	• To study vascular tissues, structure of wood sand anomalous secondary growth • To study historical development of embryology • To study structure and development of microsporangium, megasporangium, embryo and endosperm. • To study methods of pollination and fertilization • To study applications of embryology in plant tissue culture • To study structure and development of pollen grains • To study application of palynology in human welfare	
Course outcomes	Students will study the vascular tissues, structure of woods and anomalous secondary growth. • Students will study the historical development of embryology • They will get the idea of structure and development of microsporangium, megasporangium, embryo and endosperm • Students will be able to study the methods of pollination and fertilization • They will acquire understanding of applications of embryology inplant tissue culture • They will be familiar with the structure and development of pollengrains • Students will know the applications of palynology in human welfare.	
Unit	**Topic Particular**	**Hours**
Unit I	**Shoot and Root development** Organization of shoot apical meristem (SAM) Cytological and molecular analysis of SAM Control of tissue differentiation, especially xylem and phloem Organization of root apical meristem (RAM)	15
Unit II	**Leaf growth and Reproduction** Determination, phyllotaxy, control of leaf from differentiation of epidermis and mesophyll Types of Stomata - 1) Pant's classification (1965) 2) Stace 3) Stebbins and Khush Classification of trichomes – Vegetative and Sexual reproduction: Flower development in *Arabidopsis* and *Antirrhinum*	15

	Genetics of floral organ differentiation	
Unit III	**Male and Female gametophyte 8h** Development and structure of microsporangium Microsporogenesis, micro-gametogenesis Study of certain abnormal developments i. Pollen formation in Cyperaceae ii. Pollen embryo sac (Nemec phenomenon) Ovule development, megasporogenesis, megagametogenesis Structure and organization of the embryo Sac (Types of Embryo Sac) Nutrition of embryo Sac Pollination mechanisms and vectors Pollen stigma interactions Sporophytic and gametophytic self-incompatibility Double fertilization and significance	**15**
Unit IV	**Endosperm and embryo development** Development, structure, function and types Structure of dicot and monocot embryo (w.r. t. development in capsella bursa pastoris and grass) Polyembryony: origin, causes and types 5.1. Development of pollen grains- meiotic and post meiotic processes 5.2. Differentiation of wall layers, exine stratification 5.3. Polarity, symmetry, NPC and pollen polymorphism 5.4. Geopalynology 5.5. Melittopalynology 5.6. Pollen allergy and palynotaxonomy	**15**
References	• Atwell, B.J., Kriedermann, P.E. and Jurnbull, C.G.N. (eds) (1999). Plants in Action: Adaptation in Nature, Performance in Cultivation. MacMillan Education, Sydney, Australia. • Bewley, J.D.and Black, M. (1994). Seeds: Physiology of Development and Germination. Plenum Press, New York, U.S.A. • Fahn, A. (1982). Plant Anatomy. (3rd edition). Pergamon Press, Oxford, U.K. • Howell, S.H. (1998). Molecular Genetics of Plant Development. Cambridge University Press, Cambridge, U.K. • Raghavan, V. (1997). Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge, U.K. • Raghavan, V. (1999). Developmental Biology of Flowering Plants. Springer – Verlag, New York, U.K. • Raven, P.H., Evert, R.F. and Eichhorn, S.E. (1992). Biology of Plants (5th edition). Worth, New York, U.S.A. • Waisel, Y., Eshel, A. and Kafkaki, U. (eds) (1996). Plant Roots: The Hidden Hall (2nd edition). Marcel Dekker, New York, U.S.A.	

	• Shivanna, K.R. and Sawhney, V.K. (eds) (1997). Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge, U.K. • Shivanna, K.R.andRangaswamy, N.S. (1992). Pollen Biology.: A Laboratory Manual. Springer – Verlag, Berlin, Germany.	

Proposed methods of teaching/ innovative teaching

 Classroom teaching, lecture cum demonstration methods, question answer method, brain storming method, assignment method

 Innovative teaching: audio video, science museum, ICT enabled teaching, video clips/ movies, field trips.

M.Sc. II (Botany)
Semester III
BOT-DSC-613: Genetics and Plant Breedingspecial paper-I

Total Hours: 60 **Credits: 04**

Course objectives	1. To provide advance knowledge of Genetics and significance of Mendel's studies and extension and modification of basic principles of genetics. 2. To study agronomy of crops and breeding practices. 3. To study pollination methods in cash crops breeding. 4. To provide wholesome review on fundamentals of plant breeding.	
Course outcome	1. Students will know the advance knowledge of Genetics and significance of Mendel's studies and extension and modification of basic principles of genetics. 2. They will aquire knowledge of agronomy of crops and breeding practices. 3. Different pollination methods in cash crops breeding will be studied by them 4. This course will help the Students to understand wholesome review on fundamentals of plant breeding.	
Unit	**Topic Particular**	**Hours**
Unit I	**Basic Principles of Genetics** Mendel's work in brief, experimental analysis done by Mendel. Outcomes of genetic crosses Principle of segregation and Law of Independent assortment Test cross, relating principle of independent assortment to meiosis. **Extensions and Modifications of Basic Principles.** Types of dominance, Penetrance and expressivity Lethal alleles, multiple alleles. Epistasis, Gene interactions, complementation. Sex linked, sex influenced and sex-limited characteristics, Cytoplasmic inheritance,Geneticmaternal effect, Genomic Imprinting. **Pedigree analysis** Characteristics of inheritance in humans Analysis of pedigreesAutosomal and sex-linked traits.	15
Unit II	**Linkage, Recombination and Gene mapping** Comparison of linkage with Independent assortment Crossing over with linked genes Calculation of Recombination Frequency Coupling and Repulsion Linkage detection with test-cross,Two point and three-point test cross Physical gene mapping (Deletion mapping and somatic cell hybridization). **Chromosomal Variation** • Chromosomal Rearrangements- Duplication, Deletion, Inversions, Translocation, Fragile sites, Copy number variations.	15

	Variation in chromosome number – Aneuploidy and its types, polyploidy and its types. • Enlist human genetic diseases.	
Unit III	**Genetics of Cancer, Population Genetics and Quantitative Genetics** Types of tumor and its formation, role of environmental factors in cancer, cancer as a genetic disease. Mutation in oncogenes and tumor suppressor genes, genetic control at cell cycle and division. Calculation of Genotypic and allelic frequency, Hardy-Weinberg Laws. Genotypic frequencies at H.W. equilibrium, examination and implications of H.W. Laws, Extension of H.W. Law to X- linked alleles. Changes are allelic frequency- Mutation, Migration, Genetic drift, Natural selection. Relation of genotypic and phenotype, Types of quantitative characteristics, polygenic inheritance e.g. Wheat kernel colour Phenotypic variation, types of heritability and its calculations.	**15**
Unit IV	**Basic Agriculture and Plant Breeding** **Crops and Crop Production** Classification of crops, Crop adaptation and distribution, Intensive cropping, Crop rotation, Cropping patterns and systems, Crop production, Seasons and system of farming. **Agronomy of field crops** Cereals – Major and minor Milletes – Major and minor Pulses Oil seeds – Major and minor Sugar crops Narcotics Fiber crops – Major and minor **Plant Breeding** **Male sterility and plant breeding:** Introduction, genetic, cytoplasmic male sterility, cytoplasmic-genetic male sterility, Gynoeceous lines, parthenocarpic, monoecious and dioecious nature in crop lines with respect to maintenance and seed development. **Selection in self-pollinated crops:** Introduction, history pure line concept, origin of genetic variation in pure lines, genetic advance in selection. Selection **in cross pollinated crops**: Rapid gain followed by slow response, slow progress for long period, slow response for short period, Rapid gain– plateau–rapid gain response free and potential ability. Hybrid **development**: (Introduction) Development of inbreeds, evaluation of inbreeds	**15**

