Name of the Programme : Ph.D. (Botany)
Course Code : BOT-700
Title of the Course : Research Methodology
Number of Credits : 04
Effective from AY : 2022-23

Prerequisites for the course:	Basic knowledge of Biological Sciences and Biotechnology at post-graduate level.	
Course Objectives:	• To familiarize fundamental research principles, research tools, and methodologies. • To facilitate data collection, compilation, analysis, interpretation and report writing. • To conduct scientific research.	
Content:	1. **Literature collection:** Need for review of literature; Review process and bibliography; Research reading; Discriminative reading; Consulting source material; Working bibliography; index cards and reference cards.	2 hours
	2. **Literature citation:** Different systems of citing references; Name-year system-citation in the text; Name-year system-list of references; Citation-sequence system; Alphabet-number system; Journal abbreviations.	2 hours
	3. **Computers and information technology in research:** Computer operating systems; MS-office; search engines; searching e-journals; online abstracts; preparing scientific webliography; online publications; biological and taxonomic databases; basic tools of bioinformatics.	4 hours
	4. **Scientific Writing: Fundamentals**: Need for clarity, language; origins; definition of scientific paper; preparing title, listing authors; preparing abstract; writing materials and methods; writing results and discussion; citing references; preparing tables and illustrations; selecting scientific journals for publication; citation, citation index; writing a review paper; presenting a paper orally; preparing a scientific poster.	4 hours
	5. **Plagiarism**: Data errors and plagiarism; Plagiarism Check Softwares; Direct Plagiarism; Self Plagiarism; Mosaic Plagiarism; Accidental Plagiarism; Patchwriting; Invented Sources; Paraphrasing; Fake/Misleading Citations; Incremental Plagiarism; Uncredited Paraphrasing.	3 hours
	6. **Intellectual Property Rights:** Protection of IPR in India; Terminology associated with IPR: patent, copyright, trademark, design, geographical indication, plant variety and farmer's rights protection, trade secrets; Bio-piracy.	2 hours
	7. **Experimental designs:** Observation; Hypothesis and null-hypothesis; Basic principles of experiments: Experimental unit and sampling unit, experimental error, discrimination, replication, generalization, controls, randomization, measurement and a few common experimental designs.	4 hours
	8. **Basic Biostatistics**: Population and sample, variables in biology; data collection, classification, tabulation; sampling methods; inference about population; theoretical probability distribution; hypothesis testing, students t-test, ANOVA,	4 hours

	correlation, regression.	
	9. **Microscopy:** Compound microscope: Principle, resolving power of a microscope, working distance, useful magnification, illumination (Kohler illumination); Compound microscope-instrumentation; Light microscopes: Bright-field, dark-field, phase-contrast, differential interference contrast, fluorescence, polarization and confocal scanning microscope, Stereo-zoom microscope, micrometry. Electron microscopes: Scanning electron microscope (SEM), transmission electron microscope (TEM), scanning transmission electron microscope (STEM); microtomy and staining procedures.	7 hours
	10. **Photography:** Light, film, camera, operation of a camera, digital photography; image analysis.	2 hours
	11. **Centrifugation:** Centripetal and centrifugal forces; relative centrifugal force; factors affecting sedimentation rate; sedimentation coefficient and sedimentation constant; centrifuge, gradient media, types of centrifuges; applications of centrifugation; preparative centrifugation; analytical centrifugation.	2 hours
	12. **Chromatography:** General principles, techniques, and applications; Paper chromatography; Thin layer chomatography; Column chromatography; Gas chromatography; Liquid chromatography - reverse phase, HPLC, size exclusion, supercritical fluid, ion exchange, affinity and preparative liquid chromatography.	4 hours
	13. **Electrophoresis:** Principle and components of electrophoresis; factors affecting electrophoretic mobility, support medium, buffers, detection and assay, recording and storage, safety, types of electrophoresis and their applications: microelectrophoresis, moving boundary electrophoresis, paper electrophoresis, cellulose acetate electrophoresis, gel electrophoresis: Horizontal and vertical gel electrophoresis and their applications; Specialized electrophoretic techniques; Polyacrylamide gel electrophoresis; agarose gel electrophoresis; isoelectric focusing; two-dimensional PAGE; immunoelectrophoresis and immunofixation electrophoresis; denaturing gradient gel electrophoresis; temperature gradient gel electophoresis and capillary electrophoresis.	4 hours
	14. **Molecular techniques**: Flow Cytometry, Immuno-techniques, FRET (Fluorescence Resonance Energy Transfer), FRAP (Fluorescence Recovery After Photobleaching), Yeast hybrid assay, Immunoprecipitation assay, Surface Plasmon resonance, Proximity labelling, EMSA (Electrophoretic Mobility Shift Assay), Footprinting, Protein Crystallography, Microarray analysis, Site Directed Mutagenesis, Biosensors, CRISPR/Cas (Clustered Regularly Interspaced Short Palindromic Sequence/CRIPSR Associated Genes).	4 hours
	15. **Spectroscopy:** Spectrophotometry; Beer's Law; Principles, instrumentation and applications of UV-Visible Spectrophotometer, IR (infra-red), CD (circular dichoresim)	5 hours