References	• Benjamin A. Pierce (2012), Genetics a conceptual approach,W.H. Freeman and Company, New York. • Chandrasekaran B. (2010), A textbook of Agronomy, New Age International (P) Limited Publishers, New Delhi. • Chopra V. L. (2004). Plant Breeding Oxford and IBH Publications, New Delhi, India. • Falconer D. S. and Mackey J. (1998). Introduction to Quantitative Genetics. Long Publishers • Gupta S. K. (2005). Practical Plant Breeding Agribios Publications, India. • Gupta P.K. and Tuchya T (1991). Chromosome Engineering in Plants: Genetics and evolution Elsevier Publishers • Narayanan S. S. Singh P. (2007). Biometrical Techniques in Plant Breeding. Kalyani Publishers, India. • Natarajan and Gunashekharan M. (2005). Quantitative Genetics and Bio-metrical Techniques in Plant Breeding Kalyani Publishers, India. • Robert H. Tamarin (2004). Principles of Genetics 7th Edition McGraw-Hill Companies. • Roy D. (2003). Plant Breeding Ana lysis a n d Exploitation of Variation. Narosa Publication • Sharma J. R. (2001). Principles and practice of Plant Breeding.TataMacGraw Hill, Delhi.. • Singh B. D. (2006). Plant Breeding Kalyani Publishers, India. • Singh P. (2006). Essentials of plant breeding Kalyani Publishers, India. • Singh Phundan. (2014). Essentials of Plant Breeding Kalyani Publishers; 5th Edition • Singh S.& Pawar (2006). Genetic Bases and Methods of Plant Breeding CBS Publishers,	

Proposed methods of teaching/ innovative teaching

 Classroom teaching, lecture cum demonstration methods, question answer method, brain storming method, assignment method

 Innovative teaching: audio video, science museum, ICT enabled teaching, video clips/ movies, field trips.

M.Sc. II (Botany)
Semester III
BOT-DSE-614 A: Plant Biochemistry

Total Hours: 30 **Credits: 02**

Course objectives	1. To know the scope and importance of plant Biochemistry. 2. To study the biosynthesis of primary and secondary metabolites. 3. To study the process of Oxidation and reduction reactions in plants 4. To study Thermodynamicsin plants.	
Course outcome	1. Students will be get to know the scope and importance of Plant Biochemistry 2. They will be incorporated withknowledge of biosynthesis of primary and secondary metabolites 3. Students will get the platform to study the process of Oxidation and reduction reactions in plants 4. Students will be familiar with the Thermodynamicsin plants.	
Unit	**Topic Particular**	**Hours**
Unit I	Introduction: i) Definition, Scope and Importance ii) Hydrogen ion Concentration iii) PH and Buffers **Water Potential** i Biological significance, water relationship of the plants ii osmosis, permeability, diffusion, chemical potential, water potential apoplastand symplast concept. iii Translocation of solutes.	15
Unit II	Primary and Secondary Plant Metabolites i) Brief account of primary plant metabolites ii) Brief account of secondary plant metabolites iii) Biosynthesis of Trepenes, Phenols and Nitrogenous compoundsand their role.	15
Unit III	**Biological Oxidation and Reduction:** i) Introduction ii) Oxidation& reduction reactions iii) Redox reaction in biological system iv) Oxidation-reductionpotential and measurement iv) Biologically important Redox Systems. Biosignaling: i) General features of Signal and Transduction ii) G-protein mediator, couple receptor iii) Receptor Gateway	**15**
Unit IV	**Thermodynamics** i. Laws, enzyme as catalysts – enzyme kinetics ii. Nomenclature, structure, properties and mode of action of enzymes. iii. Classification, nomenclature, properties and mechanisms of enzyme action.	**15**

	iv. Primary Metabolites - Classification and structure of carbohydrates, proteins,amino acids and lipids. v. Biosynthesis of fatty acids, beta oxidation.	
References	1. Amarsingh (1977) Practical Plant Physiology.KalyaniPublishers,NewDehli, India. 2. Anand, B. K. & S. K. Manchanda (1976) Text Book of Physiology. Tata McGrawHill Publications Co. Ltd, Dehli, India. 3. Arditt, J. (1969) Experimentl Plant Physiology, Holt Rinehrt&Winst on Inc,NewYork. 4. Asbard, P. O. & K. Rodhal (1970) A text Book of Work Physiology. McGraw HillKogakusha Ltd. Tokya New York 5. Bidwell, R. G. (1979)Plant Physiology.McMillan Publishing Co. Inc. NewYork 26 6. Bonner, J. and J. E. Varner (Eds.) (1976)Plant Biochemistry 3 rd Eds. Academis PressLondon,UK. 7. Brett, C. and K. Waldran (1970) Physiology and Biochemistry of Plant Cell Wall.Unuinttyman,Boston, USA. 8. Con, E. F. and P. F. Stumpf (1976) Outlines of Biochemistry Wiley Eastern Ltd.,New Dehli, India. 9. De. Robertis, E. D. P. and De Robertis, E. M. T. (1987) Cell and Molecular Biology.VIII Eds. Lea &Febiger International Edition Info - Med. Hongkong. 10.Deb, A. C. (2004)Viva & Practical Biochemistry. New Central Book Agency,Kolkata, India. 11.Delvin, R. M. & A. V. Barker (1967) Photosynthesis. Van Nostrand Reinhold BooksLtd. London,UK. 12.Delvin, R. M. and F. H Whittam (1986) Plant Physiology IV eds. CBS Publishers &Distributors,New Delhi, India. 13. Fogg, G. E. (1972) PhotosynthesisSydenyAucklant,Australia. 14.Geise, A. C. (1979) Cell Physiology.W. B. Sunders Company Toronto, Canada. 15.Grewal, R. C. (2000)Plant Physiology. Campus Books International, Darya Ganj,New Delhi, India. 16.Hess, D. (1975) Plant Physiology.NarosaPublishingHouse, New Delhi, India . 17.Hill, R. & C. P. Whittingham(1957)Photosynthesis.London, UK.	

M.Sc. II (Botany)
Semester III
BOT-DSE-614 B: Plant Metabolism

Total Hours: 30 **Credits: 02**

Course objectives	1. To know the scope and importance of plant metabolism. 2. To study the properties, mechanism and classification of enzymes. 3. To study the process of photosynthesis in higher plants, C3, C4and CAM pathways. 4. To study respiration in higher plants.	
Course outcome	1. Students will be get to know the scope and importance of Plant metabolism 2. They will be incorporated withknowledge ofproperties, mechanism and classification of enzymes. 3. Students will get the platform to study the process of photosynthesis in higher plants, C3, C4 and CAM pathways. 4. Students will be familiar with the respiration in higher plants	
Unit	**Topic Particular**	**Hours**
Unit I	**Introduction** **1.1** Definition **1.2** Plant cell as organicLaboratory **1.3** Anabolism and catabolism **1.4** Enzymes **1.4.1** Definition, Structure and properties**.** **1.4.2** Classification of enzymes **1.4.3** Mode of enzyme action: Lock and key Model, Induced fit model	15
Unit II	**Photosynthesis -I** **2.1** Definition, photosynthetic apparatus (Structure of Chloroplast) **2.2** Role of photosynthetic pigments: Chlorophyll (Chl- a, Chl-b), Carotenoids and Phycobillins **2.3** Photosystem I and II **Photosynthesis -II** **3.1** Mechanism a) Light Reaction: Cyclic and Non-Cyclic Photophosphorylation b) Dark Reaction: C3, C4 and CAM pathway **3.2** Photorespiration: Definition, Sites and Mechanism ofphotorespiration. **3.3** Factor affecting the process ofphotosynthesis.	15
Unit III	**Respiration** **4.1** Introduction, Definition and Types of respiration. **4.2** Mechanism of Aerobic respiration. a) Glycolysis. b) Kreb'scycle. c) Electron Transfer System(ETS) **4.3** Mechanism of Anaerobic respiration: Alcoholic Fermentation **4.4** Factor affecting the process of respiration.	**15**

Unit IV	**Nitrogen metabolism (06h)** **5.1** Introduction. **5.2** Types of Nitrogen fixation. **5.3** Biological nitrogen fixation. **5.4** Nitrate and ammonia assimilation. **5.5** Importance	**15**
References	• Kochhar P. L. (1962) Plant Physiology, Atmaram and Sons, Delhi, India • Salisbury, F.B and C.W. Ross (1999): Plant Physiology CBS Publishers and Printers, New Delhi • Harborne, J.B. (1973). Phytochemical Methods. John Wiley and Sons. New York • Mukherjee, S. Ghosh A.K. (1998) Plant Physiology, Tata McGraw Hill Publishers(P) Ltd., New Delhi	

Proposed methods of teaching/ innovative teaching

 Classroom teaching, lecture cum demonstration methods, question answer method, brain storming method, assignment method

 Innovative teaching: audio video, science museum, ICT enabled teaching, video clips/ movies, field trips.

M.Sc. II (Botany)
Semester III
BOT-DSC-615: Practical Based on BOT-DSC-611 and BOT-DSC-612

Total Hours: 60 **Credits: 02**

Course objectives	• To provide the students to understand the Principle working and uses of laminar air flow hood, autoclave, hot air oven, Electrophoresis and centrifuge • To know different methods agarose-gel electrophoresis • To know the Structure and organization of the embryo Sac • To learn Polyembryony and its types	
Course outcomes	After completion of this course, the student will be able to: • Understand the Principle working and uses of laminar air flow hood, autoclave, hot air oven, Electrophoresis and centrifuge • Know different methods agarose-gel electrophoresis • know the Structure and organization of the embryo Sac • Aquired the knowledge of Polyembryony and its types	
Practical number	**Topic Particular**	**Hours**
1	Principle working and uses of laminar air flow hood, autoclave, hot air oven, Electrophoresis and centrifuge.	4
2	Sterilization of glassware and instruments steam sterilization and dry sterilization.	4
3	MS media preparation and Micropropogation of 20xplants.	**4**
4	Selection and surface sterilization of explants and Inoculation of explants on media for Callus culture.	**4**
5	Encapsulation of embryo in sodium alginate for preparation of synthetic seed.	**4**
6	PCR amplification using gene specific primers. **(Demonstration)**	**4**
7	Study of agarose-gel electrophoresis	**4**
8	Study of shoot apical meristem and root apical merisrtem (any one)by locally available plants	**4**
9	Study different types of stomata	**4**
10	Study of development and structure of microsporangium	**4**
11	Study of development and structure of Megasporangium	**4**
12	Study the Structure and organization of the embryo Sac.	**4**
13	Study of Polyembryony and its types	**4**
14	Study of Polarity, symmetry, NPC and pollen polymorphism	**4**
15	Study of Polarity, symmetry, NPC and pollen polymorphism	**4**
References	• Howe, C., (2007). Gene Cloning and Manipulation. 2nd Edition. • Watson, D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., and Losick, R. (2008). Molecular Biology of Gene. 6th Edition, Cold Spring HarborLaboratory Press Cold Spring Harbor, New York,	

U.S.A.
- Clark, D., Pazdernik, N., McGehee, M. (2018). Molecular biology. 3rd Edition.
- Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London.
- Henry, R. J. (2005). Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
- Shaw, C. H. and Brown. T.A. (1988, 2020). Gene Cloning and DNA Analysis: An Introduction. 8th Edition.
- Bewley, J.D.and Black, M. (1994). Seeds: Physiology of Development and Germination. Plenum Press, New York, U.S.A.
- Fahn, A. (1982). Plant Anatomy. (3rd edition). Pergamon Press, Oxford, U.K.
- Raghavan, V. (1999). Developmental Biology of Flowering Plants. Springer – Verlag, New York, U.K.
- Waisel, Y., Eshel, A. and Kafkaki, U. (eds) (1996). Plant Roots: The Hidden Hall (2nd edition). Marcel Dekker, New York, U.S.A.
- Shivanna, K.R.andRangaswamy, N.S. (1992). Pollen Biology.: A Laboratory Manual.

M.Sc. II (Botany)
Semester III
BOT-DSE-616A: Practical Based on BOT-DSC-614A

Total Hours: 60 **Credits: 02**

Course objectives	• To provide the students to understand the Detection of secondary plant metabolites • To know Separation of molecules by paper chromatography • To know the Estimation of alcohol in fermented grape juice • To learn the study the activity of enzyme lipase in germinating seeds	
Course outcomes	After completion of this course, the student will be able to: • Understand the Detection of secondary plant metabolites • Know Separation of molecules by paper chromatography • Learn the Estimation of alcohol in fermented grape juice • Acquired the knowledge activity of enzyme lipase in germinating seeds	
Practical number	**Topic Particular (Any 8 from this)**	**Hours**
1-2	Extraction and separation of free amino acid of germinating seed bycircular paper chromatography.	08
3-4	Extraction and separation of free amino acid of germinating seed bycircular paper chromatography.	08
5	Extraction and separation of free sugars from ripe fruits by ascending paperChromatography.	04
6	To extract and estimate the amount of Ascorbic acid present in green paper(Raw)/ Lemon (Fresh).	04
7	Extraction and Detection of secondary plant metabolites from suitableplant material i) Alkaloids ii) Phenols iii) Terpenoids iv) Proteins.	04
8	Extraction and Detection of secondary plant metabolites from suitableplant material i) Alkaloids ii) Phenols iii) Terpenoids iv) Proteins.	04
9	Estimation of amount of CO2 evolved during respiration (Germinating Peaseeds).	04
10	Estimation of ether soluble fat oil of *Ricinus*/ *Arachis*seeds by Soxhletapparatus.	04
11	To study the activity of enzyme lipase in germinating seed s (Source-*Arachis*/*Ricinus*) any one.	04
12-13	Estimation of alcohol in fermented grape juice.	08
14-15	Estimation of ether soluble fat oil of *Ricinus*/ *Arachis*seeds by Soxhletapparatus.	08
References	• Anand, B. K. & S. K. Manchanda (1976) Text Book of Physiology. Tata McGraw Hill Publications Co. Ltd, Dehli, India.	