	spectrophotometry; spectrofluorometry; luminometry, atomic absorption spectrophotometry, flame photometry; mass spectrophotometry; ESR (electron spin resonance) and NMR (nuclear spin resonance). 16. **Radiobiology:** The nature of radioactivity; atomic structure, stability and radiation; isotopes; types of radioactive decay, detection and measurement of radioactivity; Geiger-muller counter; Scintillation counter; Applications of radioisotopes in biological sciences; safety aspects of use of radioisotopes. 17. **Immunochemical techniques:** Antigens – natural, artificial antibodies, antigen-antibody interaction, kinetics, techniques. 18. **Laboratory practices and safety:** Bio-hazardous agents; Risk Groups and bio-safety levels; Laboratory-acquired Infections; Routes of exposure; Safety Measures: access to the laboratory, personal safety; Laboratory practices: cleanliness of laboratory, basic requirements of laboratory; basic and essential bio-safety equipment, disposal of bio-hazardous waste; Additional hazards: chemical hazards, fire hazards, electrical hazards, noise, radiation hazards; Safety in genetic engineering, First aid.	3 hours 2 hours 2 hours
Pedagogy:	Lectures/Tutorials/Seminars /Guided exercises.	
References/ Readings:	1. **Gurumani N.** (2005). An Introduction to biostatistics, MJP Publishers, Chennai. 2. **Gurumani N.** (2006). Research methodology for biological sciences. MJP Publishers, Chennai. 3. **Gupta, B.N. and Gupta N.** (2022). Research methodology. SBPD Publications, Uttar Pradesh. 4. **Karp, G.** (2009). Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley and Sons, USA. 5. **Kolthoff I.M. and Elving P. J.** (1978) Treatise on analytical Chemistry, Wiley Interscience, New York. 6. **Mishra, S.B. and Alok S. (2022).** Handbook of research methodology. Educreation Publishing, New Delhi. 7. **Robert D.A.** (1995). How to write and publish a scientific paper, Cambridge University Press. 8. **Saraswathy, N. and Ramalingam, P.** (2011) Concepts and Techniques in Genomics and Proteomics. Biohealthcare Publishing (Oxford) Limited, New York. 9. **Sharma, B.K.** (2006) Principal of analytical chemistry, Meerut Publication, Meerut. 10. **Venn R.F.** (2004). Principles and practices of bio-analysis, Taylor and Francis. 11. **Walker, J. M. and Rapley, R.** (2008). Molecular Biomethods Handbook, Hertfordshire, UK. 12. **Willard H.F., Merritt L.L., Dean, J.A. and Settle F.A.** (1988) Instrumental Method of analysis. CBS Publishers and distribution, New Delhi. 13. **Wilson K and Walker J.** (1996). Principles and techniques of practical biochemistry, Cambridge University Press. 14. **Xiong Jin.** (2006). Essential Bioinformatics. Cambridge University Press. 15. **Yau W. W., Kirkland J.J. and Bly D.D.** (2009) Modern size exclusion	

	chromatography, Wiley Interscience, New York.
Course Outcomes:	1. Able to develop an understanding of basic research methodologies, instrumentation, and designs. 2. Gain comprehensive knowledge of valid scientific measuring and scaling approaches along with theory of computational tools. 3. Able to analyse and interpret qualitative and quantitative data. 4. Able to investigate specific biological questions. 5. Able to conceive knowledge about scientific writing and presentation of valid and credible scientific report.