	• Arditt, J. (1969) Experimentl Plant Physiology, Holt Rinehrt&Winst on Inc,NewYork. • Bidwell, R. G. (1979)Plant Physiology.McMillan Publishing Co. Inc. NewYork 26 • Brett, C. and K. Waldran (1970) Physiology and Biochemistry of Plant Cell Wall. Unuinttyman,Boston, USA. • De. Robertis, E. D. P. and De Robertis, E. M. T. (1987) Cell and Molecular Biology. VIII Eds. Lea &Febiger International Edition Info -Med. Hongkong. • Fogg, G. E. (1972) PhotosynthesisSydenyAucklant,Australia. • Grewal, R. C. (2000)Plant Physiology. Campus Books International, Darya Ganj, New Delhi, India. • Hess, D. (1975) Plant Physiology.NarosaPublishingHouse, New Delhi, India	

M.Sc. II (Botany)
Semester III
BOT-DSE-616B: Practical Based on BOT-DSC-614B

Total Hours: 60 **Credits: 02**

Course objectives	• To provide the students to understand the activity of catalase and the effect of pH and enzyme concentration. • To know Separation of molecules by paper chromatography • To know the Isolation and Inoculation of *Rhizobium* • To learn the R. Q. in different plants parts	
Course outcomes	After completion of this course, the student will be able to: • Understand the the activity of catalase and the effect of pH and enzyme concentration. • Know Separation of molecules by paper chromatography • Learn the Isolation and Inoculation of *Rhizobium* • Aquired the knowledge of R. Q. in different plants parts	
Practical number	**Topic Particular (Any 8 from this)**	**Hours**
1	Study the activity of catalase and study the effect of pH and enzyme concentration.	04
2	Study the activity of catalase and study the effect of pH and enzyme concentration.	04
3	Study the activity of catalase and study the effect of pH and enzyme concentration.	04
4	To study the effect of light intensity and bicarbonate concentration on O2evolution in photosynthesis.	04
5-6	To study the effect of light intensity and bicarbonate concentration on O2evolution in photosynthesis.	08
7-8	Separation of amino acids by paper chromatography.	08
9-10	Separation of Sugar by paper chromatography.	08
11	**Demonstration experiments** i. To demonstrate the presence of starch in chloroplast ii. CO2 essential for Photosynthesis iii. R.Q. (Respiratory Quotient) iv. Kuhne's Tube experiment	04
12	**Demonstration experiments** i. To demonstrate the presence of starch in chloroplast ii. CO2 essential for Photosynthesis iii. R.Q. (Respiratory Quotient) iv. Kuhne's Tube experiment	04
13	Isolation and Inoculation of *Rhizobium*	04
14	Isolation and Inoculation of *Rhizobium*	04
15	To study the R. Q. by using different plants parts	04

References	• Kochhar P. L. (1962) Plant Physiology, Atmaram and Sons, Delhi, India • Salisbury, F.B and C.W. Ross (1999): Plant Physiology CBS Publishers and Printers, New Delhi • Harborne, J.B. (1973). Phytochemical Methods. John Wiley and Sons. New York • Mukherjee, S. Ghosh A.K. (1998) Plant Physiology, Tata McGraw Hill Publishers(P) Ltd., New Delhi	

MSc II (Botany)
Semester III
BOT-RM-617: Research Project I

Hours: 120 **Credits: 4**

Course objectives	1. To give exposure to the students to research culture and technology 2. To introduce students to how to select a research topic, plan, perform experiments, collect and analyze the data **3.** To foster self-confidence and self-reliance in the students as they learn to work and think independently
Course outcomes	After successful completion of this course, students are expected to: • Conceive a problem based on published research and conduct a comprehensive literature survey. • Learn handling of instruments, use of chemicals and how to conduct the experiments • Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.

Unit	Contents	Hours

Credit distribution (1 credit for each unit)

- Identification of a research topic, formulation of research problem, objectives, sample size and hypothesis, etc
- Preparation of Outline
- Review of literature
- Bibliography

The systematic approach towards the execution of the project should be as follows:
(Wherever applicable)

1. The complete tenure of the research project should be one year. It should be allotted during the third semester and completed in the fourth semester.
2. Weekly 8 hours should be allotted to the research project in a regular timetable.
3. In the third semester, students will be evaluated based on a credit distribution mentioned above. In the fourth semester, students should perform further research work, collect and analyze the data, compile the results and prepare and submit the final dissertation.
4. Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.
5. Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.
6. Each research group should have a different research topic with some possible level of novelty.
7. The student should select the topic relevant to priority areas of concern or allied subjects with the guidance of supervisor/ head of the department.
8. Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.
9. At the beginning, students should submit the outline of the research work to be carried out in the project. (Writing in order: Title, Aim and objectives, Literature to be collected, Experimental plan or method design, expected outcome etc.)

10. Write and submit a Literature Review Report and Research outline
    Tentative order for review: Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim of the Project, Materials and Methods, Bibliography/reference etc.
    Tentative order for research outline: Title page, introduction, background and significance of study, problems to be investigated, objective, hypothesis, chapter scheme, bibliography.
11. At the end of the third semester, each student should submit a detailed Literature Review Report and research outline.
12. An appropriate and essentialconclusive statement must be drawn at the end of the study.
13. Students should maintain lab notebooks, and the Supervisor may ask them to submit the mid-semester progress report.
14. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.
15. Three copies of the Literature Review Report, research outline should be prepared (one copy for each department, guide, and student).
16. At the end of the semester, the candidate should prepare and present research work using a PowerPoint presentation with modern ICT tools and present the same in front of his/ her respective department during the Internal Examination.
17. For external examination the candidate will have to present the research work and face viva voce.
18. Students may present their research work in Avishkar/Webinars/Conferences.
19. Students should note that plagiarism is strictly prohibited.

Internal examination (40 marks): Components of continuous internal assessment:

- Draft Research Outline (10 marks)
- Draft Review of literature (10 marks)
- Working Bibliography (10 marks)
- PowerPoint presentation, and oral examination (10 marks)

External examination (60 marks)and Components of external assessment:

- Final submitted review report, research outline in bound form at the time of examination **(40 marks)**
- Overall presentation reflecting the contribution of work, response to questions **(20 marks)**

References

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- Gurumani, N. (2014). Research methodology for biological science, MJP Publisher, Chennai
- Kothari, C. R. (2004). Research methodology: Methods and techniques. New Age International.
- Malmfors, B., Garnsworthy, P., & Grossman, M. (2003). Writing and presenting scientific papers. Nottingham University Press.
- Joshua, O. Miluwi&Hina Rashid, R. M. (2015). Principle Method and Practices, Mangalam Publication.
- Krishnaswamy O. P & Reddy, D. Obul. (2010). Research Methodology and Statistical Analysis, Himalaya Publishing House

Semester IV

M.Sc. II (Botany)
Semester IV
BOT-DSC-621: Genetics and Plant Breeding special paper- II

Total Hours: 60 **Credits: 04**

Course objectives	**1**Acquaint students from modern strategies applied in Genetics and Plant Breeding to sequence and analyse genomes. 2. To provide detail knowledge about modern strategies applied in Plant Breeding targeted with specific character improvement. 3. To provide detail knowledge about exploitation of Heterosis, hybrid and variety development and their release 4. To provide the detailed knowledge of molecular techniques used for molecular breeding. 5. To provide basic idea about the organic farming techniques**.**	
Course outcomes	1. .Student will know modern strategies applied in Genetics and Plant Breeding to sequence and analyse genomes. 2. 2.Student will get knowledge of modern strategies applied in Plant Breeding targeted with specific character improvement. 3. 3.The course will help the student to acquire the knowledge of exploitation of Heterosis, hybrid and variety development and their release 4. 4.The course will help the students to get acquainted with molecular techniques used for molecular breeding. 5. 5.The student will be provided with knowledge of basic idea about the organic farming techniques.	
Unit	**Topic Particular**	**Hours**
Unit I	**Advanced Plant Breeding** Ideotype concept in crop improvement: i) Concept, types, ii) Development of ideotypes, iii) Identification of traits for analysis, iv) Determination of the value of a trait, ideotypes of selected crops Maize, cotton. Breeding for resistant to a-biotic stresses: a) Drought resistance Salinity tolerance c) Heat and cold resistance. Breeding for resistant to biotic stresses: A) Disease resistance, B) Insect resistance.	15
Unit II	**Breeding for quality**: Protein quality, Quality traits for cotton, Wheat, elimination of toxic substances, protein content and quality, genetic control of nutritional traits. Breeding for oil quality: Introduction to oil seed crops, Oil quality, breeding approaches Mutation breeding: Introduction, Effect of mutations mutagenic agents, physical mutagens, chemical mutagens, procedure for mutation breeding through chemical mutagens for oligogenic traits, application of mutation breeding.	15

	Variation in chromosome behaviour, endo-mitosis ploidy, aneuploidy, evolutionary significance of chromosome aberrations– balanced lethal and chromosome complexes. Role of polyploidy in plant breeding, evolutionary advantages of autopolyploid and allopolyploids- role of aneuploidy in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping, gene block transfer, allele addition and substitution lines, creation and utilization, distant hybridization. Concept of diploid for development of homozygous line from segregating population. Inter-specific hybridization and allopolyploids, synthesis of new crops Wheat, Triticale and *Brassica* hybrids between species same and different chromosome numbers bridge species.	
Unit III	**Fertilization barriers in crops plants** *In-vitro* techniques to overcome the fertilization barriers in crop, production and use of haploid, di-haploids and double haploids Heterosis breeding prediction of heterosis, study of F2 and segregating population, genetic distance and heterosis, development of heterotic pool. Use of male sterility in heterosis. Hybrid seed production system 1, 2, and 3-line system. Inbred and parental A, B, R lines. Maintenance of hybrid lines. Male sterile line creation, heterosis breeding in cotton, maize, pearl millet okra and oil seed crops. Breeding of cotton and groundnut–Breeding objectives, characters associated with breeding, commercial hybrid development and seed production, Evaluation procedure for Bt cotton. Oil quality characters in groundnut.	**15**
Unit IV	**Molecular Breeding** Molecular mapping, Tagging of Agronomically important traits, Statistical tools in marker analysis. Marker assisted selection for qualitative and quantitative traits. QTL analysis in crop plants, gene pyramiding. Marker assisted selection and molecular breeding, genomics and genomic information for crop improvement. Integrating functional genomics information on agro-nomically important traits in Plant Breeding. Marker assisted back cross breeding for rapid introgression Molecular mapping, molecular polymorphism, RFLP, RAPD, STS, AFLP, SNP markers, construction of genetic and physical map, gene mapping and cloning. Introduction to DNA micro-array. **Functional genomics, proteomics and Organic Farm Management.** Approaches to analyse differential expression of genes ESTS, SAGE, Micro-arrays and their application, Gene tagging, Gene trapping, Gene silencing, knock out mutants, Approaches to proteome analysis, Dynamic modulation of protein structure and function, Structure to function-virtual organism. Plant Engineering - Insect Resistance, Virus	**15**

	Resistance, Herbicide Resistance,Fungus and Bacterium Resistance, Oxidative stress, Salt and drought stress, Fruit Ripening and flower wilting.Concepts, Definition and components.Green Manuring, Biological Nitrogen Fixation, Application of VermicultureBiotechnology.Composting of Agriculture Waste, Weed and Pest Management. Nutrient Management and Crop residue management.	
References	Bruce A. (2004) Essential Cell Biology, Garland Publication Klug W. S. &Cammings M. R. (2003). Concepts Genetics Scoot Forman & Co Lodishh. Berk A &Zipursky S. L. (2004) Molecular Cell Biology 5thedition W. H. Freeman and Co. N. Nadarajan (2018), Quantitative Genetics and Biometrical Techniques in Plant Breeding, Kalyani Publishers, New Delhi, India. Nelson D.L. and CoxM. M. (2005) Lehninnger Principles of Biochemistry W. H. Freemon and Co. Singh B. D. (2006) Plant Breeding Kalyani Publishers, New Delhi, India. Singh P. (2014) Essentials of Plant Breeding Kalyani Publishers, New Delhi, India. Singh P. (2008) Plant Breeding at a Glance Kalyani Publishers. Singh P. (2019), Biometrical Techniques in Plant Breeding, Kalyani Publishers, New Delhi, India	

Possible methods of teaching/ innovative teaching

- Discussion, analysis and feedback, discussion and problem solving, classroom teaching, lecture method, demonstration methods, lecture cum demonstration methods, laboratory method, project method, problem solving method, question answer method, brain storming method, assignment method,
- Innovative teaching: audio video hands on learning, science museum, project-based learning, ICT enabled teaching, video clips/ movies, science fairs, science kit, field trips, mobile apps like zoom, google platform etc.

M.Sc. II (Botany)
Semester IV
BOT-DSC-622: Genetics and Plant Breeding special paper- III

Total Hours: 60 **Credits: 04**

Course objectives	**To provide knowledge of biometrical tools applied in plant breeding.** 1. Acquaint students about principles, methodology and application Plant Biotechnology to improve crops. 2. To provide detail knowledge about intellectual properties and different issues, GMO, current techniques applied in Molecular Plant Breeding for future challenges in crop improvement. 3. To provide knowledge about the legal issues with respect to certification of seed and the organizations of crop improvement.	
Course outcomes	1. Student will acquire knowledge of biometrical tools applied in plant breeding. 2. Student will acquainted with principles, methodology and application Plant Biotechnology to improve crops. 3. They will be provided with knowledge of intellectual properties and different issues, GMO, current techniques applied in Molecular Plant Breeding for future challenges in crop improvement. 4. Students will be provided with knowledge of legal issues with respect to certification of seed and the organizations of crop improvement.	
Unit	**Topic Particular**	**Hours**
Unit I	**Biometrical Genetics:** Mendelian traits verse polygenic traits Nature of quantitative traits and its inheritance Multiple factor hypothesis analysis of continuous variation Variation associated with polygenic traits- phenotypic genotypic and environmental. Nature of gene action– additive, dominance, epistatic and linkage effect. Principals of analysis of variances (ANOVA): Expected variance of components random and fixed models,Comparison of means and variances for significance.	15
Unit II	**Design for plant breeding experiments:** Principal and application, genetic diversity analysis metroglyph, cluster and D2 analysis, association analysis phenotypic and genotypic correlations path analysis. Parent progeny regression analysis. General mean analysis, mating designs diallel cross partial diallel, Line x tester analysis, Biparental cross analysis, combining ability and gene action. Analysis of genotype and environment interaction adaptability and stability, models of GXE analysis and stability parameters. QTL mapping, desired population for QTL mapping, statistical methods in QTL mapping. Marker assisted selection (MAS) its application in plant breeding.	15

Unit III	**Modern Trends in Genetics and Plant Breeding** Genetically modified organisms. International regulation of bio- safety issues of GMOs, regulatory procedures in India, ethical, legal and social issues. Release of new varieties: Evaluation, identification of entries for release at state and national level, multiplication. Quality seed production: **a)** Seed industries in India**, b)** The Indian seed act 1996**, c)** Classes of improved seeds, d**)** Requirements for certified seeds, **e)** Operations essentials to a seed industry**, f)** Quality seed production, processing and seed certification, **g)** Certified seed production in Maize and Cotton.	**15**
Unit IV	**UNIT-IV: Crop improvement organizations andIntellectual Property Rights** ICAR, IARI, CICR, Sugar cane breeding institute (SBI), NBPGR. Organization for crop improvement at international level Introduction, CIMMYT, IRRI, ICRISAT, IPGRI. Intellectual property rights (IPR) and its managementHistorical perspectives and need for the introduction of intellectual property rights regimeTRIPS and various provisions in TRIPS agreementIPR and their benefitsIndian legislations for the protection of various types of intellectual properties fundamentals of patentCopyrightsGeographical indication designs and layoutTrade secrets trademarks. Protection of plant varieties and formers rightBiodiversity protection, protectable subject matterProtection in biotechnologyPeriod of protection international treaty on plant genetic resources for food and agriculture's licensing of technologiesMaterial transfer agreements research collaboration agreementLicense agreement. **Functional Genomics and Proteomics** Functional genomics using micro-array technology SNP detection, environmental agent's detection micro-array design, experimentation with micro-array computational analysis of micro- array data. Proteome analysis, electrophoresis, iso-electical focusing HPLC, MASS spectroscopy in proteomics MALDITOF, electro-spray ionization, and MUDPIT and protein arrays. Protein Structural Genomics–Introduction, determination of gene function by comparison of sequences through conserved protein structure. Approaches to protein structural genomics and protein expression. Protein interactions, their screening and informatics tools.	**15**
References	Chopra V. L. and Nasim A. (1990) Genetic engineering and Biotechnology concepts, methods and applications Oxford and IBH, New Delhi, India. Das, H.K. and others Textbook of Biotechnology (3rd edition) Wiley India (P) Ltd, India. Ganguli P. (2001) Intellectual Property Rights Unleashing Knowledge Economy McGraw Hill, Gupta P. K. (1997) Elements of Biotechnology Rastogi Publishers, Meerut, India. Joseph G. (2000) Handbook for Writers of Research Paper (5thedition)	

	Affiliated East-West New Delhi. India. Press. Primrose S. B. and Twyman R. M. Principles of Genome analysis and Genomics. Edition 3rd Blackwell Publishing 2003. Saha R(Ed) (2006) Intellectual Property Rights in NAM and Other Developing Countries Sanbrrok J. and Russel D (2001) Molecular Cloning: A laboratory manual 3rd Old Edition Singh Singh B. D. (2005) Biotechnology Expanding Horizons, Kalyani Publishers, India. Singh P (2020) Commercial Plant Breeding, Daya Publishing House, Astral International Pvt. Ltd., New Delhi, India. Yumbi Xu. (2010) Molecular Plant Breeding. CABI Spring Harbour Lab Press)	

Possible methods of teaching/ innovative teaching

- Discussion, analysis and feedback, discussion and problem solving, classroom teaching, lecture method, demonstration methods, lecture cum demonstration methods, laboratory method, project method, problem solving method, question answer method, brain storming method, assignment method,
- Innovative teaching: audio video hands on learning, science museum, project-based learning, ICT enabled teaching, video clips/ movies, science fairs, science kit, field trips, mobile apps like zoom, google platform etc.

M.Sc. II (Botany)
Semester IV
BOT- DSE-623 A:Natural Resource Management

Total Hours: 30 **Credits: 02**

Course objectives	1. To introduce the students with "Natural Resources". 2. To study biological resources and forests 3. To study the scope and importance of energy resources 4. To study the practices and accounting of resources	
Course outcomes	On completion of this course the students will be able to: 1. Students will be well versed with Natural resources 2. Student will acquire the knowledge of biological resources and forests 3. Students will know the scope and importance of energy resources 4. Student will familiar with the practices and accounting of resources	
Unit	**Topic Particular**	**Hours**
Unit I	**Natural resources**: Definition and types. **Sustainable utilization** :Concept, approaches (economic, ecological and sociocultural). **Land:** Utilization (agricultural, horticultural, silvicultural); Soil degradation and management. **Water:** Fresh water (rivers, lakes, groundwater, water harvesting technology, rain water storage and utilization.	15
Unit II	**Biological Resources:** Biodiversity-definition and types; Significance; Threats; Managementstrategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan). **Forests:** Definition, Cover and its significance (with special reference to India); Major andminor forest products; Depletion; Management.	15
Unit III	**Energy**: Renewable and non-renewable sources of energy-solar, wind, tidal,geothermal and bioenergy resources. **Contemporary practices in resource management**: EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbonfootprint.	**15**
Unit IV	Resource Accounting; Waste management. National and international efforts in resource management and conservation	**15**
References	• B. W. Pandey. 2005. Natural Resource Management. Mittal Publication, New DelhiReference Books: • Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House,New Delhi. • Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment andResourceConservation. Anamaya Publications, New Delhi. • Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to SustainableDevelopment. Prentice Hall of India Private Limited, New Delhi.	

M.Sc. II (Botany)
Semester IV
BOT- DSE-623 B: Cell and Molecular Biology

Total Hours: 30 **Credits: 02**

Course objectives	1. To introduce the students with "Cell Science". 2. To study Cell wall Plasma membrane, Cell organelles and cell division. 3. To study the scope and importance of molecular biology. 4. To study the biochemical nature of nucleic acids, their role in living systems, experimental evidences to prove DNA as a genetic material. **5.** To understand the process of synthesis of proteins and role of genetic code in polypeptide formation.	
Course outcomes	On completion of this course the students will be able to: 1. Students will be well versed with cell science 2. Student will acquire the knowledge of Cell organelles and cell division 3. Students will know the scope and importance of molecular biology 4. Student will familiar with biochemical nature of nucleic acids, their role in living systems, experimental evidences to prove DNA as a genetic material. 5. Students will be acquainted with knowledge of process of synthesis of proteins and role of genetic code in polypeptide formation.	
Unit	**Topic Particular**	**Hours**
Unit I	**Introduction, Cell wall and Plasma membrane** 1.1. Definition and Brief History 1.2. Prokaryotic and Eukaryotic cell 1.3. Scope and Importance 1.4. Morphology, Ultra-structure, Chemical composition, Functions of Cell wall, Plasma membrane. (Lamellar model and fluid mosaic model)	15
Unit II	**Cytoplasmic matrix and Cell organelles, cell cycle and cell division** 2.1. Physical nature of Cytoplasmic matrix 2.2. Chemical organization- organic and inorganic compounds of cytoplasmic matrix. 2.3. Morphology, Ultrastructure, Chemical composition, Functions of Endoplasmic Reticulum, Golgi apparatus, Lysosomes, Mitochondria, Chloroplast, Vacuoles, Ribosomes 2.4. Nucleus- Morphology, Ultra-structure, Nucleoplasm, Nucleolus, Functions 2.5. Chromosome- Number, Morphology, Structure, Euchromatin and Heterochromatin and Karyotype 2.6. Special types of chromosome: Lamp-brush chromosome and salivary gland chromosome 2.7. Definition of cell cycle 2.8. Brief explanation of Cell Cycle 2.9. Cell division: Mitosis and Meiosis Significance of Mitosis and Meiosis	15

Unit III	**Introduction and DNA as Genetic Material** 4.1. Definition and History 4.2. Scope and Importance 4.3. Discovery of genetic material 4.4. Watson and Crick's model of DNA, Rosalind Franklin work 4.5. Chargaff rule 4.6. Forms of DNA: A-DNA, B-DNA, Z-DNA **DNA Replication and Transcription** 5.1. Introduction and types of DNA Replication 5.2. Meselson and Stahal's Experiment 5.3. Molecular Mechanism of DNA Replication 5.4. Sanger Method of DNA Sequencing 5.5. Central Dogma of Molecular Biology 5.6. Types of RNA and its role (m-RNA, r-RNA, t-RNA) 5.7. Definition and Mechanism of Transcription in Prokaryotes	**15**
Unit IV	**Genetic Code, Translation and gene regulation in prokaryotes (Prote synthesis)** Definition, Concept and Properties of Genetic code 6.1. Work of Nirenberg 6.2. Definition of Translation 6.3. Mechanism of Translation, Initiation, Elongation and Termination 6.4. Operon concept 6.5. Inducible and Repressible operon	**15**
References	• Cell and Molecular Biology, P. K. Gupta • Cell and Molecular Biology, DeRobertis and DeRobertis 7th Edition • Cell Biology, C. B. Powar, Himalaya Publishing House • Fundamentals of Molecular Biology, Veer BalaRastogi • A Text Book of Cell and Molecular Biology, RastogiPublication, Meerut. India, Gupta, P.K. (1999) • Molecular Biology of Gene, Watson J. D. • Cell Biology, Genetics, Molecular biology, Evolution and Ecology.3rd edition S.Chand& co. New Delhi, India.Verma, P. S., V. K. Agrawal. (2008) • Watson J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., Losick, R. (2007). Molecular	

M.Sc. II (Botany)
Semester IV
BOT- DSC-624: Practical based on BOT-DSC-621

Total Hours: 60 **Credits: 02**

Course objectives	1. To provide the techniques of Genetics and Plant Breeding 2. To make student familiar with methods of the course. 3. To make students aware of methods and practices of Genetics and Plant Breeding
Course outcomes	1. The techniques of DNA isolation quantification of DNA and RNA, PCR amplification electrophoresis will be provided to the students 2. Students will acquire the methods of biometry plant breeding. 3. Course will help students to make aware preparation of green leaf manure, plant-based repellent etc.

Practical	**Topic Particular**	**Hours**
1	Isolation of DNA	4
2	Isolation of DNA	4
3	Quantification of RNA by Orcinol method	4
4	Quantification of RNA by Orcinol method	4
5	Isolation and purification of proteins from plant materials	4
6	Protein or iso-enzyme gel electrophoresis	4
7	Agarose gel electrophoresis of DNA	4
8	PCR amplification of DNA	4
9	Study of protein content by Lowry's method from the plant samples of different lines which are recovered from crossing program carried in Semester III practical schedule.	4
10	Study of enzymes defines stress tolerance in crops. (any two)	4
11	Preparation of Green leaf manure and estimate the nutrient composition of manure.	4
12	Preparation of plant-based repellent for pest management.	4
13	Analysis of variance (ANOVA)	4
14	Estimation of heritability	4
15	Estimation of genetic advance	4
References	Bruce A. (2004) Essential Cell Biology, Garland Publication Klug W. S. &Cammings M. R. (2003). Concepts Genetics Scoot Forman & Co Lodishh. Berk A &Zipursky S. L. (2004) Molecular Cell Biology 5thedition W. H. Freeman and Co. N. Nadarajan (2018), Quantitative Genetics and Biometrical Techniques	

	in Plant Breeding, Kalyani Publishers, New Delhi, India. Nelson D.L. and CoxM. M. (2005) Lehninnger Principles of Biochemistry W. H. Freemon and Co. Singh B. D. (2006) Plant Breeding Kalyani Publishers, New Delhi, India. Singh P. (2014) Essentials of Plant Breeding Kalyani Publishers, New Delhi, India. Singh P. (2008) Plant Breeding at a Glance Kalyani Publishers. Singh P. (2019), Biometrical Techniques in Plant Breeding, Kalyani Publishers, New Delhi, India	

M.Sc. II (Botany)
Semester IV
BOT-DSC-625: Practical based on BOT-DSC-622

Total Hours: 60 **Credits: 02**

Course objectives	4. To provide the techniques of Genetics and Plant Breeding 5. To make student familiar with methods of the course. 6. To make students aware of methods and practices of Genetics and Plant Breeding	
Course outcomes	4. The techniques of DNA isolation quantification of DNA and RNA, PCR amplification electrophoresis will be provided to the students 5. Students will acquire the methods of biometry plant breeding. 6. Course will help students to make aware preparation of green leaf manure, plant-based repellent etc.	
Unit	**Topic Particular**	**Hours**
1.	Preparation of fixative, and stains (Acetocarmine or suitable cytological stain)	4
2.	Study of Mitosis techniques (Root tip of onion or any suitable material)	4
3.	Study of Meiosis techniques	4
4.	Study of Meiosis techniques	4
5.	Study of polytene chromosome from Chironomus larvae	4
6.	Isolation of DNA from any plant material (e.g., Cauliflower, Banana etc.) or any suitable plant material	4
7.	Isolation of DNA from any plant material (e.g., Cauliflower, Banana etc.) or any suitable plant material	4
8.	Mitochondrial staining by Janus green stain.	4
9.	Statistical analysis of F1 populations and finding out their results and conclusion, finding of GCA and SCA with gene action	4
10.	Statistical analysis of F1 populations and finding out their results and conclusion, finding of GCA and SCA with gene action	4
11.	Study of cluster and path analysis.	4
12.	Visit to Agricultural research station	4
13.	Visit to Agricultural research station	4
14.	Study of correlation and regression from given data.	4
15.	Maintenance of experimental records	4
References	Das, H.K. and others Textbook of Biotechnology (3rd edition) Wiley India (P) Ltd, India. Ganguli P. (2001) Intellectual Property Rights Unleashing Knowledge Economy McGraw Hill, Gupta P. K. (1997) Elements of Biotechnology Rastogi Publishers, Meerut, India. Joseph G. (2000) Handbook for Writers of Research Paper (5thedition) Affiliated East-West New Delhi. India. Press.	

	Saha R(Ed) (2006) Intellectual Property Rights in NAM and Other Developing Countries Sanbrrok J. and Russel D (2001) Molecular Cloning: A laboratory manual 3rd Old Edition Singh Singh B. D. (2005) Biotechnology Expanding Horizons, Kalyani Publishers, India. Singh P (2020) Commercial Plant Breeding, Daya Publishing House, Astral International Pvt. Ltd., New Delhi, India. Yumbi Xu. (2010) Molecular Plant Breeding. CABI Spring Harbour Lab Press)	

M.Sc. II (Botany)
Semester IV
BOT- DSE-626A: Practical based on BOT-DEC-623A

Total Hours: 60 **Credits: 02**

Course objectives	1. To introduce the students with "solid waste and natural Resources". 2. To study biological resources and forest cover 3. To study the scope and importance of dominance of a species 4. To study the GPS and GIS Technology	
Course outcomes	On completion of this course the students will be able to: 1. Students will be well versed with solid waste and natural Resources 2. Student will acquire the knowledge of biological resources and forest cover 3. Students will know the scope and importance dominance of a species 4. Student will familiar with the GPS and GIS Technology	
Sr. No.	**Particulars**	**Hours**
1	Estimation of solid waste generated by a domestic system (biodegradable and nonbiodegradable) and its impact on land degradation.	4
2	Estimation of solid waste generated by a domestic system (biodegradable and nonbiodegradable) and its impact on land degradation.	4
3	Collection of data on forest cover of specific area.	4
4	Collection of data on forest cover of specific area.	4
5	Measurement of dominance of woody species by DBH (diameter at breast height) method	4
6	Measurement of dominance of woody species by DBH (diameter at breast height) method	4
7	Calculation and analysis of ecological footprint.	4
8	Ecological modeling.	4
9	Satellite Imagery FCC image interpretation	4
10	Digital Image classifications : Supervised	4
11	Digital Image classifications : Supervised	4
12	Digital Image classifications :Unsupervised	4
13	Digital Image classifications :Unsupervised	4
14	GPS Point Location Identification	4
15	GPS Point Location Identification	4
References	• B. W. Pandey. 2005. Natural Resource Management. Mittal Publication, New Delhi Reference Books: • Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House,New Delhi. • Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment andResourceConservation. Anamaya Publications, New Delhi. • Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.	

M.Sc. II (Botany)
Semester IV
BOT- DSE-626B: Practical based on BOT-DEC-623B

Total Hours: 60 **Credits: 02**

Course objectives	1. To introduce the students with "Fixative and stains". 2. To study of mitosis and meiosis 3. To study the isolation of DNA 4. To study the estimation of Protein and DNA	
Course outcomes	On completion of this course the students will be able to: 1. Students will be well versed with solid "Fixative and stains". 2. Student will acquire the knowledge of mitosis and meiosis 3. Students will know the methods of isolation of DNA 4. Student will familiar with estimation of Protein and DNA	
Sr. No.	**Particulars**	**Hours**
1.	Preparation of fixative	04
2.	Preparation of stains (Acetocarmine or suitable cytological stain)	04
3.	Study of Mitosis techniques (Root tip of onion or any suitable material)	04
4.	Study of Mitosis techniques (Root tip of onion or any suitable material)	04
5.	Study of Meiosis techniques	04
6.	Study of Meiosis techniques	04
7.	Study of polytene chromosome from Chironomus larvae	04
8.	Study of Lampbrush chromosome	04
9.	Isolation of DNA from any plant material (e.g., Cauliflower, Banana etc.) or any suitable plant material	04
10.	Isolation of DNA from any plant material (e.g., Cauliflower, Banana etc.) or any suitable plant material	04
11.	Mitochondrial staining by Janus green stain.	04
12.	Estimation of Protein by kjeldahl method	04
13.	Estimation of Protein by kjeldahl method	04
14.	Estimation of DNA by DPA method	04
15.	Estimation of DNA by DPA method	04
References	• Cell and Molecular Biology, P. K. Gupta • Cell and Molecular Biology, DeRobertis and DeRobertis 7th Edition	

	• Cell Biology, C. B. Powar, Himalaya Publishing House • Fundamentals of Molecular Biology, Veer BalaRastogi • A Text Book of Cell and Molecular Biology, RastogiPublication, Meerut. India, Gupta, P.K. (1999) • Molecular Biology of Gene, Watson J. D. • Cell Biology, Genetics, Molecular biology, Evolution and Ecology.3rd edition S.Chand& co. New Delhi, India.Verma, P. S., V. K. Agrawal. (2008) • Watson J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., Losick, R. (2007). Molecular	

Possible methods of teaching/ innovative teaching

- Discussion, analysis and feedback, discussion and problem solving, classroom teaching, lecture method, demonstration methods, lecture cum demonstration methods, laboratory method, project method, problem solving method, question answer method, brain storming method, assignment method,
- Innovative teaching: audio video hands on learning, science museum, project-based learning, ICT enabled teaching, video clips/ movies, science fairs, science kit, mobile apps like zoom google platform, field trips

MSc II (Botany)
Semester IV
BOT- 627: Research Project II

Hours: 180 **Credits: 6**

Course objectives	1. To give exposure to the students to research culture and technology 2. To introduce students to how to select a research topic, plan, perform experiments, collect data and analyze the data **3.** To foster self-confidence and self-reliance in the students as they learn to work and think independently
Course outcomes	After successful completion of this course, students are expected to: • Conceive a problem based on published research and carry out a comprehensive survey of the literature • Learn handling of instruments, use of chemicals and how to conduct the experiments • Learn how to present the project in PowerPoint and answer the queries to examiners as well as the science of writing

The systematic approach towards the execution of the project should be as follows: (Wherever applicable)

The complete tenure of the research project should be one academic year. It should be allotted during the third semester and completed in the fourth semester.

1. Weekly 12 hours should be allotted to the research project in a regular timetable.
2. In the fourth semester, students should perform further experimental work, analyze the data and compile the results.
3. Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.
4. Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.
5. Each research group should have a different research topic with some possible level of novelty.
6. The student should select the topic relevant to priority areas of concern or allied subjects.
7. Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.
8. Students are expected to work in line with the research outline and literature review, which was submitted in the third semester.
9. Students are expected to learn how to execute the research work systematically and overcome the hurdles. Students will get the opportunity to learn about practical aspects of many characterization techniques or models and further how to effectively employ them in the research work. Students should be able to critically evaluate the literature on the topic, identify the research gaps, plan and perform the experiments, interpret the results, understand the limitations of the work and draw conclusions.
10. At the end of the semester, each student should submit a detailed Research Report.
11. The format of the final research report shall be as per the guidelines of respective department. (**Example**: Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim and objective, Materials and Methods, Result, Data analysis and Discussions, conclusion, limitations, suggestion, future scope, Bibliography,

Appendix etc.)

12. An appropriate and essential conclusive statement must be drawn at the end of the study.
13. Students should maintain lab notebooks, and the supervisor may ask them to submit the mid-semester progress report.
14. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.
15. Three copies of the dissertation should be prepared (one copy for each department, guide, and student).
16. At the end of the semester, the candidate should prepare and present research using a PowerPoint presentation using modern ICT tools during the Internal and External Examination.
17. Besides writing a dissertation, students are encouraged to write a manuscript/patent if the results obtained are worthy of publication.
18. Students may present their research work in Avishkar/Webinars/Conferences.
19. Students should note that plagiarism is strictly prohibited.

Internal examination (60 marks): Components of continuous internal assessment:

- Literature collected, methodological planning, analysis of data, design and work, progress reports etc (30 marks)
- Presentation in Webinars/Conferences/publication and departmental presentation etc (20 marks)
- Oral examination (10 marks)

External examination (90 marks) and Components of external assessment:

- Evaluation of dissertation submitted in bound form at the time of examination **(60 marks)**
- Presentation (PPT format) **(15 marks)**
- Overall presentation reflecting the contribution of work, Response to questions **(15 marks)**